S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
1	ENG	NAL	ENG-NAL-1-3501	Applied Mathematical Methods	3	0	0	3
2	ENG	NAL	ENG-NAL-1-3502	Applied Numerical Methods	3	0	0	3
3	ENG	NAL	ENG-NAL-1-3503	Aircrafts and Systems	3	0	0	3
4	ENG	NAL	ENG-NAL-1-3504	Aerodynamics	2	0	0	2
5	ENG	NAL	ENG-NAL-1-3505	Aerospace Propulsion	2	0	0	2
6	ENG	NAL	ENG-NAL-1-3506	Flight Mechanics	2	0	0	2
7	ENG	NAL	ENG-NAL-1-3507	Avionics	2	0	0	2
8	ENG	NAL	ENG-NAL-1-3508	Aerospace Materials	2	0	0	2
9	ENG	NAL	ENG-NAL-1-3509	Structural Mechanics	2	0	0	2
10	ENG	NAL	ENG-NAL-2-3501	Fluid Dynamics	3	0	0	3
11	ENG	NAL	ENG-NAL-2-3502	Computational Fluid Dynamics	3	0	0	3
12	ENG	NAL	ENG-NAL-2-3503	Gas dynamics	3	0	0	3
13	ENG	NAL	ENG-NAL-2-3504	Low speed aerodynamics	3	0	0	3
14	ENG	NAL	ENG-NAL-2-3505	Boundary layer theory	3	0	0	3
15	ENG	NAL	ENG-NAL-2-3506	Gas Turbine Propulsion	3	0	0	3
16	ENG	NAL	ENG-NAL-2-3507	Heat Transfer in Propulsion Systems	3	0	0	3
17	ENG	NAL	ENG-NAL-2-3508	Aircraft Stability and Control	3	0	0	3
18	ENG	NAL	ENG-NAL-2-3509	Systems Engineering	3	0	0	3
19	ENG	NAL	ENG-NAL-2-3510	Advanced Avionics	3	0	0	3
20	ENG	NAL	ENG-NAL-2-3511	Advanced Embedded Systems and Software Engineering	3	0	0	3
21	ENG	NAL	ENG-NAL-2-3512	Mechanical behaviour of Materials	3	0	0	3
22	ENG	NAL	ENG-NAL-2-3513	Processing and Characterization of Metals	3	0	0	3
23	ENG	NAL	ENG-NAL-2-3514	Advanced Ceramics Materials	3	0	0	3
24	ENG	NAL	ENG-NAL-2-3515	Piezoelectric Materials and Devices	3	0	0	3
25	ENG	NAL	ENG-NAL-2-3516	Corrosion Engineering	3	0	0	3
26	ENG	NAL	ENG-NAL-2-3517	Surface Modification Technologies	3	0	0	3
27	ENG	NAL	ENG-NAL-2-3518	Nanostructured Coatings and Materials	3	0	0	3
28	ENG	NAL	ENG-NAL-2-3519	Advanced Structural Mechanics	3	0	0	3
29	ENG	NAL	ENG-NAL-2-3520	Finite Element Methods	3	0	0	3
30	ENG	NAL	ENG-NAL-2-3521	Structural Dynamics	3	0	0	3
31	ENG	NAL	ENG-NAL-2-3522	Stability of Structures	3	0	0	3
32	ENG	NAL	ENG-NAL-2-3523	Mechanics of Composites	3	0	0	3
33	ENG	NAL	ENG-NAL-2-3524	Design of Composite Structures	3	0	0	3

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
34	ENG	NAL	ENG-NAL-2-3525	Analysis of Composite Structures	3	0	0	3
35	ENG	NAL	ENG-NAL-2-3526	Processing & Characterization of Composite Materials	3	0	0	3
36	ENG	NAL	ENG-NAL-3-3501	Grid generation techniques for CFD	2	0	2	3
37	ENG	NAL	ENG-NAL-3-3502	Kinetic schemes for the computation of compressible flows	2	0	2	3
38	ENG	NAL	ENG-NAL-3-3503	Turbulent Flows	3	0	0	3
39	ENG	NAL	ENG-NAL-3-3504	Experimental Aerodynamics	3	0	0	3
40	ENG	NAL	ENG-NAL-3-3505	Mechanical aspects of Turbo Machinery	3	0	0	3
41	ENG	NAL	ENG-NAL-3-3506	Propulsion Systems for Light Aero Vehicles	3	0	0	3
42	ENG	NAL	ENG-NAL-3-3507	Experimental techniques in Propulsion	2	0	2	3
43	ENG	NAL	ENG-NAL-3-3508	Flight Vehicle Identification – Tools & Techniques	3	0	0	3
44	ENG	NAL	ENG-NAL-3-3509	Digital Image Processing and Applications	3	0	0	3
45	ENG	NAL	ENG-NAL-3-3510	Multi Sensor Data Fusion	3	0	0	3
46	ENG	NAL	ENG-NAL-3-3511	INS/GPS Multi-sensor Kalman Filter for Navigation	3	0	0	3
47	ENG	NAL	ENG-NAL-3-3512	Vision based Guidance and Control	3	0	0	3
48	ENG	NAL	ENG-NAL-3-3513	Advanced Experimental Techniques in Materials Science	2	0	2	3
49	ENG	NAL	ENG-NAL-3-3514	Materials for Energy Conversion	3	0	0	3
50	ENG	NAL	ENG-NAL-3-3515	Nano-Dimensional Magnetic Thin Films	2	0	2	3
51	ENG	NAL	ENG-NAL-3-3516	Computational Structural Dynamics and Aeroelasticity	2	0	2	3
52	ENG	NAL	ENG-NAL-3-3517	Computational Nonlinear Structural Mechanics and Vulnerability	2	0	2	3
53	ENG	NAL	ENG-NAL-3-3518	Computational Stochastic Structural Mechanics and Reliability	2	0	2	3
54	ENG	NAL	ENG-NAL-3-3519	Applied Aeroelasticity	3	0	0	3
55	ENG	NAL	ENG-NAL-3-3520	Smart Materials and Structures	3	0	0	3
56	ENG	NAL	ENG-NAL-3-3521	Vibration Control Techniques for Aerospace Structures	3	0	0	3
57	ENG	NAL	ENG-NAL-3-3522	Finite Element Methods for Aircraft Structures	3	0	0	3
58	ENG	NAL	ENG-NAL-3-3523	Fatigue and Fracture Mechanics	3	0	0	3
59	ENG	NAL	ENG-NAL-3-3524	Mechanical Design and CAD/CAM	3	0	0	3
60	ENG	NAL	ENG-NAL-3-3525	Mechanical Systems Design and Aircraft Systems	3	0	0	3
61	ENG	NAL	ENG-NAL-3-3526	Optimization Techniques in Engineering Design	3	0	0	3
62	ENG	NAL	ENG-NAL-3-3527	Impact and Crashworthiness	3	0	0	3
63	ENG	NAL	ENG-NAL-3-3528	Finite Element Methods for Composites	3	0	0	3
64	ENG	NAL	ENG-NAL-3-3529	Digital Signal Processing and Applications	2	0	2	3
65	ENG	NAL	ENG-NAL-3-3530	Manufacturing Techniques for Composites	2	0	2	3
66	ENG	NAL	ENG-NAL-3-3531	Repair Technology for Aircraft Structures using Composites	2	0	2	3

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
67	ENG	NAL	ENG-NAL-3-3532	Experimental Techniques for Composites	2	0	2	3
68	ENG	NAL	ENG-NAL-3-3533	Non-Destructive Testing and Evaluation	2	0	2	3
69	ENG	NAL	ENG-NAL-3-3534	Introduction to Continuum mechanics	3	0	0	3
70	ENG	NAL	ENG-NAL-3-3535	Textile Reinforcements for Composites	2	0	2	3
71	ENG	NAL	ENG-NAL-4-0001	Project Proposal	0	0	4	2
72	ENG	NAL	ENG-NAL-4-0002	Review Article	0	0	4	2
73	ENG	NAL	ENG-NAL-4-0003	CSIR-800 Project	0	0	8	4
74	ENG	NCL	ENG-NCL-1-3701	Research Methodology	2	0	0	2
75	ENG	NCL	ENG-NCL-1-3702	Numerical Methods and Programming	3	0	0	3
76	ENG	NCL	ENG-NCL-1-3703	Mathematical fundamentals	3	0	0	3
77	ENG	NCL	ENG-NCL-2-3701 to 2-3704	Lab courses	0	0	4	2
78	ENG	NCL	ENG-NCL-2-3705	Reaction and ReactorEngineering	3	0	0	3
79	ENG	NCL	ENG-NCL-2-3706	Transport phenomena	3	0	0	3
80	ENG	NCL	ENG-NCL-2-3707	Thermodynamics and Statistical Mechanics	3	0	0	3
81	ENG	NCL	ENG-NCL-2-3708	Advanced Mathematics	2	0	0	2
82	ENG	NCL	ENG-NCL-2-3709	Advanced Numerical Methods	2	0	0	2
83	ENG	NCL	ENG-NCL-2-3710	Seminar Participation	0	1	0	1
84	ENG	NCL	ENG-NCL-2-3711	Seminar Participation	0	1	0	1
85	ENG	NCL	ENG-NCL-2-3712	Seminar Participation	0	1	0	1
86	ENG	NCL	ENG-NCL-2-3713	Seminar Participation	0	1	0	1
87	ENG	NCL	ENG-NCL-2-3714	Symposium participation	0	0	2	1
88	ENG	NCL	ENG-NCL-2-3715	Statistical Analysis	3	0	0	3
89	ENG	NCL	ENG-NCL-2-3716	Fundamentals of Biology	3	0	0	3
90	ENG	NCL	ENG-NCL-3-3701	Advanced topics in materials and processes	2	0	0	2
91	ENG	NCL	ENG-NCL-3-3702	Advanced topics in chemical engineering	2	0	0	2
92	ENG	NCL	ENG-NCL-3-3703	Multiscale simulations in materials	3	0	0	3
93	ENG	NCL	ENG-NCL-3-3704	Industrial flow modeling	3	0	0	3
94	ENG	NCL	ENG-NCL-3-3705	Data driven modeling	2	0	0	2
95	ENG	NCL	ENG-NCL-3-3706	Non-linear dynamics	2	0	0	2
96	ENG	NCL	ENG-NCL-3-3707	Modeling of biological systems	3	0	0	3
97	ENG	NCL	ENG-NCL-3-3708	Advanced separation processes	2	0	0	2
98	ENG	NCL	ENG-NCL-3-3709	Envirinmental Pollution Control	3	0	0	3
99	ENG	NCL	ENG-NCL-3-3710	Statistical Analysis	2	0	0	2

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
100	ENG	NCL	ENG-NCL-3-3711	Advanced Algorithms	1	0	0	1
101	ENG	NCL	ENG-NCL-3-3712	Advanced Reaction Engineering	2	0	0	2
102	ENG	NCL	ENG-NCL-3-3713	Advanced Transport Phenomena	2	0	0	2
103	ENG	NCL	ENG-NCL-3-3714	Advanced Thermodynamics	2	0	0	2
104	ENG	NCL	ENG-NCL-3-3715	Advance Topics in Bioengineering	2	0	0	2
105	ENG	NCL	ENG-NCL-3-3716	Pharmokinetics for Chemical Engineers	2	0	0	2
106	ENG	NCL	ENG-NCL-3-3717	Modelling of Drug Formulation Process	2	0	0	2
107	ENG	NCL	ENG-NCL-3-3718	Critical survey	0	0	4	2
108	ENG	NCL	ENG-NCL-3-3719	Kinetics of Biological Reactions and Reactors	2	0	0	2
109	ENG	NCL	ENG-NCL-3-3720	Systems Biology	3	0	0	3
110	ENG	NCL	ENG-NCL-3-3721	Epidemiology and Ecology	3	0	0	3
111	ENG	NCL	ENG-NCL-3-3722	Chemoinformatics	2	0	0	2
112	ENG	NCL	ENG-NCL-3-3723	Computational Functional Genomics	2	0	0	2
113	ENG	NCL	ENG-NCL-3-3724	Biochemistry and Structural biology: Computational Techniques Techniques	2	0	0	2
114	ENG	NCL	ENG-NCL-3-3725	Biochemistry and Structural Biology: Biomolecular Dynamics	2	0	0	2
115	ENG	NCL	ENG-NCL-3-3726	Independent Study	4	0	0	4
116	ENG	NCL	ENG-NCL-3-3727	Systems Pharmacology	2	0	0	2
117	ENG	NCL	ENG-NCL-4-0001	Project Proposal	0	0	4	2
118	ENG	NCL	ENG-NCL-4-0002	Review Article	0	0	4	2
119	ENG	NCL	ENG-NCL-4-0003	CSIR-800 Project	0	0	8	4
120	PHY/ENG	CSIO	PHY/ENG-CSIO-1-0001	Research Methodology	1	1	0	2
121	ENG	CSIO	ENG-CSIO-1-2402	Mathematics for Engineers and Scientists	3	0	0	3
122	ENG	CSIO	ENG-CSIO-1-2403	Circuit Theory and Electronic Devices	3	0	0	3
123	ENG	CSIO	ENG-CSIO-1-2404	Material Science and Engineering	3	0	0	3
124	ENG	CSIO	ENG-CSIO-2-2401	Signal Processing	3	0	0	3
125	ENG	CSIO	ENG-CSIO-2-2402	Computer Aided Design and Simulation	3	0	0	3
126	ENG	CSIO	ENG-CSIO-2-2403	Human Physiology	3	0	0	3
127	PHY/ENG	CSIO	PHY/ENG-CSIO-3-2401	Advanced Self Study	0	2	4	4
128	ENG	CSIO	ENG-CSIO-3-2402	Digital Image Processing	3	0	2	4
129	ENG	CSIO	ENG-CSIO-3-2403	Statistical Analysis & Machine Intelligence	3	0	2	4
130	ENG	CSIO	ENG-CSIO-3-2404	Biological Control Systems	3	0	2	4
131	ENG	CSIO	ENG-CSIO-3-2405	Bio Instrumentation	3	0	2	4

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
132	ENG	CSIO	ENG-CSIO-3-2406	Agri-Physics and Agro Control Systems	3	0	2	4
133	ENG	CSIO	ENG-CSIO-3-2407	Agro Mechanical Systems	3	0	2	4
134	ENG	CSIO	ENG-CSIO-3-2408	Optical Instrumentation	3	0	2	4
135	ENG	CSIO	ENG-CSIO-3-2409	Opto-Mechanical Systems	3	0	2	4
136	ENG	CSIO	ENG-CSIO-3-2410	Embedded System	3	0	2	4
137	ENG	CSIO	ENG-CSIO-4-0001	Project proposal writing	1	1	0	2
138	ENG	CSIO	ENG-CSIO-4-0002	Review Article	1	1	0	2
139	ENG	CSIO	ENG-CSIO-4-0003	CSIR-800 Societal Program	0	0	8	4
140	ENG	IICT	ENG-IICT- 1-2901	Research Methodology & Technical Communication Skills	3	0	0	3
141	ENG	IICT	ENG-IICT- 2-2901	Numerical methods and Process Modeling	2	1	0	3
142	ENG	IICT	ENG-IICT- 2-2902	Advanced Separation Processes	3	0	0	3
143	ENG	IICT	ENG-IICT- 2-2903	Reaction Technology	3	0	0	3
144	ENG	IICT	ENG-IICT- 2-2904	Advanced Chemical Engineering Thermodynamics	3	0	0	3
145	ENG	IICT	ENG-IICT- 2-2905	Advanced Process Design	2	1	0	3
146	ENG	IICT	ENG-IICT- 2-2906	Advanced Process Optimization	2	1	0	3
147	ENG	IICT	ENG-IICT- 2-2907	Membrane Technology	3	0	0	3
148	ENG	IICT	ENG-IICT- 2-2908	Advanced Process Monitoring and Control	3	0	0	3
149	ENG	IICT	ENG-IICT- 3-2901	Process Engineering	3	1	0	4
150	ENG	IICT	ENG-IICT- 3-2902	Process Integration and Intensification	4	0	0	4
151	ENG	IICT	ENG-IICT- 3-2903	Artificial Intelligence in Process Engineering	3	0	0	3
152	ENG	IICT	ENG-IICT- 3-2904	Biochemical Engineering	3	0	0	3
153	ENG	IICT	ENG-IICT- 1-2951	Research Methodology	2	0	0	2
154	ENG	IICT	ENG-IICT- 2-2951	Wireless Sensor Networks	2	0	0	2
155	ENG	IICT	ENG-IICT- 2-2952	Simulation of Computer Systems and Networks	2	0	0	2
156	ENG	IICT	ENG-IICT- 2-2953	Mobile and Pervasive Computing	2	0	0	2
157	ENG	IICT	ENG-IICT- 3-2951	Real Time Systems	2	0	0	2
158	ENG	IICT	ENG-IICT- 3-2952	Network Protocols	2	0	0	2
159	ENG	IICT	ENG-IICT- 2-2909	Software Applications in Chemical Engineering Problem Solving	2	2	0	4
160	ENG	4PI	ENG-4PI-1-2201	Research Methodology	1	1	0	2
161	ENG	4PI	ENG-4PI-2-2202	Statistical and Computational Methods	2	1	0	3
162	ENG	4PI	ENG-4PI-2-2203	Global Navigation Satellite System (GNSS) theory and it applications	2	1	0	3
163	ENG	4PI	ENG-4PI-2-2204	Principles and Techniques of Mathematical Modelling	2	1	0	3

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
164	ENG	4PI	ENG-4PI-2-2205	High Performance Scientific Computing	2	1	0	3
165	ENG	4PI	ENG-4PI-2-2206	Nonlinear Dynamics	2	1	0	3
166	ENG	4PI	ENG-4PI-2-2207	Applied Computational Methods	2	1	0	3
167	ENG	4PI	ENG-4PI-2-2208	Numerical Analysis and Fortran Programming	3	0	0	3
168	ENG	4PI	ENG-4PI-2-2209	Finite Element Method	3	0	0	3
169	ENG	4PI	ENG-4PI-2-2210	Qualitative and Quantitative Aspects of Water Cycle	3	0	0	3
170	ENG	4PI	ENG-4PI-3-2201	Advanced Self Study	0	2	4	4
171	ENG	4PI	ENG-4PI-4-0001	Project proposal writing	0	0	4	2
172	ENG	4PI	ENG-4PI-4-0002	Review Article	0	0	4	2
173	ENG	4PI	ENG-4PI-4-0003	CSIR-800 Societal Programme	0	0	8	4
174	ENG	CIMFR	ENG-CIMFR-1-1901	Mathematics For Engineers	3	0	0	3
175	ENG	CIMFR	ENG-CIMFR-1-1902	Rock Mechanics And Ground control In Mining	2	0	2	3
176	ENG	CIMFR	ENG-CIMFR-1-1903	Engineering Geology	3	0	0	3
177	ENG	CIMFR	ENG-CIMFR-1-1904	Mine Safety Legislations And Safety Management	3	0	0	3
178	ENG	CIMFR	ENG-CIMFR-1-1905	Rock Mechanics Instrumentation And Monitoring	3	0	0	3
179	ENG	CIMFR	ENG-CIMFR-1-1906	Methods Of Mining	3	0	0	3
180	ENG	CIMFR	ENG-CIMFR-1-1907	Rock Excavation Engineering	3	0	0	3
181	ENG	CIMFR	ENG-CIMFR-1-1908	Reliability And Maintenance Engineering In Mining Systems	3	0	0	3
182	ENG	CIMFR	ENG-CIMFR-1-1909	Environmental Management In Mining Industry	3	0	0	3
183	ENG	CIMFR	ENG-CIMFR-2-1901	Numerical Simulation And Stability Evaluation Of Mining Structures	2	0	2	3
184	ENG	CIMFR	ENG-CIMFR-2-1902	Advanced Mine Ventilation And Environment	2	0	2	3
185	ENG	CIMFR	ENG-CIMFR-2-1903	Advanced Mine Surveying And Subsidence Engineering	2	0	2	3
186	ENG	CIMFR	ENG-CIMFR-2-1904	Mine Fire, Accidents And Disasters - Analysis And Prevention	3	0	0	3
187	ENG	CIMFR	ENG-CIMFR-2-1905	Mine Safety Equipment: Design, Testing And Evaluation	1	0	2	2
188	ENG	CIMFR	ENG-CIMFR-2-1906	Advanced Mining Methods	3	0	0	3
189	ENG	CIMFR	ENG-CIMFR-2-1907	Mechanisation And Automation For Mine Safety	3	0	0	3
190	ENG	CIMFR	ENG-CIMFR-2-1908	Rock Blasting And Fragmentation	3	0	0	3
191	ENG	CIMFR	ENG-CIMFR-2-1909	Industrial Physiology And Ergonomics	3	0	0	3
192	ENG	CIMFR	ENG-CIMFR-3-1901	Advanced Self Study	3	1	0	4
193	ENG	CIMFR	ENG-CIMFR-3-1902	Advanced Numerical Simulation For Design Of Underground Mining Structures	**3**	0	2	4
194	ENG	CIMFR	ENG-CIMFR-3-1903	Open Pit Slope Design Engineering	**3**	0	2	4
195	ENG	CIMFR	ENG-CIMFR-3-1904	Mine Fire And Mitigations	**3**	0	2	4

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
196	ENG	CIMFR	ENG-CIMFR-3-1905	Mine Closure	3	2	0	4
197	ENG	CIMFR	ENG-CIMFR-3-1906	Communication Technologies For Underground Mines	3	0	2	4
198	ENG	CIMFR	ENG-CIMFR-3-1907	In Situ Gasification And CBM	3	0	2	4
199	ENG	CIMFR	ENG-CIMFR-3-1908	Geology, Remote Sensing And GIS	3	0	2	4
200	ENG	CIMFR	ENG-CIMFR-3-1909	Clean Development Mechanisms	3	0	2	4
201	ENG	CIMFR	ENG-CIMFR-3-1910	Environmental Risk Assessment In Mines	3	0	2	4
202	ENG	CIMFR	ENG-CIMFR-3-1911	Fly Ash Management	3	0	2	4
203	ENG	CIMFR	ENG-CIMFR-3-1912	Mining Land Reclamation And Biodiversity Conservation	3	0	2	4
204	ENG	CIMFR	ENG-CIMFR-3-1913	Environmental Monitoring And Instrumentation	3	0	2	4
205	ENG	CIMFR	ENG-CIMFR-3-1914	Mine Air Emissions Monitoring And Control Engineering	3	0	2	4
206	ENG	CIMFR	ENG-CIMFR-3-1915	Water Resource Management In Mining Areas	3	0	2	4
207	ENG	CIMFR	ENG-CIMFR-3-1916	Paleontology, Stratigraphy And Geophysical Exploration	3	0	2	4
208	ENG	CIMFR	ENG-CIMFR-4-0001	Project Proposal	0	1	2	2
209	ENG	CIMFR	ENG-CIMFR-4-0002	Review Article	0	1	2	2
210	ENG	CIMFR	ENG-CIMFR-4-0003	CSIR-800 Societal Programme	0	0	8	4
211	ENG	CMERI	ENG-CMERI-1-2101	RESEARCH METHODOLOGY	1	1	0	2
212	ENG	CMERI	ENG-CMERI-1-2102	MATHEMATICS FOR ENGINEERS	3	0	0	3
213	ENG	CMERI	ENG-CMERI-1-2103	INTRODUCTION TO MECHATRONICS SYSTEM	3	0	0	3
214	ENG	CMERI	ENG-CMERI-1-2104	ADVANCED CONTROL SYSTEM	3	0	0	3
215	ENG	CMERI	ENG-CMERI-1-2105	CAD & COMPUTER GRAPHICS	2	0	2	3
216	ENG	CMERI	ENG-CMERI-1-2106	ELECTRICAL AND ELECTRONIC CIRCUITS & DEVICES	3	0	0	3
217	ENG	CMERI	ENG-CMERI-1-2107	MACHINES & MECHANISMS	3	0	0	3
218	ENG	CMERI	ENG-CMERI-1-2108	ROBOTICS	3	0	0	3
219	ENG	CMERI	ENG-CMERI-1-2109	MICROCONTROLLERS & EMBEDDED SYSTEM DESIGN	2	0	2	3
220	ENG	CMERI	ENG-CMERI-1-2110	DIGITAL SIGNAL PROCESSING & APPLICATIONS	3	0	0	3
221	ENG	CMERI	ENG-CMERI-1-2111	ADVANCED MECHANICS OF SOLIDS	3	0	0	3
222	ENG	CMERI	ENG-CMERI-1-2112	ADVANCED MECHANICS OF FLUIDS	3	0	0	3
223	ENG	CMERI	ENG-CMERI-1-2113	MECHANICAL VIBRATIONS	3	0	0	3
224	ENG	CMERI	ENG-CMERI-1-2114	COMPUTER LAB-I	1	1	2	3
225	ENG	CMERI	ENG-CMERI-1-2115	FINITE ELEMENT METHODS	3	0	0	3
226	ENG	CMERI	ENG-CMERI-1-2116	ANALYSIS AND SYNTHESIS OF MECHANISMS	3	0	0	3
227	ENG	CMERI	ENG-CMERI-1-2117	COMPUTATIONAL FLUID FLOW & HEAT TRANSFER	3	0	0	3
228	ENG	CMERI	ENG-CMERI-1-2118	COMPUTER LAB -II	0	0	4	2

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
229	ENG	CMERI	ENG-CMERI-2-2101	INTRODUCTION TO COMPUTER VISION	2	0	2	3
230	ENG	CMERI	ENG-CMERI-2-2102	ROBOTICS AND MACHINE INTELLIGENCE	2	0	2	3
231	ENG	CMERI	ENG-CMERI-2-2103	INTRODUCTION TO NAVIGATION & DATA FUSION	3	0	0	3
232	ENG	CMERI	ENG-CMERI-2-2104	MICRO SYSTEMS TECHNOLOGIES	2	0	2	3
233	ENG	CMERI	ENG-CMERI-2-2105	ADVANCED MATERIALS	3	0	0	3
234	ENG	CMERI	ENG-CMERI-2-2106	OPTIMAL CONTROL	3	0	0	3
235	ENG	CMERI	ENG-CMERI-2-2107	PRECISION MACHINE DESIGN	2	0	2	3
236	ENG	CMERI	ENG-CMERI-2-2108	NUMERICAL METHODS & COMPUTER PROGRAMMING	2	0	2	3
237	ENG	CMERI	ENG-CMERI-2-2109	ELECTRO-MECHANICAL SYSTEMS DESIGN	3	0	0	3
238	ENG	CMERI	ENG-CMERI-2-2110	ANALYTICAL MECHANICS	3	0	0	3
239	ENG	CMERI	ENG-CMERI-2-2111	FINITE ELEMENT METHODS FOR FLUID DYNAMICS	3	0	0	3
240	ENG	CMERI	ENG-CMERI-2-2112	NONLINEAR DYNAMICS & CHAOS	3	0	0	3
241	ENG	CMERI	ENG-CMERI-2-2113	MECHANICS OF COMPOSITE MATERIALS	3	0	0	3
242	ENG	CMERI	ENG-CMERI-2-2114	ROTOR DYNAMICS	3	1	0	4
243	ENG	CMERI	ENG-CMERI-2-2115	COMPRESSIBLE FLOW	3	1	0	4
244	ENG	CMERI	ENG-CMERI-2-2116	FLOW THROUGH TURBO MACHINES	3	1	0	4
245	ENG	CMERI	ENG-CMERI-2-2117	FLUIDIZED BED DRYING	3	1	0	4
246	ENG	CMERI	ENG-CMERI-2-2118	FLUIDIZED BED COMBUSTION & GASIFICATION	3	1	0	4
247	ENG	CMERI	ENG-CMERI-2-2119	THERMODYNAMICS	3	1	0	4
248	ENG	CMERI	ENG-CMERI-2-2120	PRINCIPLES OF CASTING SOLIDIFICATION	3	1	0	4
249	ENG	CMERI	ENG-CMERI-2-2121	CONVECTIVE HEAT & MASS TRANSFER	3	1	0	4
250	ENG	CMERI	ENG-CMERI-2-2122	TURBULENCE	3	1	0	4
251	ENG	CMERI	ENG-CMERI-2-2123	STATISTICAL METHODS FOR ENGINEERS	3	1	0	4
252	ENG	CMERI	ENG-CMERI-2-2124	ADVANCED ELECTRICAL DRIVES	3	1	0	4
253	ENG	CMERI	ENG-CMERI-2-2125	MTech DISSERTATION PART-I	0	8	16	16
254	ENG	CMERI	ENG-CMERI-2-2126	MTech DISSERTATION PART-II WITH VIVA VOCE	0	8	16	16
255	ENG	CMERI	ENG-CMERI-3-2101	ADVANCED COMPUTER ORGANIZATION & ARCHITECTURE	3	1	0	4
256	ENG	CMERI	ENG-CMERI-3-2102	APPLIED SOFTCOMPUTING	3	1	0	4
257	ENG	CMERI	ENG-CMERI-3-2103	OPTIMIZATION TECHNIQUES IN ENGINEERING	3	1	0	4
258	ENG	CMERI	ENG-CMERI-3-2104	LOW POWERED EMBEDDED SYSTEM DESIGN	3	1	0	4
259	ENG	CMERI	ENG-CMERI-3-2105	COMPUTER AIDED METROLOGY AND MACHINE VISION	3	1	0	4
260	ENG	CMERI	ENG-CMERI-3-2106	ADVANCED FLUID FILM BEARINGS	3	1	0	4

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
261	ENG	CMERI	ENG-CMERI-3-2107	WEAR OF MATERIALS & SURFACE MODIFICATIONS TECHNOLOGIES	3	1	0	4
262	ENG	CMERI	ENG-CMERI-3-2108	FUNCTIONALIZATION OF SURFACE AND INTERFACES OF BIOMATERIALS	3	1	0	4
263	ENG	CMERI	ENG-CMERI-3-2109	NANOTRIBOLOGY AND ITS APPLICATION TO MICROSYSTEMS	3	1	0	4
264	ENG	CMERI	ENG-CMERI-3-2110	ADVANCED PASSIVE AND ACTIVE MAGNETIC BEARINGS	3	1	0	4
265	ENG	CMERI	ENG-CMERI-3-2111	LATTICE BOLTZMANN AUTOMATA	3	1	0	4
266	ENG	CMERI	ENG-CMERI-3-2112	ROBOTS WITH JOINT FLEXIBILITY: MECHANICS AND CONTROL	3	1	0	4
267	ENG	CMERI	ENG-CMERI-3-2113	ARTIFICIAL INTELLIGENCE AND DATA MINING	3	1	0	4
268	ENG	CMERI	ENG-CMERI-3-2114	ADVANCED COMPUTER VISION	3	1	0	4
269	ENG	CMERI	ENG-CMERI-3-2115	ADVANCED NAVIGATION & DATA FUSION	3	1	0	4
270	ENG	CMERI	ENG-CMERI-3-2116	MOBILE ROBOTICS	3	1	0	4
271	ENG	CMERI	ENG-CMERI-3-2117	ADVANCED ROBOT DYNAMICS AND CONTROL	3	1	0	4
272	ENG	CMERI	ENG-CMERI-4-2101	ADVANCED SELF STUDY	3	1	0	4
273	ENG	CMERI	ENG-CMERI-4-0001	PROJECT PROPOSAL	0	1	2	2
274	ENG	CMERI	ENG-CMERI-4-0002	REVIEW ARTICLE	0	1	2	2
275	ENG	CMERI	ENG-CMERI-4-0003	CSIR-800 PROJECT	0	0	8	4
276	ENG	IMMT	ENG-IMMT-1-3301	Research Methodology	2	0	0	2
277	ENG	IMMT	ENG-IMMT-2-3301	Computational Methods & Numerical Analysis	3	0	2	4
278	ENG	IMMT	ENG-IMMT-2-3302	Technologies for Mineral Resource Utilization	3	0	2	4
279	ENG	IMMT	ENG-IMMT-2-3303	Materials Characterization Technique	3	0	2	4
280	ENG	IMMT	ENG-IMMT-2-3304	Recycling of Material Resources	3	0	2	4
281	ENG	IMMT	ENG-IMMT-2-3305	Process Instrumentation & Control	3	1	0	4
282	ENG	IMMT	ENG-IMMT-2-3306	Science for engineers	3	0	0	3
283	ENG	IMMT	ENG-IMMT-2-3307	Fundamentals of Engineering Analysis	3	0	0	3
284	ENG	IMMT	ENG-IMMT-2-3308	Process Design & Simulation	3	0	2	4
285	ENG	IMMT	ENG-IMMT-2-3309	Advanced Topics in Materials Resource Engineering	3	0	2	4
286	ENG	IMMT	ENG-IMMT-2-3310	Energy & Environment	3	0	2	4
287	ENG	IMMT	ENG-IMMT-2-3311	Comminution and Classification	3	0	2	4
288	ENG	IMMT	ENG-IMMT-2-3312	Separation Processes	3	0	2	4
289	ENG	IMMT	ENG-IMMT-2-3313	Mineralogy and Mineral chemistry	3	0	2	4
290	ENG	IMMT	ENG-IMMT-2-3314	Introduction to Optimization Methods	3	0	0	3

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
291	ENG	IMMT	ENG-IMMT-3-3301	Computational Fluid Dynamics	3	0	2	4
292	ENG	IMMT	ENG-IMMT-3-3302	Advanced Materials: Characterization and Processing	3	0	2	4
293	ENG	IMMT	ENG-IMMT-3-3303	Signal Processing for Intelligent Sensor	4	0	0	4
294	ENG	IMMT	ENG-IMMT-3-3304	Soft and Evolutionary Computing	4	0	0	4
295	ENG	IMMT	ENG-IMMT-3-3305	Digital Image Processing	3	1	0	4
296	ENG	IMMT	ENG-IMMT-3-3306	System Design for Process Control	3	1	0	4
297	ENG	IMMT	ENG-IMMT-3-3307	Intelligent Sensor Systems Laboratory	0	0	4	2
298	ENG	IMMT	ENG-IMMT-3-3308	Process control and Instrumentation Laboratory	0	0	4	2
299	ENG	IMMT	ENG-IMMT-3-3309	Image and Video Processing Laboratory	0	0	4	2
300	ENG	IMMT	ENG-IMMT-3-3310	Process Control Laboratory	0	0	4	2
301	ENG	IMMT	ENG-IMMT-3-3311	Design, Simulation and Optimisation of Mineral Processing Plants	3	0	2	4
302	ENG	IMMT	ENG-IMMT-3-3312	Surface Phenomena and its Application	3	0	2	4
303	ENG	IMMT	ENG-IMMT-3-3313	Agglomeration and Direct Reduction of Iron Ore	3	0	2	4
304	ENG	IMMT	ENG-IMMT-4-0001	PROJECT PROPOSAL	0	1	2	2
305	ENG	IMMT	ENG-IMMT-4-0002	REVIEW ARTICLE	0	1	2	2
306	ENG	IMMT	ENG-IMMT-4-0003	CSIR-800 PROJECT	0	0	8	4
307	ENG	CFTRI	ENG-CFTRI-1-1601	Mathematical fundamentals	2	0	0	2
308	ENG	CFTRI	ENG-CFTRI-1-1602	Heat and Mass Transfer Operations	1	0	0	1
309	ENG	CFTRI	ENG-CFTRI-1-1603	Research Methodology	1	0	0	1
310	ENG	CFTRI	ENG-CFTRI-2-1601	Principles of Food Engineering	1	0	0	1
311	ENG	CFTRI	ENG-CFTRI-2-1602	Instrumental Techniques	2	0	0	2
312	ENG	CFTRI	ENG-CFTRI-2-1603	Innovative Food Processing Technologies	1	0	0	1
313	ENG	CFTRI	ENG-CFTRI-2-1604	Fermentation Technology	2	0	0	2
314	ENG	CFTRI	ENG-CFTRI-2-1605	Industrial Microbiology	1	0	0	1
315	ENG	CFTRI	ENG-CFTRI-2-1606	Significance of Food Preservation	1	0	0	1
316	ENG	CFTRI	ENG-CFTRI-2-1607	Canning of Foods	1	0	0	1
317	ENG	CFTRI	ENG-CFTRI-2-1608	Critical survey	0	1	0	1
318	ENG	CFTRI	ENG-CFTRI-2-1609	Thermal processing of Foods	1	0	0	1
319	ENG	CFTRI	ENG-CFTRI-2-1610	Hurdle Technology	1	0	0	1
320	ENG	CFTRI	ENG-CFTRI-3-1601	Seminars in topics of courses listed in level 300	1	0	0	1
321	ENG	CFTRI	ENG-CFTRI-3-1602	Food Process Engineering	2	0	0	2
322	ENG	CFTRI	ENG-CFTRI-3-1603	Nano-Technology in Food Processing	1	0	0	1
323	ENG	CFTRI	ENG-CFTRI-3-1604	Packaging Technology	1	0	0	1

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
324	ENG	CFTRI	ENG-CFTRI-3-1605	Advanced Separations	1	0	0	1
325	ENG	CFTRI	ENG-CFTRI-3-1606	Food Plant Management	1	0	0	1
326	ENG	CFTRI	ENG-CFTRI-3-1607	Advances in drying technology	2	0	0	2
327	ENG	CFTRI	ENG-CFTRI-3-1608	Modelling in Food Processing	1	0	0	1
328	ENG	CFTRI	ENG-CFTRI-3-1609	Technology of Cereals and Pulses	1	0	0	1
329	ENG	CFTRI	ENG-CFTRI-3-1610	Technology of Fruits and Vegetables	1	0	0	1
330	ENG	CFTRI	ENG-CFTRI-3-1611	Food Safety	1	0	0	1
331	ENG	CFTRI	ENG-CFTRI-4-0001	Project Proposal	0	1	1	2
332	ENG	CFTRI	ENG-CFTRI-4-0002	Review Article	0	1	1	2
333	ENG	CFTRI	ENG-CFTRI-4-0003	CSIR-800 Societal Programme	0	2	2	4
334	ENG	NML	ENG-NML-1-4501	Tools & techniques of materials characterization	3	0	2	4
335	ENG	NML	ENG-NML-1-4502	Advanced Metallurgical Thermodynamics	3	0	0	3
336	ENG	NML	ENG-NML-1-4503	Kinetics of Metallurgical Processes	3	0	0	3
337	ENG	NML	ENG-NML-1-4504	Introduction to Materials	3	0	0	3
338	ENG	NML	ENG-NML-1-4505	Advanced Mathematics and Numerical Analysis	3	0	0	3
339	ENG	NML	ENG-NML-1-4506	Advanced Materials	3	0	0	3
340	ENG	NML	ENG-NML-1-4507	Research Methodology & Technical Communication Skills	2	0	0	2
341	ENG	NML	ENG-NML-2-4501	Principles and Advances in Iron Making	3	0	0	3
342	ENG	NML	ENG-NML-2-4502	Principles and Advances in Non-ferrous Metallurgy	2	0	2	3
343	ENG	NML	ENG-NML-2-4503	Transport Phenomena in Metallurgical Processes	3	0	0	3
344	ENG	NML	ENG-NML-2-4504	Mineral Processing	2	0	2	3
345	ENG	NML	ENG-NML-2-4505	Advanced Minerology	3	0	2	4
346	ENG	NML	ENG-NML-2-4506	Materials processing and manufacturing	2	0	2	3
347	ENG	NML	ENG-NML-2-4507	Materials Selection and Design	2	1	0	3
348	ENG	NML	ENG-NML-2-4508	Mechanical Behaviour of Materials	2	0	2	3
349	ENG	NML	ENG-NML-2-4509	Smart advanced materials for functional applications	3	1	0	4
350	ENG	NML	ENG-NML-2-4510	Physical Metallurgy of Steels	3	0	2	4
351	ENG	NML	ENG-NML-2-4511	Corrosion and Control	2	0	2	3
352	ENG	NML	ENG-NML-2-4512	Principles and Advances in Steel Making	3	0	0	3
353	ENG	NML	ENG-NML-2-4513	Advances in Non-ferrous Metal Extraction	2	0	2	3
354	ENG	NML	ENG-NML-2-4514	Coal preparation technology	3	0	2	4
355	ENG	NML	ENG-NML-2-4515	Advanced metal working techniques	3	0	2	4
356	ENG	NML	ENG-NML-2-4516	Principles of Physical Metallurgy	2	0	2	3
357	ENG	NML	ENG-NML-2-4517	Creep, Fatigue and Fracture mechanics	3	0	2	4
358	ENG	NML	ENG-NML-2-4518	NDE techniques for materials evaluation	3	0	2	4
359	ENG	NML	ENG-NML-2-4519	Introduction to Magnetic Materials	3	1	0	4
360	ENG	NML	ENG-NML-2-4520	Waste processing and recycling	2	0	2	3

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
361	ENG	NML	ENG-NML-2-4521	Advanced Manufacturing	2	0	2	3
362	ENG	NML	ENG-NML-3-4501	Structural Integrity & Assessment	2	2	0	4
363	ENG	NML	ENG-NML-3-4502	Microstructural Engineering	2	1	2	4
364	ENG	NML	ENG-NML-3-4503	Thermodynamics and kinetics of metal extraction processes	3	1	0	4
365	ENG	NML	ENG-NML-3-4504	Coating Technology	2	0	4	4
366	ENG	NML	ENG-NML-3-4505	Advanced mechanical property characterization	3	0	2	4
367	ENG	NML	ENG-NML-3-4506	Integrated Computational Materials Engineering	3	1	0	4
368	ENG	NML	ENG-NML-3-4507	Life Cycle Assessment	2	2	0	4
369	ENG	NML	ENG-NML-3-4509	Science Management	3	1	0	4
370	ENG	NML	ENG-NML-3-4510	Advanced Surface Characterization Techniques	2	0	2	3
371	ENG	NML	ENG-NML-4-4501	Project Proposal & Seminar				14
372	ENG	NML	ENG-NML-4-4502	Dissertation Seminar Final Presentation & viva voce				14
373	ENG	NML	ENG-NML-2-4522	Dissertation Report				4
374	ENG	NML	ENG-NML-4-0001	PROJECT PROPOSAL	0	1	2	2
375	ENG	NML	ENG-NML-4-0002	REVIEW ARTICLE	0	1	2	2
376	ENG	NML	ENG-NML-4-0003	CSIR-800 PROJECT	0	0	8	4
377	ENG	CEERI	ENG-CEERI-1-1501	Research Methodology	1	1	0	2
378	ENG	CEERI	ENG-CEERI-1-1502	Technical Communication	2	0	0	2
379	ENG	CEERI	ENG-CEERI-2-1501	MTech Dissertation-I	0	7	14	14
380	ENG	CEERI	ENG-CEERI-2-1502	MTech Dissertation-II	0	9	18	18
381	ENG	CEERI	ENG-CEERI-2-1503	Project Management	2	0	0	2
382	ENG	CEERI	ENG-CEERI-2-1504	Platforms and Techniques for Process Control	2	0	0	2
383	ENG	CEERI	ENG-CEERI-2-1505	Digital Systems Engineering	2	0	0	2
384	ENG	CEERI	ENG-CEERI-2-1506	Intelligent Instrumentation	2	0	0	2
385	ENG	CEERI	ENG-CEERI-2-1507	Signal and Image Processing-I	2	0	0	2
386	ENG	CEERI	ENG-CEERI-2-1508	Power Electronics	2	0	0	2
387	ENG	CEERI	ENG-CEERI-2-1509	Real-time Embedded System Design	3	0	0	3
388	ENG	CEERI	ENG-CEERI-2-1510	Lab : Process Control Techniques and Platforms	0	0	2	1
389	ENG	CEERI	ENG-CEERI-2-1511	Lab: Digital Systems Engineering	0	0	2	1
390	ENG	CEERI	ENG-CEERI-2-1512	Lab: Intelligent Instrumentation	0	0	2	1
391	ENG	CEERI	ENG-CEERI-2-1513	Lab: Signal and Image Processing-I	0	0	2	1
392	ENG	CEERI	ENG-CEERI-2-1514	Lab: Power Electronics	0	0	2	1
393	ENG	CEERI	ENG-CEERI-2-1515	Lab: Real-time Embedded System Design	0	0	4	2
394	ENG	CEERI	ENG-CEERI-2-1516	Physics of Semiconductor Materials and Devices	4	0	0	4
395	ENG	CEERI	ENG-CEERI-2-1517	Unit Processes in Semiconductor Technologies	3	0	0	3

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
396	ENG	CEERI	ENG-CEERI-2-1518	CMOS Digital VLSI Design	3	0	0	3
397	ENG	CEERI	ENG-CEERI-2-1519	Characterization Techniques for Semiconductor, Materials, Technologies and Devices	3	0	0	3
398	ENG	CEERI	ENG-CEERI-2-1520	Lab: Semiconductor Processing Technologies	0	0	4	2
399	ENG	CEERI	ENG-CEERI-2-1521	Lab: CMOS-based Physical Design	0	0	4	2
400	ENG	CEERI	ENG-CEERI-2-1522	Lab: Semiconductors Related Characterization and Measurement Techniques	0	0	4	2
401	ENG	CEERI	ENG-CEERI-2-1523	Lab: HDL-based Digital Design	0	0	4	2
402	ENG	CEERI	ENG-CEERI-2-1524	Electromagnetic Theory and Transmission Lines	3	0	0	3
403	ENG	CEERI	ENG-CEERI-2-1525	Microwave Communication	2	0	0	2
404	ENG	CEERI	ENG-CEERI-2-1526	Numerical Analysis and Techniques for Microwave Applications	4	0	0	4
405	ENG	CEERI	ENG-CEERI-2-1527	Microwave and Millimeter Wave Tube Technologies	3	0	0	3
406	ENG	CEERI	ENG-CEERI-2-1528	Lab: Microwave Components Characterization and Tube Processing Techniques	0	0	4	2
407	ENG	CEERI	ENG-CEERI-2-1529	Lab: Microwave Devices Characterization and Tube Subassembly Fabrication	0	0	4	2
408	ENG	CEERI	ENG-CEERI-3-1501	Advanced Self-study (Special Topic)	0	2	4	4
409	ENG	CEERI	ENG-CEERI-3-1502	Advances in Process Control	2	0	0	2
410	ENG	CEERI	ENG-CEERI-3-1503	Signal and Image Processing-II	2	0	0	2
411	ENG	CEERI	ENG-CEERI-3-1504	Applications of Power Electronics	2	0	0	2
412	ENG	CEERI	ENG-CEERI-3-1505	Lab: Advances in Process Control	0	0	2	1
413	ENG	CEERI	ENG-CEERI-3-1506	Lab: Signal and Image Processing-II	0	0	2	1
414	ENG	CEERI	ENG-CEERI-3-1507	Lab: Applications of Power Electronics	0	0	2	1
415	ENG	CEERI	ENG-CEERI-3-1508	MEMS and Nano-structures Technologies	3	0	0	3
416	ENG	CEERI	ENG-CEERI-3-1509	Physics and Design of MEMS and Microsensors	3	0	0	3
417	ENG	CEERI	ENG-CEERI-3-1510	Nanoelectronic Devices and Technologies	3	0	0	3
418	ENG	CEERI	ENG-CEERI-3-1511	CMOS Analog Design	3	0	0	3
419	ENG	CEERI	ENG-CEERI-3-1512	Advanced VLSI System Architectures	3	0	0	3
420	ENG	CEERI	ENG-CEERI-3-1513	Optoelectronic Materials, Devices and Technologies	3	0	0	3
421	ENG	CEERI	ENG-CEERI-3-1514	Photonic Materials, Devices and Technologies	3	0	0	3
422	ENG	CEERI	ENG-CEERI-3-1515	Lab: MEMS and Nano-structures Technologies	0	0	4	2
423	ENG	CEERI	ENG-CEERI-3-1516	Lab: Design of MEMS and Microsensors	0	0	4	2

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
424	ENG	CEERI	ENG-CEERI-3-1517	Lab: Nanoelectronic Technologies	0	0	4	2
425	ENG	CEERI	ENG-CEERI-3-1518	Lab: CMOS Analog Design	0	0	4	2
426	ENG	CEERI	ENG-CEERI-3-1519	Lab: Optoelectronic Devices and Technologies	0	0	4	2
427	ENG	CEERI	ENG-CEERI-3-1520	Lab: Photonic Devices and Technologies	0	0	4	2
428	ENG	CEERI	ENG-CEERI-3-1521	Slow-wave Devices : Principles and Design	4	0	0	4
429	ENG	CEERI	ENG-CEERI-3-1522	Fast-wave Devices : Principles and Design	3	0	0	3
430	ENG	CEERI	ENG-CEERI-3-1523	High Power Microwave Systems and Applications	3	0	0	3
431	ENG	CEERI	ENG-CEERI-3-1524	Plasma-filled Microwave Sources	2	0	0	2
432	ENG	CEERI	ENG-CEERI-3-1525	Vacuum Microelectronic Devices	2	0	0	2
433	ENG	CEERI	ENG-CEERI-3-1526	Lab: CAD of Microwave Tubes	0	0	4	2
434	ENG	CEERI	ENG-CEERI-4-0001	Project Proposal	0	0	4	2
435	ENG	CEERI	ENG-CEERI-4-0002	Review Article	0	0	4	2
436	ENG	CEERI	ENG-CEERI-4-0003	CSIR-800 Societal Programme Project	0	0	8	4
437	ENG	IIP	ENG-IIP-1-3101	Research Methodology	1	0	0	1
438	ENG	IIP	ENG-IIP-2-3101	Internal Combustion Engines	3	0	0	3
439	ENG	IIP	ENG-IIP-2-3102	Analytical Methods used in Petroleum Industry	2	0	4	4
440	ENG	IIP	ENG-IIP-2-3103	Tribology and Tribo – Component Design	3	0	0	3
441	ENG	IIP	ENG-IIP-2-3104	Chemistry of Lubricants	3	0	0	3
442	ENG	IIP	ENG-IIP-2-3105	Alternative Fuels	3	0	0	3
443	ENG	IIP	ENG-IIP-2-3106	Renewable Energy Conversion Technologies	3	0	2	4
444	ENG	IIP	ENG-IIP-3-3101	Advanced Thermodynamics for Mechanical Engineers	3	0	0	3
445	ENG	IIP	ENG-IIP-3-3102	Automotive Lubricants	3	0	0	3
446	ENG	IIP	ENG-IIP-3-3103	Automotive Emissions & Fuel Quality	3	0	0	3
447	ENG	IIP	ENG-IIP-3-3104	Automotive Test Equipments and Procedures	2	0	2	3
448	ENG	IIP	ENG-IIP-4-0001	Project Proposal	0	0	4	2
449	ENG	IIP	ENG-IIP-4-0002	Review Article	0	0	4	2
450	ENG	IIP	ENG-IIP-4-0003	CSIR-800 Societal Programme Project	0	0	8	4
451	ENG	AMPRI	ENG-AMPRI-1-1001	Materials Science and Engineering	2	0	0	2
452	ENG	AMPRI	ENG-AMPRI-1-1002	Scientific Ethics, Technical Communication and Safety	2	0	0	2
453	ENG	AMPRI	ENG-AMPRI-2-1001	Characterization and Analytical Techniques	2	0	0	2
454	ENG	AMPRI	ENG-AMPRI-2-1002	Phase Transformation	2	0	0	2
455	ENG	AMPRI	ENG-AMPRI-2-1003	Heat Treatment	2	0	0	2
456	ENG	AMPRI	ENG-AMPRI-2-1004	Materials Synthesis and Processing	2	0	0	2

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
457	ENG	AMPRI	ENG-AMPRI-2-1005	Computer Simulation & Design	2	0	0	2
458	ENG	AMPRI	ENG-AMPRI-2-1006	Lightweight Materials	2	0	0	2
459	ENG	AMPRI	ENG-AMPRI-2-1007	Polymer Science and Engineering	2	0	0	2
460	ENG	AMPRI	ENG-AMPRI-2-1008	Tribology - Science and Practice	2	0	0	2
461	ENG	AMPRI	ENG-AMPRI-3-1001	Powder Metallurgy	2	0	0	2
462	ENG	AMPRI	ENG-AMPRI-3-1002	Advanced Polymeric Materials	2	0	0	2
463	ENG	AMPRI	ENG-AMPRI-3-1003	Composites Science and Engineering	2	0	0	2
464	ENG	AMPRI	ENG-AMPRI-3-1004	Functional and Smart Materials	2	0	0	2
465	ENG	AMPRI	ENG-AMPRI-3-1005	Waste Utilization and Value Addition	2	0	0	2
466	ENG	AMPRI	ENG-AMPRI-3-1006	Fibre Science and Technology	2	0	0	2
467	ENG	AMPRI	ENG-AMPRI-3-1007	Cellular Materials	2	0	0	2
468	ENG	AMPRI	ENG-AMPRI-3-1008	Nano Science and Engineering	2	0	0	2
469	ENG	AMPRI	ENG-AMPRI-3-1009	Analysis of Metal Forming Processes	2	0	0	2
470	ENG	AMPRI	ENG-AMPRI-3-1010	Fatigue and Fracture Evaluation of Materials	2	0	0	2
471	ENG	AMPRI	ENG-AMPRI-3-1011	Corrosion and Corrosion Protection	2	0	0	2
472	ENG	AMPRI	ENG-AMPRI-3-1012	Conducting Polymers	1	0	0	1
473	ENG	AMPRI	ENG-AMPRI-3-1013	Glass Fibre Reinforced Polymer composites	2	0	0	2
474	ENG	AMPRI	ENG-AMPRI-3-1014	Tribology of Polymers and Their Composites	2	0	0	2
475	ENG	AMPRI	ENG-AMPRI-3-1015	Bio Degradable Polymers	1	0	0	1
476	ENG	AMPRI	ENG-AMPRI-3-1016	Natural Fibres	1	0	0	1
477	ENG	AMPRI	ENG-AMPRI-3-1017	Microfluidics and Microseparation	2	0	0	2
478	ENG	AMPRI	ENG-AMPRI-3-1018	Unit Operations in Environmental Chemistry	2	0	0	2
479	ENG	AMPRI	ENG-AMPRI-4-1001	Project Proposal	0	0	4	2
480	ENG	AMPRI	ENG-AMPRI-4-1002	Review Article	0	0	4	2
481	ENG	AMPRI	ENG-AMPRI-4-1003	CSIR-800 Societal Programme Project	1	0	6	4
482	ENG	CBRI	ENG-CBRI-1-1101	Numerical Methods	3	0	0	3
483	ENG	CBRI	ENG-CBRI-1-1102	Design of Building Structures	3	0	0	3
484	ENG	CBRI	ENG-CBRI-1-1103	Advanced Foundation Engineering	3	0	0	3
485	ENG	CBRI	ENG-CBRI-1-1104	Disaster Resistant Building System - I	3	0	0	3
486	ENG	CBRI	ENG-CBRI-1-1105	Engineering Materials for Infrastructure	3	0	0	3
487	ENG	CBRI	ENG-CBRI-1-1106	Laboratory - II Structural Engineering & Fire Engineering	0	0	4	2
488	ENG	CBRI	ENG-CBRI-1-1107	Analysis of Building Structure	3	0	0	3
489	ENG	CBRI	ENG-CBRI-1-1108	Seminar-II	0	0	2	1

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
490	ENG	CBRI	ENG-CBRI-1-1110	Dissertation-II	0	8	24	20
491	ENG	CBRI	ENG-CBRI-1-1111	Laboratory - I Geotechnical Engineering, Materials and Environmental Laboratory	0	0	4	2
492	ENG	CBRI	ENG-CBRI-1-1113	Seminar-I	0	0	2	1
493	ENG	CBRI	ENG-CBRI-1-1115	Disaster Resistant Building System II	3	0	0	3
494	ENG	CBRI	ENG-CBRI-1-1117	Dissertation-I	0	4	16	12
495	ENG	CBRI	ENG-CBRI-1-1120	Concrete Technology	3	0	0	3
496	ENG	CBRI	ENG-CBRI-1-1124	Industrialized Building Systems	3	0	0	3
497	ENG	CBRI	ENG-CBRI-1-1126	Repair, Rehabilitation & Retrofitting of Structures	3	0	0	3
498	ENG	CBRI	ENG-CBRI-1-1128	Environmental Impact Assessment	3	0	0	3
499	ENG	CBRI	ENG-CBRI-1-1130	Sustainable Design and Energy Efficient Building Systems	3	0	0	3
500	ENG	CBRI	ENG-CBRI-1-1132	Construction, Planning & Management	3	0	0	3
501	ENG	CBRI	ENG-CBRI-1-1134	Fire Protection Engineering	3	0	0	3
502	ENG	CBRI	ENG-CBRI-1-1136	Environmental Engineering & Management	3	0	0	3
503	ENG	CBRI	ENG-CBRI-1-1140	Ground Improvement Techniques	3	0	0	3
504	ENG	CBRI	ENG-CBRI-1-1142	Optimization Techniques	3	0	0	3
505	ENG	CBRI	ENG-CBRI-1-1144	Deep Excavation	3	0	0	3
506	ENG	CBRI	ENG-CBRI-1-1146	Fundamentals of Structural Engineering	3	0	0	3
507	ENG	CBRI	ENG-CBRI-1-1148	Fundamentals of Soil Mechanics	3	0	0	3
508	ENG	CBRI	ENG-CBRI-2-1104	Health Monitoring of Building Structures	3	0	0	3
509	ENG	CBRI	ENG-CBRI-2-1106	Tall Buildings & Structures	3	0	0	3
510	ENG	CBRI	ENG-CBRI-2-1108	Behaviour of Metal Structures	3	0	0	3
511	ENG	CBRI	ENG-CBRI-3-1101	Wind Effects on Building Structures (WEBS)	3	0	0	3
512	ENG	CBRI	ENG-CBRI-3-1102	Re-engineering of Structures	3	0	0	3
513	ENG	CBRI	ENG-CBRI-3-1103	Structural Response Control for Seismic Protection	3	0	0	3
514	ENG	CBRI	ENG-CBRI-3-1105	Computational Nonlinear Mechanics	3	0	0	3
515	ENG	CBRI	ENG-CBRI-3-1107	Continuum Mechanics & Finite Element Analysis	3	0	0	3
516	ENG	CBRI	ENG-CBRI-3-1109	Corrosion Control in Reinforced Concrete Structures	2	0	2	3
517	ENG	CBRI	ENG-CBRI-3-1111	Applied Soil Mechanics	3	0	0	3
518	PHY/ENG	CBRI	PHY/ENG-CBRI-1-0001	Research Methodology	1	0	0	1
519	PHY/ENG	CBRI	PHY/ENG-CBRI-1-1119	Fundamentals of Engineering Geology	3	0	0	3
520	PHY/ENG	CBRI	PHY/ENG-CBRI-1-1138	Rock Mechanics	3	0	0	3
521	PHY/ENG	CBRI	PHY/ENG-CBRI-2-1102	Advanced Seismology	3	0	0	3

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
522	PHY/ENG	CBRI	PHY/ENG-CBRI-2-1110	Landslide Disaster Mitigation	3	0	0	3
523	CHE/ENG	CBRI	CHE/ENG-CBRI-3-1113	Advanced Instruments in Materials Research	2	0	2	3
524	CHE/PHY/EN	CBRI	CHE/PHY/ENG-CBRI-4-0001	Project Proposal	**0**	1	2	2
525	CHE/PHY/EN	CBRI	CHE/PHY/ENG-CBRI-4-0002	Review Article	**0**	1	2	2
526	CHE/PHY/EN	CBRI	CHE/PHY/ENG-CBRI-4-0003	Housing related societal issues under CSIR-800 Programme	**0**	0	8	4
527	ENG	SERC-EoS	ENG-SERC-1-4701	Instrumentation & Sensors for Structural Response Measurement	3	0	2	4
528	ENG	SERC-EoS	ENG-SERC-1-4702	Advanced Mechanics of Materials	3	0	0	3
529	ENG	SERC-EoS	ENG-SERC-1-4703	Computational Methods	3	0	0	3
530	ENG	SERC-EoS	ENG-SERC-1-4704	Advanced Engineering Mathematics	3	0	0	3
531	ENG	SERC-EoS	ENG-SERC-1-4705	Non-Destructive Testing & Forensic Engineering	3	0	0	3
532	ENG	SERC-EoS	ENG-SERC-1-4706	Non-Destructive Testing -Lab	0	0	1	1
533	ENG	SERC-EoS	ENG-SERC-1-4707	Research Methodology & Professional Practice	2	0	1	2
534	ENG	SERC-EoS	ENG-SERC-2-4701	Dynamics of Structures	3	0	1	3
535	ENG	SERC-EoS	ENG-SERC-2-4702	RCC & Prestressed Concrete Structures	3	1	0	3
536	ENG	SERC-EoS	ENG-SERC-2-4703	Finite Element Technology-I	3	1	0	3
537	ENG	SERC-EoS	ENG-SERC-2-4704	Bridge Engineering	3	0	0	3
538	ENG	SERC-EoS	ENG-SERC-2-4705	Plate and Shell Structures	3	0	0	3
539	ENG	SERC-EoS	ENG-SERC-2-4706	Earthquake Engineering	3	0	0	3
540	ENG	SERC-EoS	ENG-SERC-2-4707	Engineering for Natural Hazards	3	0	1	3
541	ENG	SERC-EoS	ENG-SERC-2-4708	Fundamentals of Probability and Statistics	3	0	0	3
542	ENG	SERC-EoS	ENG-SERC-2-4709	Stochastic Mechanics	3	0	0	3
543	ENG	SERC-EoS	ENG-SERC-2-4710	Wind Engineering	3	0	0	3
544	ENG	SERC-EoS	ENG-SERC-2-4711	Thesis Work and Seminar	0	0	0	12
545	ENG	SERC-EoS	ENG-SERC-2-4712	Dissertation Seminar	0	0	0	6
546	ENG	SERC-EoS	ENG-SERC-2-4713	Dissertation Report and Viva-voce	0	0	0	14
547	ENG	SERC-EoS	ENG-SERC-3-4701	Metal Structure Behaviour and Design	3	1	0	3
548	ENG	SERC-EoS	ENG-SERC-3-4702	Finite Element Technology-II	3	0	1	3
549	ENG	SERC-EoS	ENG-SERC-3-4703	Uncertainty Handling in Engineering Decision Making	3	0	0	3
550	ENG	SERC-EoS	ENG-SERC-3-4704	Soft Computing	3	1	0	3
551	ENG	SERC-EoS	ENG-SERC-3-4705	Repair & Rehabilitation of Concrete Structures	3	0	1	3
552	ENG	SERC-EoS	ENG-SERC-3-4706	New Composite Materials in Civil Engineering Applications	3	0	1	3
553	ENG	SERC-EoS	ENG-SERC-3-4707	Advanced techniques for characterisation of Materials	3	0	0	3
554	ENG	SERC-EoS	ENG-SERC-3-4708	Characterisation Techniques for Cementitious materials-Lab	0	0	1	1

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
555	ENG	SERC-EoS	ENG-SERC-3-4709	Molecular Dynamics	3	0	0	3
556	ENG	SERC-EoS	ENG-SERC-3-4710	Advanced Cementious Composites & Characterisation of Materials	3	0	1	3
557	ENG	SERC-EoS	ENG-SERC-3-4711	Advanced Fatigue & Fracture of Engineering Structures	3	0	1	3
558	ENG	SERC-EoS	ENG-SERC-3-4712	Advanced Numericals methods for Fracture Mechanics	3	1	0	3
559	ENG	SERC-EoS	ENG-SERC-3-4713	Mechanics of wave propagation	3	0	0	3
560	ENG	SERC-EoS	ENG-SERC-3-4714	Advanced Structural Health Monitoring	3	1	0	3
561	ENG	SERC-EoS	ENG-SERC-3-4715	Advanced stability of Structures	3	0	0	3
562	ENG	SERC-EoS	ENG-SERC-3-4716	Micromechanics of Brittle Materials	3	0	0	3
563	ENG	SERC-EoS	ENG-SERC-3-4717	Fatigue of Concrete Structures	3	1	0	3
564	ENG	SERC-EoS	ENG-SERC-3-4718	Sustainable Materials	3	0	1	3
565	ENG	SERC-EoS	ENG-SERC-3-4719	Shear Thickening Fluids for Engineering Applications	2	0	1	2
566	ENG	SERC-EoS	ENG-SERC-3-4720	Computational Fluid Dynamics	3	1	0	3
567	ENG	SERC-EoS	ENG-SERC-3-4721	Advanced Modelling Techniques	3	1	0	3
568	ENG	SERC-EoS	ENG-SERC-3-4722	Smart Materials and Structures	3	0	0	3
569	ENG	SERC-EoS	ENG-SERC-3-4723	Advanced Analysis and Design of Steel Structures	3	1	0	3
570	ENG	SERC-EoS	ENG-SERC-3-4724	Multiscale Modelling of structures	3	0	1	3
571	ENG	SERC-EoS	ENG-SERC-3-4725	Advanced Course for self-study-I	3	1	0	3
572	ENG	SERC-EoS	ENG-SERC-3-4726	Advanced Course for self-study-II	3	1	0	3
573	ENG	SERC-EoS	ENG-SERC-3-4730	Plasticity in Metals	3	0	0	3
574	ENG	SERC-EoS	ENG-SERC-4-0001	Research Proposal Writing	0	1	2	2
575	ENG	SERC-EoS	ENG-SERC-4-0002	Review Article	0	1	2	2
576	ENG	SERC-EoS	ENG-SERC-4-0003	CSIR-800 Societal Programme	0	0	8	4
577	ENG	SERC-RE	ENG-SERC-1-4771	Effective Presentation Skills and Dissertation Writing	1	0	0	1
578	ENG	SERC-RE	ENG-SERC-1-4772	Mathematics for Engineers	1	1	0	2
579	ENG	SERC-RE	ENG-SERC-2-4771	Renewable Energy Sources for a Sustainable Future	2	0	0	2
580	ENG	SERC-RE	ENG-SERC-2-4772	Harnessing the power of Sun: Science and Technology of Solar Photovoltaics	3	0	2	4
581	ENG	SERC-RE	ENG-SERC-2-4773	Energy Storage and Conversion: Science & Technology	3	0	2	4
582	ENG	SERC-RE	ENG-SERC-2-4774	"View from the TOP" Seminar Series I	1	0	0	1
583	ENG	SERC-RE	ENG-SERC-2-4775	Design and Engineering for Sustainability	1	0	2	2
584	ENG	SERC-RE	ENG-SERC-2-4776	View from the TOP Seminar Series II	1	0	0	1
585	ENG	SERC-RE	ENG-SERC-4-4703	3-4 weeks Industrial training/CSIR 800 (Report and Presentation)	0	0	2	1

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
586	ENG	SERC-RE	ENG-SERC-3-4771	Solar Photovoltaics: Power Electronics, Power Transmission and Energy Monitoring	3	0	2	4
587	ENG	SERC-RE	ENG-SERC-3-4772	Advanced course on Lithium-Ion Batteries	3	0	2	4
588	ENG	SERC-RE	ENG-SERC-3-4773	Design of Structures For Renewable Energy	2	1	2	4
589	ENG	SERC-RE	ENG-SERC-3-4774	Bio Energy: The Plants Work & Let Us Reap	3	0	2	4
590	ENG	SERC-RE	ENG-SERC-3-4775	Self-study course on Advanced topics in Renewable Energy	0	2	4	4
591	ENG	SERC-RE	ENG-SERC-3-4776	4 week Solar Energy Workshop for High-school students (Organizing and Mentoring)	0	1	0	1
592	ENG	SERC-RE	ENG-SERC-3-4777	Dissertation (Seminars and report)	0	4	8	8
593	ENG	SERC-RE	ENG-SERC-3-4778	Dissertation seminars	0	6	0	6
594	ENG	SERC-RE	ENG-SERC-3-4779	Dissertation report and Viva-Voice	0	9	18	18
595	ENG	CGCRI	ENG-CGCRI-1-1701	Introduction to Materials Engineering	3	1	0	4
596	ENG	CGCRI	ENG-CGCRI-1-1702	Materials Characterization-I	3	0	2	4
597	ENG	CGCRI	ENG-CGCRI-1-1703	Fundamentals of Glass and Ceramics	3	1	0	4
598	ENG	CGCRI	ENG-CGCRI-1-1704	Research Methodology and Applied Statistical Techniques for Materials Engineering	3	1	0	4
599	ENG	CGCRI	ENG-CGCRI-1-1705	Laboratory Safety Practices	1	0	0	1
600	ENG	CGCRI	ENG-CGCRI-2-1701	Processing of Glass and Ceramics	3	0	2	4
601	ENG	CGCRI	ENG-CGCRI-2-1702	Materials Characterization- II	3	0	2	4
602	ENG	CGCRI	ENG-CGCRI-2-1703	Technical Communication	1	0	0	1
603	ENG	CGCRI	ENG-CGCRI-2-1704	Transport Phenomena in Materials Processing	3	1	0	4
604	ENG	CGCRI	ENG-CGCRI-2-1705	Term Paper	0	0	0	1
605	ENG	CGCRI	ENG-CGCRI-2-1706	Seminar	0	0	0	2
606	ENG	CGCRI	ENG-CGCRI-2-1707	Comprehensive Viva	0	0	0	2
607	ENG	CGCRI	ENG-CGCRI-3-1701	Advanced Glass Science and Technology	3	0	2	4
608	ENG	CGCRI	ENG-CGCRI-3-1702	Fibre Optics and Devices	3	0	2	4
609	ENG	CGCRI	ENG-CGCRI-3-1703	Structural and Functional Coatings	3	0	2	4
610	ENG	CGCRI	ENG-CGCRI-3-1704	Nanostructured Photonic and Optical Materials	3	0	2	4
611	ENG	CGCRI	ENG-CGCRI-3-1705	Advanced Structural Ceramics and Refractories	3	0	2	4
612	ENG	CGCRI	ENG-CGCRI-3-1706	Bioceramic Prosthesis and Implants	3	0	2	4
613	ENG	CGCRI	ENG-CGCRI-3-1707	Ceramic Based Energy and Separation Technology	3	0	2	4
614	ENG	CGCRI	ENG-CGCRI-3-1708	Electronic Ceramics	3	0	2	4
615	ENG	CGCRI	ENG-CGCRI-3-1709	Project and Thesis- I	0	0	0	16
616	ENG	CGCRI	ENG-CGCRI-3-1710	Project and Thesis- II	0	0	0	16
617	ENG	CGCRI	ENG-CGCRI-4-0001	Project Proposal	0	0	4	2

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
618	ENG	CGCRI	ENG-CGCRI-4-0002	Review Article	0	0	4	2
619	ENG	CGCRI	ENG-CGCRI-4-0003	Project with societal/rural issues under CSIR-800	0	0	8	4
620	ENG	CRRI	ENG-CRRI-1-2301	Statistical Methods in engineering	3	0	0	3
621	ENG	CRRI	ENG-CRRI-1-2302	Design and Construction of Pavements	3	0	0	3
622	ENG	CRRI	ENG-CRRI-1-2303	Traffic Engineering & Road Safety	3	0	0	3
623	ENG	CRRI	ENG-CRRI-1-2304	Transportation Planning	3	0	0	3
624	ENG	CRRI	ENG-CRRI-1-2305	Advanced Highway Engineering Materials	3	0	0	3
625	ENG	CRRI	ENG-CRRI-1-2306	Advanced Geotechnical Engineering	3	0	0	3
626	ENG	CRRI	ENG-CRRI-1-2307	Research Methodology	1	1	0	2
627	ENG	CRRI	ENG-CRRI-1-2308	Transport and Environment	3	0	0	3
628	ENG	CRRI	ENG-CRRI-1-2309	Geospatial Techniques for Infrastructure	3	0	0	3
629	ENG	CRRI	ENG-CRRI-1-2310	Economic Evaluation of Highway Projects	3	0	0	3
630	ENG	CRRI	ENG-CRRI-1-2311	Advanced Concrete Technology	3	0	0	3
631	ENG	CRRI	ENG-CRRI-1-2312	Soft Computing Techniques in Transportation Engineering	3	0	0	3
632	ENG	CRRI	ENG-CRRI-2-2301	Pavement Evaluation Techniques and Management System	3	0	0	3
633	ENG	CRRI	ENG-CRRI-2-2302	Bridge and Tunnel Engineering	3	0	0	3
634	ENG	CRRI	ENG-CRRI-2-2303	Public Transportation System	3	0	0	3
635	ENG	CRRI	ENG-CRRI-2-2304	Health Monitoring of Road Infrastructure	3	0	0	3
636	ENG	CRRI	ENG-CRRI-2-2305	Transport Logistics and Operations	3	0	0	3
637	ENG	CRRI	ENG-CRRI-2-2306	Environmental Impact Assessment of Infrastructure Projects	3	0	0	3
638	ENG	CRRI	ENG-CRRI-3-2301	Advanced Self Study	0	2	4	4
639	ENG	CRRI	ENG-CRRI-4-0001	Project Proposal	0	0	4	2
640	ENG	CRRI	ENG-CRRI-4-0002	Review Article	0	0	4	2
641	ENG	CRRI	ENG-CRRI-4-0003	CSIR-800 Societal Program	0	0	8	4
642	ENG	CRRI	ENG-CRRI-1-2313	Basic Pavement Engineering	1	0	0	1
643	ENG	CRRI	ENG-CRRI-1-2314	Super Pave Asphalt Binders and Mixtures	1	0	0	1
644	ENG	CRRI	ENG-CRRI-1-2315	Introduction to Optimization Techniques	1	0	0	1
645	ENG	CRRI	ENG-CRRI-1-2316	BASICS OF PAVEMENT EVALUATION	1	0	0	1
646	ENG	CRRI	ENG-CRRI-1-2317	INTRODUCTION TO PAVEMENT MANAGEMENT SYSTEM	1	0	0	1
647	ENG	CRRI	ENG-CRRI-2-2307	Introduction to Engineering Mechanics (Solid Mechanics)	2	0	0	2
648	ENG	CRRI	ENG-CRRI-2-2308	Introduction to Big Data Analytics	2	0	0	2
649	ENG	CRRI	ENG-CRRI-2-2309	PRINCIPLES OF PAVEMENT EVALUATION	2	0	0	2
650	ENG	CRRI	ENG-CRRI-2-2310	PRINCIPLES PAVEMENT MANAGEMENT SYSTEM	2	0	0	2

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
651	ENG	CRRI	ENG-CRRI-2-2311	ADVANCED PAVEMENT EVALUATION	3	0	0	3
652	ENG	CRRI	ENG-CRRI-2-2312	ADVANCED PAVEMENT MANAGEMENT SYSTEM	3	0	0	3
653	ENG	CRRI	ENG-CRRI-2-2313	Basics of Soil Mechanics	3	0	2	4
654	ENG	CRRI	ENG-CRRI-2-2314	Basics of Engineering Geology	3	0	0	3
655	ENG	CRRI	ENG-CRRI-2-2315	Atmospheric Chemistry	3	0	0	3
656	ENG	CRRI	ENG-CRRI-2-2316	Optimization Techniques	3	1	0	4
657	ENG	CRRI	ENG-CRRI-2-2317	Planning for Sustainable Transport System	3	1	0	4
658	ENG	CRRI	ENG-CRRI-2-2318	Life Cycle Assessment Applications in Transport Sector	2	1	0	3
659	ENG	CRRI	ENG-CRRI-2-2319	Durability of Concrete Structures	3	0	2	4
660	ENG	CRRI	ENG-CRRI-2-2320	Dynamics of Structures	3	1	0	4
661	ENG	CRRI	ENG-CRRI-2-2321	Transport Network Analysis	3	1	0	4
662	ENG	CRRI	ENG-CRRI-2-2322	Microstructure and Mechanics of Cement Concrete	3	1	0	4
663	ENG	CRRI	ENG-CRRI-2-2323	Air Quality & Dispersion Modeling	3	0	2	4
664	CHE/ENG	CRRI	CHE/ENG-CRRI-1-2318	Chemistry of Portland Cement and Pozzolanic Admixtures	1	0	0	1
665	CHE/ENG	CRRI	CHE/ENG-CRRI-1-2319	Polymers for Construction and Maintenance of Bridges	1	0	0	1
666	CHE/ENG	CRRI	CHE/ENG-CRRI-1-2320	Polymers in Road Construction Applications	1	0	0	1
667	CHE/ENG	CRRI	CHE/ENG-CRRI-1-2321	Asphalt Emulsions, Foamed Asphalt and Cold Mixes	1	0	0	1
668	CHE/ENG	CRRI	CHE/ENG-CRRI-1-2322	Metallurgical Slag for Construction Procedures	1	0	0	1
669	CHE/ENG	CRRI	CHE/ENG-CRRI-1-2323	Polymer Materials	1	0	0	1
670	CHE/ENG	CRRI	CHE/ENG-CRRI-2-2324	Polymer Chemistry and Characterization	2	0	0	2
671	CHE/ENG	CRRI	CHE/ENG-CRRI-2-2325	Instrumental methods for Characterization of Environmental Pollutants	2	0	2	2
672	CHE/ENG	CRRI	CHE/ENG-CRRI-2-2326	Instrumental methods for Characterization of Engineering Materials (Bituminous Materials)	2	0	0	2
673	PHY/ENG	CRRI	PHY/ENG-CRRI-1-2324	Nanotechnology for Infrastructure	1	0	0	1
674	PHY/ENG	CRRI	PHY/ENG-CRRI-1-2325	Material Characterization Instrumentation	1	0	0	1
675	MIS/ENG	CRRI	MIS/ENG-CRRI-1-2326	Human Value & Professional Ethics	1	0	0	1
676	MIS/ENG	CRRI	MIS/ENG-CRRI-1-2327	Introduction to Finite Element Analysis	1	0	0	1
677	ENG	NIIST	ENG-NIIST-1-4101	Research Methology	2	0	0	2
678	ENG	NIIST	ENG-NIIST-1-4102	Mathematics for Engineers and Scientists	2	0	0	2
679	ENG	NIIST	ENG-NIIST-2-4101	Advanced Materials Science and Engineering	2	0	0	2
680	ENG	NIIST	ENG-NIIST-2-4102	Advanced Materials Characterization	2	0	2	3
681	ENG	NIIST	ENG-NIIST-2-4103	Physical Metallurgy	2	0	0	2

S.No.	Faculty	Lab Name	Course Nomenclature	Course Name	L	T	P	C
682	ENG	NIIST	ENG-NIIST-2-4104	Thin film technology (new-approval requested)	2	0	0	2
683	ENG	NIIST	ENG-NIIST-3-4101	Nanomaterials Science and Technology	3	0	0	3
684	ENG	NIIST	ENG-NIIST-3-4102	Advanced Composite Materials	3	0	0	3
685	ENG	NIIST	ENG-NIIST-3-4103	Advanced Ceramics Processing	3	0	0	3
686	ENG	NIIST	ENG-NIIST-3-4104	Materials Chemistry	3	0	0	3
687	ENG	NIIST	ENG-NIIST-3-4105	Light and Rare Earth Metals, Alloys and Composites	3	0	0	3
688	ENG	NIIST	ENG-NIIST-3-4106	Polymers and Composites	3	0	0	3
689	ENG	NIIST	ENG-NIIST-3-4107	Advanced Materials Processing	3	0	0	3
690	ENG	NIIST	ENG-NIIST-3-4108	Advanced Functional Materials	3	0	0	3
691	ENG	NIIST	ENG-NIIST-3-4109	Surface Science and Technology	3	0	0	3
692	ENG	NIIST	ENG-NIIST-3-4110	Advanced Foundry Technology	3	0	0	3
693	ENG	NIIST	ENG-NIIST-3-4111	Modeling for Casting and solidification processing	3	0	0	3
694	ENG	NIIST	ENG-NIIST-3-4112	Magnetic materials and their technological application	3	0	0	3
695	ENG	NIIST	ENG-NIIST-3-4113	Cryogenics, Vacuum technology and its process applications	3	0	0	3
696	ENG	NIIST	ENG-NIIST-4-0001	Project Proposal Writing	0	0	4	2
697	ENG	NIIST	ENG-NIIST-4-0002	Review Article Writing	0	0	4	2
698	ENG	NIIST	ENG-NIIST-4-0003	CSIR-800 Societal Programme Project	0	0	8	4
	ENG	ALL LABS	ENG-LAB NAME-4-0098	Pre-thesis research	-----	-----	-----	-----
	ENG	ALL LABS	ENG-LAB NAME-4-0099	Thesis Research	-----	-----	-----	-----

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-1-3501**			
Course Title	**Applied Mathematical Methods**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Linear Algebra: Matrices and matrix algebra, systemof linear equations, LU decomposition, introduction to vector spaces, linear transformation, orthogonalization, eigensystems, diagonalization,singular value decomposition, introduction to tensor and tensor calculus. Ordinary Differential Equations: Introduction to first order ODEs, method of separation of variables, exact solutions, introduction to second order ODEs, homogeneous linear equations, equations with constant and variable coefficients, nonhomogeneous equations, series solutions of ODEs, Legendre and Bessel functions, Strum Louville problems, Laplace transform and its application to ODEs. Partial Differential Equations: Introduction to first order PDEs, method of characteristics, method of separation of variables, classification of second order PDEs, reduction to standard form, heatand wave equations in one and two dimensions, two dimensional Laplace equation, PDEs in infinite and semi infinite spatial domain, integral transform, Fourier transform, solving PDEs using Fourier and Laplace transforms, non-homogeneous PDEs

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-1-3502**			
Course Title	**Applied Numerical Methods**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Modeling and Error Analysis: Mathematical Modeling and Engineering Problem Solving, Approximations and Round-off Errors, Truncation Errors and the Taylor Series. Interpolation and Approximation: Lagrange and Newton Interpolations, Interpolating Polynomials using Finite Differences, Hermite Interpolation, Piecewise and Spline Interpolation; Least Squares Approximation, Gram-Schmidt Orthogonalizing Process, Legendre Polynomials, Chebyshev Polynomials; Uniform Polynomial Approximation. Linear Algebraic Equations: Direct Methods: Cramer's Rule, Gauss Elimination Method, Gauss Jordan Elimination Method, Triangularization Method, Cholesky Method, Partition Method; Error Analysis and System Condition for Direct Methods; Iteration Methods: Jacobi Iteration Method, Gauss-Seidal Iteration Method, Successive Over Relaxation Method; Convergence Analysis of Iterative Methods. Eigenvalues and Eigenvectors: Bounds on Eigenvalues, Jacobi Method for Symmetric Matrices,Givens method for Symmetric Matrices, Householder's Method for Symmetric Matrices, Rutishauser Method for Arbitrary Matrices, Power Method, Inverse Power Method. Differentiation and Integration: Numerical Differentiation:Methods Based on Interpolation, Non-Uniform Nodal Points, Uniform Nodal Points; Methods Based on Finite Differences; Methods Based on Undetermined Coefficients; Optimum Choice of StepLength; Extrapolation Methods; Partial Differentiation; Numerical Integration: Methods Based on Interpolation, Newton-Cotes Methods, Trapezoidal and Simpson's Rules; Open Type Integration Rules, Methods Based on Undetermined Coefficients, Newton-Cotes Methods, Trapezoidal and Simpson's Methods, Gauss Quadrature Methods, Radau Integration 9 Methods, Composite Integration Methods, Romberg Integration, Double Integration. Roots of Equations: Bracketing Methods: Graphical, Bisection and False-Position Methods; Open Methods:Simple Fixed Point Iteration, The Newton-Raphson and Secant Methods, Multiple Roots, Systems of Nonlinear Equations; Roots of Polynomials:Polynomials in Engineering and Science, Computing with Polynomials, Conventional Methods, Muller's and Bairstow's Methods. Ordinary Differential Equations- Initial and Boundary Value Problems: Single-Step and Multi-Step Methods, Convergence and Stability, Euler Method, Backward Euler Method, Mid-point Method, Taylor Series Method, Runge-KuttaMethods, Finite Difference Methods, Finite Element Methods. Partial Differential Equations: Method of Finite Differences, Elliptic and Parabolic Equations. Signals and signal processing:Characterization and classification of signals, signal processing operations and applications. Transform –domain representation of Signals: Fast Fourier Transform its applicationsand properties, z-Transform. Introduction to Analog and Digital Filters and its applications, basics of filter design procedures and design examples. Introduction to time_frequency methods. Seminars on advanced/special topics in Numerical Methods.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-1-3503**			
Course Title	**Aircrafts and Systems**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Evolution of heavier-than air aircraft for several applications: passenger, transport, freight, military applications. Configurations of various types of aircraft: Fixed wing aircraft, various types of aircraft, identification of various structural parts, materials used and their functions. Interplay of aerodynamics, structural mechanics, propulsion, avionics and controls in their conceptualization and performance. Introduction to aircraft specifications: Standards for both Military and Civil aircraft, Airworthiness certification aspects aircraft introduction to flight-testing: Purpose and Scope of Flight Testing; introduction to general flying and handling characteristics of aircraft. Flight test plans and procedures, Flight test data acquisition, analysis and interpretation. Aircraft systems: Mechanical, Electrical and Avionics subsystems integration.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-1-3504**			
Course Title	**Aerodynamics**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Introduction, relevant properties of a fluid, pressure, temperature, density, viscosity, bulk elasticity, Thermodynamic properties. Hydrostatics, aerostatics and the atmosphere. Aeronautical definitions: Wing geometry, airfoil geometry, aerodynamic force, force and moment coefficients, pressure distribution on an airfoil, estimation of the lift, drag and pitching moment coefficients, Trailing vortex drag,lift dependent drag, airfoil characteristics. Basic Fluid mechanics: One dimensional flow: The basic equations of conservation, measurement of air speed, compressible one-dimensional flow, speed of sound, onedimensional normal shock waves.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-1-3505**			
Course Title	**Aerospace Propulsion**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Introduction to Aerospace Propulsion, Basics of Aerospace Flight and Propulsion, Standard Atmosphere & Operational Envelopes, Basics of Aircraft Engines and Rocket Engines. Thermodynamics & Gas Dynamics: Basics of Fluid Mechanics and Thermodynamics, Laws of thermodynamics, Isentropic Flow, Flow with Shocks, Fanno Flow, Rayleigh Flow, Multidimensional Flow. Combustion & Heat Transfer: Chemistry & Stoichiometry, Premixed Fames, Diffusion Flames, Ignition, Subsonic Combustion, Supersonic Combustion, Heat transfer basics, Heat transfer challenges of propulsion systems. Aircraft Propulsion: History & Classification, Propellers, Gas Turbine Engines, Cycle Analyses, Components (Inlets, Compressor, Combustion Chamber, Turbine, Afterburner & Nozzle) Analyses, Engine Performance Analyses. Turbomachinery Mechanical: Components (Compressor, turbine, rotor etc.), Materials (Conventional & Advanced), Failure Theories, Structural Vibrations, Rotor dynamics, Bearings. Rocket Propulsion: History & Classification of Rockets (Solid, Liquid, Hybrid, Cryo, Electric & Nuclear), Nozzle Theory, Basics of Rocket Flight & Orbital Mechanics, Solid Rocket Propulsion, Liquid Rocket Propulsion.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-1-3506**			
Course Title	**Flight Mechanics**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Systems of Axes, Euler Angles and quaternions, Axes Transformation, Static Equilibrium and Trim, Aircraft Static Stability, Contributions of Wing and Tail, Neutral Point and Static Margin, Longitudinal Stability and Control, Directional Stability and Control, Roll Stability and Control, Equations of Motion and their alternative forms, Solution of Equations of Motion, elastic airplane equations of motion, Transfer function and response characteristics, State Space Method, Aerodynamic stability and control derivatives, Aircraft modes of motion, Longitudinal and Lateral dynamic stability modes, mathematical model structure, reduced order models, frequency responses and time histories, aerodynamic Modeling, flight path reconstruction techniques, aerodynamic derivative estimation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-1-3507**			
Course Title	**Avionics**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Role in Aircraft, avionics environment. Avionics Systems: Equipments, Principle and operation. Communication Systems: VHF, HF, AMS, RTU. Navigation: Introduction and basic principles, Radio direction finding; Radio ranges; hyperbolic system of navigation (LORAN, DECCA). VOR/DME and TACAN; Doppler navigation; Inertial navigation: GPS; Terrain reference navigation. Aids to approach and landing. FMS, Gyros and accelerometers. Attitude and heading reference systems. Surveillance systems: EGPWS; SWS; TCAS. Data recording systems: FDAU, SSCVFDR. Data bus protocols: A429, A629, AFDX, CSDB, Mil-Std-1553. Basic Avionics Architecture, Packaging and EMI/EMC

Faculty	ENGINEERING SCIENCES			
Lab Name	CSIR-NAL, BANGALORE			
Course Nomenclature	ENG-NAL-1-3508			
Course Title	Aerospace Materials			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Aerospace Materials: Design requirements for aerospace structural materials, general perspectives of advanced aeropace materials with regard to fuselage, propulsion and space vehicle applications. Metallic Materials: Aluminium alloys-Physical metallurgy and mechanical properties with emphasis on aeronautical requirement, temper designations, processing and properties, alloy specifications of aerospace grade Al-alloys; magnesium alloys used for aerospace applications; structural steels-various grades of steels used for landing gear, transmission systems and fatigue critical applications; Titanium alloys-Physical metallurgy, mechanical properties, processing and applications of aerospace grade alloys; Ni-base superalloys-evolution of materials for aero-engine applications, recent developments for aero-gas turbine, advanced thermal barrier coatings on superalloys used for gas turbine. Polymeric based composite (PMC) materials- Introduction, quasi-static strength of PMCs, reinforcements and matrices in PMCs, interfaces, processing and properties of composites, advantages of composites; carbon fibres, Carbon fibre-reinforced plastics (CFRP) and glass fibre reinforced plastics (GFRP), joining and repair of composites, Introduction to Damage tolerant composites, Destructive and Non-destructive testing, fracture and toughness of composites, fatigue strength of PMCs. Metal-based composite materials-Introduction, metalceramic composites, laminates, and applications of MMCs. Recent advances in smart materials' applications in aerospace, superplastic forming and diffusion bonding processing of aerospace alloys. Life prediction of materials and structures in aerospace-fatigue and fracture of metallic materials, random load fatigueand life prediction, physical reason for the existence of effective ΔK (ΔK_{eff}), crack growth and life prediction, special testing techniquesSCC, fracture toughness, microstructural degradation, stress rupture etc.,

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-1-3509**			
Course Title	**Structural Mechanics**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Basic elasticity- Stress and Strain, Equations of equilibrium, Plane stress and strain, Boundary conditions, Principal stresses and strains, Compatibility equations, Mohr’s circle, Stress-strain relationships, Hooke's law; Two-dimensional elasticity problems in Rectangular and Polar coordinates: Stress functions, Bending ofan end-loaded cantilever, Plate with a hole; Torsion of solid sections; Stresses in Simple Structural Members: Axially loaded members, Stresses in beams, Deflection of beams by integration, Euler column buckling, Thin-walled pressure vessels, Yield and fracture criteria, Introduction to bending of thin plates.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3501**			
Course Title	**Fluid Dynamics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: Concept of a fluid, continuum, properties of a fluid. Pressure Distribution in Fluid: Pressure and pressure gradient, equilibrium of a fluid element, hydrostatic forces. Fundamental conservation equations: Integral and differential forms of Mass, Momentum and Energy conservation , Boundary conditions, stream function, vorticity and irrotationality. Viscous flow: Reynolds Number and Geometry effects, Introduction to Boundary layer theory. Potential Flows: Elementary Plane-Flow solutions. Introduction to Compressible flows: Introduction, speed of sound, adiabatic and isentropic steady flow, convergingdiverging nozzles.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3502**			
Course Title	**Computational Fluid Dynamics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to CFD, Equations governing fluid flow, Hyperbolic partial differential equations and shocks, finite difference technique and difference equations, Implicit difference formula, Time discretization and stability, Schemes for linear convective equation, Analysis of time integration schemes, Monotonicity , Schemes for Euler equations, Finite volume methodology, Introduction to unstructured mesh computations.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3503**			
Course Title	**Gas dynamics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Fundamentals of thermodynamics; propagation of small disturbances in gases; normal and oblique shock relations, nozzle flows; one-dimensional unsteady flow; small disturbance theory of supersonic speeds, generation of supersonic flows in tunnels, supersonic flow diagnostics, supersonic flow over two-dimensional bodies; shock expansion analysis, method of characteristics; one-dimensional rarefaction and compression waves; flow in shock tube. Laboratory classes for demonstrating the concepts and conducting of experiments.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3504**			
Course Title	**Low speed aerodynamics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Elementary flows, Introduction to small perturbation theory, 2-D airfoils in subsonic flow, numerical methods for 2-D airfoils, similarity rules, Multhops method, vortex lattice and double lattice methods, aerodynamics of wing-fuselage system and aerodynamics of control surfaces. High angle of attack aerodynamics: non-linear aerodynamics, unsteady aerodynamics. 2D numerical solutions. Thin aerofoiltheory, lifting line theory.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3505**			
Course Title	**Boundary layer theory**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Navier-Stokes equation and its importance, Prandtl's boundary layer approximations, Significance of scaling, 2D boundary layer equations, asymptotic theory, Blasius solutions, momentum integral methods, Axisymmetric and 3D boundary layer, thermal boundary layer, compressible boundary layer, Unsteady boundary layer, Instability, turbulent boundary layer, Reynolds stress, turbulent boundary layer on flat plate, pipe flows, introduction to perturbation techniques.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3506**			
Course Title	**Gas Turbine Propulsion**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: History of gas turbine, Introduction to gas turbine-components, Classifications of gas turbines, Thermodynamics of aircraft jet engines, Classification of jet engines, Performance parameters, Specific thrust, Specific fuel consumption, Thermal efficiencies and Propulsive efficiency. Intakes and diffusers: Introduction, Inlet ducts geometry, Diffusers/ Classifications/ Characteristics, Methods of flow control, Subsonic inlets, Transition ducts. Compressors: Cascade Aerodynamics - Compressor cascades, Turbine cascades, Losses. Axial Compressor Aerodynamics – Introduction, Axial compressor /fan, Euler's equation, Velocity triangle/ h-s/ t-s diagrams, Performance parameters, Compressor characteristics Instabilities in compressor & theircontrols, Losses, Compressor design methodology, Radial equilibrium method & Stream line curvature method, Degree of reaction, Diffusion factor & Work coefficient, Multi-staging, Recent trend in turbo machinery design. Centrifugal Compressor Aerodynamics – Introduction, Stage dynamic, Inducer and impeller, Diffuser & its performance characteristics, Introduction to stage design, Introduction to Aero elasticity/ Optimization techniques, Measurement techniques in turbo machines. Combustion chambers: Basic considerations, Combustion fundamentals, Diffusers, Combustion aerodynamics, Swirler aerodynamics, Combustion performance, Fuel injection, Combustion noise, Heat transfer, Emissions. Turbines: Introduction, Eulers equation for turbines, Velocity triangles, Dimensionless parameters, Secondary drag/ losses, Comparison between axil compressors and turbines, Free vortex theory, Mean line design, CFD for turbines. Afterburners & nozzles: Basic principle and Components of Afterburners, Ignition, Flame stabilization and combustion in Afterburners, Heat transfer in Afterburner, Afterburner performance evaluation and test facilities, Basic principle and types of propulsive nozzles, Fixed and variable aircraft nozzles, Performance evaluation. Component matching: Introduction, Performance characteristics, Equilibrium running diagram, Procedure to find equilibrium point, Balancing. Coupling and alignment, Performance evaluation, General matching procedure, Operating line & Transient Operation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3507**			
Course Title	**Heat Transfer in Propulsion Systems**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Fundamentals of heat transfer: Conduction, Convection, Radiation, Concept of boundary layers - velocity / thermal. Temperature measurement techniques: Infra red thermography. Thermocouples, Heat flux gauges, Liquid crystal thermography, Temperature sensitive paints. Heat exchangers: Types, Design Factors. Turbine blade heat transfer and film cooling: Leading edge film cooling and heat transfer, Trailing Edge film cooling and heat transfer. Impingement cooling and heat transfer: Effect of geometrical parameters, Effect of flow parameters. Effusion / transpiration cooling: Flat and curved Plates, Starter films, Effect of compound angle. Anti-icing and De-icing: Theory,Application. Turbine rim seals: Types, Flow through rim seals, Ingestion, Geometrical and flow parameters. Engine Temperature and Health Monitoring: Thermal barrier coatings, Engine temperature monitoring, Engine safety and health monitoring.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3508**			
Course Title	**Aircraft Stability and Control**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to open- and closed-loop control systems and examples, Differential equation models of physical systems and solution methods, choice of linear models, Laplace transforms, transfer functions, and block diagrams, State-variable system models, relative stability, gain and phase margins, Bode plots, Nyquist stability Criterion, Nichols chart, linear design process, Root locus design methods, System bandwidth, Feedback system characteristics, Design of feedback systems in the frequency- and time-domain, Pole placement method, Observability and controllability, angle-of-attack limiter, sideslip angle and sideslip rate feedback, roll rate feedback, design of command paths, nonlinear design and verification, control power requirements for unstable aircraft, control actuator rate requirements, limits on static instability, controlsurface sizing, center-of-gravity limits, inertia cross coupling, roll coupling, autorotation, roll reversal, Longitudinal and Lateral stability Augmentation, Fundamentals of Inertial Navigation, Basic autopilot control laws

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3509**			
Course Title	**Systems Engineering**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Principles and processes of Systems Engineering, Need of Systems Engineering, Meaning and Context of Safety Integrity Targets. Systems Engineering Process: Functional analysis and Specifications, Requirements Analysis and allocation, System Synthesis, Analysis and Design Optimisation, Development of the System Logical Solution, Effectiveness Evaluation and Decision Making. System Design and Integration:Design Requirements, Specifications, Architecture analysis and design, Model Based Design, UML/SysML, Model Driven Development, Integrated Model driven verification and validation, System requirements, analysis, systems integration, Systems certification, Systems Engineering Review Process. Selected Design Engineering Activities: Software Engg, Reliability Engg, Maintainability Engg, Human Factor Engg, Safety Engg, Quality Engg,Environmental Engg and Life Cycle costing Engineering. Reliability Modelling: Block Diagram Analysis, Common cause Failure, Fault Tree Analysis. Engineering Design Methods and Tools, System Reviews, Systems Engg Program planning, Integration design and test planning, Organization of Systems Engg, System Engineering Program Evaluation, SystemEngineering Management.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3510**			
Course Title	**Advanced Avionics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Aircraft Architectures: Federated and Integrated modular avionics, DIMA, Avionics systems integration. Displays: Introduction to EFIS, EICAS, Head-Up displays. Advanced Visualization Concepts: Intelligent displays management, EVS/SVS, LIDAR. Advanced Navigation Concepts: Vision aided Navigation, Highway In the Sky, CNS/ATM, GNSS. Advanced Surveillance Systems: TAWS, TCAS I and II. Control Systems: PFCS, Fly-bywire, Fly-by-light control systems, Automatic Flight Control Systems. Landing systems: ILS and MLS, IESVS. Aircraft Data Networks, Bus Architectures, Advanced bus protocols, AFDX. Avionics Health Management Techniques. Model Based Design, Model Driven Development, Tool Based Automation. Software Engineering: Life cycle management, IV&V process, planning and testing, Formal Methods, Software Quality management, Configuration management and certification. Integrated System engineering Platform, Integrated System Integration Platform, Integrated Model Driven IV&V. Standards and regulations related to Civil Aircraft: DO and FAR. Terminal guidance systems, Telemetry systems, Man machine interface. Modular Avionics Packaging, ARINC and Mil types, system cooling, EMI/EMC requirements BIT and CFDS, Automatic Test Equipment, Speeds maintenance, ATLAS, Remote diagnostics and maintenance support-Life Cycle Costs for Military and Civil Avionics, Software costs, Establishing spares level.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3511**			
Course Title	**Advanced Embedded Systems and Software Engineering**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Embedded System Basics. System Architecture: von Neumann, Harvard and differences. Memory Architecture and their implementation. ADC and DAC. I/O Devices and Mechanisms. Instruction Set and Addressing Modes. Interfacing of Memory and Peripheral Devices. Bus Architecture: evolution and implementations. Embedded Systems Software: Issues. RTOS: Introduction, scheduling, memory, I/O, device driver. Embedded Software Development perspective. Performance Analysis and Optimization for advanced avionics system design. System Specification and Modeling. Basic Digital signal processing: wavelet and speech transformation. Embedded image processing: vision based tracking. Micro Air Vehicle systems, hardware, MEMS sensors, interfaces, software platform, development suite and hardware in loop testing.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3512**			
Course Title	**Mechanical behaviour of Materials**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Structure and deformation in materials-introduction, bonding in solids, structure in crystalline materials, elastic deformation and theoretical strength, inelastic deformation, summary. A survey of engineering materials-introduction, alloying and processing of metals, irons and steels, non-ferrous metals, polymers, ceramics and glasses, composite materials, materials selection for engineering components, summary. Mechanical testing-introduction to tension test and other basic tests-engineering stress-strain properties, trends in tensile behavior, true stress-strain interpretation of tensile test, compression test, hardness tests, notch impact tests, bending and torsion test. Stress-strain relationships and behavior of materialsIntroduction, models for deformation behavior, elastic deformation, anisotropic materials. Review of complex and principal states of stress and strain-Plane stress, principal stresses and maximum shear stress, 3-D states of stress, stresses on the octahedral planes, complex states of strain. Yielding and fracture under combined stresses-general form of failure criteria, maximum normal stress fracture criterion, maximum shear stress yieldcriterion, octahedral shear stress yield criterion, discussion of the basic failure criterion, Coulomb-Mohr fracture criterion, modified Mohr's fracture criterion. Time dependant behavior- creep testing, physical mechanism of creep, time-temperature parameters and life estimates, creep failure and varying stress. Fatigue of materials-introduction and stress based approach-definition and concepts, sources of cyclic loading, fatigue testing, physical nature of fatigue damage, trends in S-N curves, mean stresses, multi-axial stresses, variable amplitude loading. Fracture mechanics-application of K to design and analysis, fracture toughness values and trends, plastic zone size and plasticity limitations on LEFM, fracture toughness testing, fracture mechanics beyond linear elasticity. Fatigue crack growth-introduction, fatigue crack growth rate testing, effects of stress ratio on fatigue crack growth, trends in fatigue crack growth behavior, life estimates for constant amplitude loading, life estimates for variable amplitude loading, design considerations, plasticity aspects and limitations of LEFM for fatigue crack growth, environmental crack growth.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3513**			
Course Title	**Processing and Characterization of Metals**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Preparation of metals and alloys by liquid metallurgy, powder metallurgy routes. Atomisation technique for preparation of metallic powders. Processing routes such as rolling, extrusion and forging. Advantage and limitations of processing methods. Preparation techniques for advanced composites and alloys. Elastic deformation. Plastic deformation. Interpretation of tensile stress-strain curves. Yielding under multi axial stress. Yield criteria and macroscopic aspects of plastic deformation. Importance of sever plastic deformation. Strengthening of metals by cold work, solute atoms and grain boundaries. Dislocation and their role in plastic deformation. Mechanisms of strengthening in metals.Recovery, recrystallization and grain growth. Strengthening by second phase particles. Optimum distribution of particles. Lattice esistance to dislocation motion. Methods of deformation, conventional thermo-mechanical processing of metals and alloys. Basics of optical microscopy and SEM imaging, including instruments, signals, uncertainties, imaging (SE, BSE), diffraction, resolution, aberrations, depth of Composition analysis using EDS, capabilities & limitations. Identification of phases by metallographic and XRD studies, microstructural studies using optical, scanning and transmission electron microscopy.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3514**			
Course Title	**Advanced Ceramics Materials**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Physical Ceramics: Introduction and classification of ceramics, oxide ceramics (alumina, silica, zirconia, magnesia etc.), non oxide ceramics (SiC, Si 3N4, SiAlON, Boron Carbide etc), chemical bonding and crystal structure, defects in crystal, x-ray diffraction, Bragg's law, phase analysis of ceramics by XRD technique, morphology and ceramic microstructure by scanning electron microscopy (SEM), phase equilibria of binary and ternary ceramic systems. Processing of Ceramics: Hydrothermal synthesis, sol-gel, co-precipitation, reaction synthesis, colloidal processing, slip casting and tape casting, injection moulding, isostatic pressing, Gas phase synthesis: chemical vapor deposition (CVD), chemical vapor infiltration (CVI), Fabrication of ceramic components by CVI/CVD, sintering and crystallization, hot pressing, nucleation and grain growth, hot isostatic pressing, spark plasma sintering, Liquid phase synthesis: melt infiltration and polymeric derived ceramics (PDC). Characterization of Ceramics: particle size and surface area analysis, porosity and density, theoretical fracture strength, Griffith's theory of brittle fracture, toughness and fracture toughness, factors influencing the strength of ceramic materials, toughening mechanisms in ceramics, Mechanical testing of ceramic materials: modulus ofrupture (MOR): 3point and 4 point bend, Tensile strength, Fracture toughness (KIC) by indentation, Single Edge Notched Beam (SENB) and R curve methods, Hardness measurements, creep and fatigue, thermal properties (heat capacity, thermal onductitvity, coefficient of thermal expansion) of ceramics, thermal stress and thermal shock resistance (Kingery's and Hasselmann theory), thermal fatigue etc, Electrical properties: dielectric, ferroelectric, piezoelectric properties, barium titanate and lead zirconate titanate (PZT), sensors and actuators, magnetic properties (diamagnetic, paramagnetic and ferromagnetic). Applications of ceramic materials for aerospace applications, high temperature structural application, as sensors and actuators etc.

Faculty	ENGINEERING SCIENCES			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3515**			
Course Title	**Piezoelectric Materials and Devices**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: Definition, Introduction of Piezoelectricity, Different types of Piezoelectric Materials. General Principles and Theoretical Considerations: Origin of Piezoelectricity, Principles of Piezoelectricity, Dielectric and ferroelectrics, Polarisation and domain wall movement, Alternative formulation of piezoelectric theory, Secondary piezoelectric effect, Piezoelectricity in the light of atomic theory, Basic mechanics of piezoelectricity and Constitutive Constants. Nonlinear Piezoelectric Effects. Piezoelectric Materials: Natural & Synthetic Piezo Materials (Barium titanate, lead titanate, lead zirconate titanate (PZT), Effect of composition, Phase diagram, Soft and hard PZTs, Effect of dopants on piezo properties, Lead –free Piezo Materials, Piezoelectric Polymers and their Composites. Material Preparation: Bulk Piezoceramics:Mixed oxide route, hydrothermal, sol-gel, co-precipitation, wet-chemical method, spray drying etc., calcinations and sintering, electroding and poling. Thin/Thick Film Piezoceramics:Preparation Methods, Physical Vapour Deposition, Chemical Vapour Deposition, Chemical Solution Deposition, Pulsed Laser Deposition, Electron beam heating. Piezo-Polymer: Solvent Cast Method, Hot Press, Extrusion method and their combinations, Spin coating technique. Characterization of Piezoelectric Materials: X rayAnalysis, Differential scanning calorimetry, IR, Raman, Tensile Properties, Measurement of Piezo-electric coefficients for bulk and thin films, Dielectric constant and loss factor, Hysteresis, Strain and block force measurement, IEEE standard on Piezoelectricity. Piezoelectric Devices: Fabrication of Multi-layeredsensors and actuators, Different types of actuators. Low dimensional piezoelectric devices and MEMS, Flexible Sensor Devices. Applications: Vibration control, Flow control, Structural Health Monitoring, Dynamic Pressure Sensor, Noise detection/cancellation, Bio-medical applications, Electronic Applications, Piezoelectric Transducers (Acoustic, Strain gauge &Ultrasonic), etc.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3516**			
Course Title	**Corrosion Engineering**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Electrochemical and thermodynamic principles, Nernst equation and electrode potentials of metals, EMF and galvanic series, merits and demerits; origin of Pourbaix diagram and its importance to iron, aluminium and magnesium metals. Exchange current density, polarization - concentration, activation and resistance, Tafel equation; passivity, electrochemical behaviour of active/passive metals, Flade potential, theories of passivity. Atmospheric, pitting, dealloying, stress corrosion cracking, intergranular corrosion, corrosion fatigue, fretting corrosion and high temperature oxidation; causes and remedial measures. Susceptibility tests for IGC, stress corrosion cracking and pitting, sequential procedure for laboratory and on-site corrosion investigations, corrosion auditing and corrosion map of India, Salt Spray Test and standards. Corrosion prevention by design improvements, anodic and cathodic protection, metallic, non-metallic and inorganic coatings, mechanical and chemical methods and various corrosion inhibitors.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3517**			
Course Title	**Surface Modification Technologies**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to Surface Modification – Importance and Methods. Surface degradation- tribology, wear and corrosion- types of wear, adhesive, abrasive, oxidative, corrosive, erosive and fretting wear, role of friction and lubrication; overview of different forms of corrosion, Tribocorrosion. Chemical and electrochemical polishing, chemical conversion coatings- phosphating, chromating, chemical colouring, anodization; Electro/elctroless deposition - deposition of copper, zinc, nickel and chromium, alloy and composite plating by electro/electroless methods, sol-gel coatings, their properties and applications. Thermochemical and plasma chemical processes- nitriding, carburising, ion implantation etc. Vacuum deposition techniques - physical vapour deposition (PVD), evaporation, sputtering, ion plating, plasma nitriding, chemical vapour deposition (CVD), plasma assisted CVD. Thermal spraying, techniques, advanced spraying techniques - plasma surfacing, detonation gun and high velocity oxy-fuel processes, laser surface alloying, laser cladding, specific industrial applications.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3518**			
Course Title	**Nanostructured Coatings and Materials**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: Concept of nanomaterials – scale / dimensional aspects, nano and nature, effect of size reduction on various properties, advantages and limitations at the nano level. Methods to produce nanomaterials: Plasma methods, chemical vapour deposition, sol-gel process, electro/electroless deposition, ball milling, severe plastic deformation, combustion synthesis etc. Applications: Fullerenes, carbon nano tubes, nano composites, nanosensors, nanomedicines, multilayered coatings, Superhard coatings, Magnetic materials etc. Health Issues: Understanding the toxicity of nanoparticlesand fibers, exposure to quartz, asbestos, air pollution. Environmental issues: Effect on the environmental and other species. Societal implications: Implications of nanoscience and technology in society, government regulations. Introduction to characterization of nanomateials. Nanofibers, methods of preparation, electrospinning, polymer and ceramic nanofibers by electrospinning, applications of nanofibers.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3519**			
Course Title	**Advanced Structural Mechanics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Thin plates: Kirchhoff theory – strain-displacement relations, stress-strain relations, stress resultants, equilibrium equations, boundary conditions; Analysis of rectangular and circular plates with different boundary conditions and loadings; Buckling of plates; Thermal stresses in plates; Membrane theories for the analysis of circular cylindrical, spherical and conical shells; Bending, shear and torsion of open and closed, thin-walled beams: Bending of open and closed section beams, General stress, strain and displacement relationships for open and single cell closed section thin-walled beams, Shear of open section beams, Shear of closed section beams, Torsion of closed section beams, Torsion of open section beams, Analysis of combined open and closed sections; Stress analysis of aircraft components: Tapered Beams, Fuselage, Wing. Introduction to fatigue, fracture and damage tolerance analysis of aircraft structural components.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3520**			
Course Title	**Finite Element Methods**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: Historical background, The basic concepts of the Finite Element Method, Fundamental concepts in elasticity, Potential energy and equilibrium, Raleigh-Ritz method, Galerkin's method, Solutions of linear equations. One-Dimensional Elements: Introduction, Interpolation and shape functions, Governing differential equations of bars and beams, weak form and finite element modeling; Potential energy and Galerkin approaches, classical EulerBernoulli and Timoshenko beam, linear and quadratic elements; Assembly of stiffness matrices and load vector, Treatment of boundary conditions, Stress computation, Temperature effects. Two-Dimensional Elements: Introduction, Finite element modeling and formulation, Plane elasticity and axisymmetric problems, Isoparametric four-noded quadrilateral element, Numerical integration, Higher order elements, Bending of Elastic Plates, Shear Deformation Plate Theory, Convergence studies. Three-Dimensional Elements: Introduction, Finite element modeling and formulation of hexahedral elements, higher order elements, Shell Elements. Introduction to FEM in Composites, Structural Dynamics and Nonlinear Mechanics. Seminars on special topics in FEM.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3521**			
Course Title	**Structural Dynamics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to vibration and airframe structures, single and multi degrees of freedom systems, different structural models (physical, spatial, modal), vibration of beams & plates, numerical techniques in structural vibration, measurement devices & instrumentation, structural testing methodologies, structural coupling and vibration controls.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3522**			
Course Title	**Stability of Structures**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Concepts of stability, bifurcation and limit point instability, stability of discrete systems, linear and nonlinear behavior, stability of beams and columns, energy methods, static and dynamic formulations, axial-flexural buckling, lateral-torsion buckling, buckling of beams on elastic foundations, imperfection sensitivity analysis, stability of plates, axial-flexural buckling, shear-flexural buckling, buckling under combined loads, introduction to inelastic buckling and dynamic stability, parametric instabilities and stability under non-conservative forces, introduction to aeroelasticity, divergence and flutter.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3523**			
Course Title	**Mechanics of Composites**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Classification of composites, behaviors of unidirectional composites, prediction of elastic constants using micromechanics, Homogenization theory, Voigt and Reuss approximation, two and three phase composite cylinder models; strength of composites, failure modes, macromechanical analysis of lamina; Properties of laminates and their constitutive equations, classical laminate and shear deformation theories, analysis of laminates, interlaminar stresses, failure theories, analysis of laminates after initial failure. Analysis of laminated composite beams.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3524**			
Course Title	**Design of Composite Structures**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Refresher on composite analysis: Lamina micromechanics, Lamina macromechanics, Classical lamination theory, Failure theories, Strength of laminates and examples. Vibration and stability of composite plates: Governing equations for vibration and buckling of composite plates, Vibration of simply supported composite plates, buckling of simply supported composite plates under in-plane loads andapproximate methods. Introduction to structural design: Inputs for structural design, Steps in structural design, Selection of structural configuration and Structure sizing, Laminate design and carpet plots , Design principles with composites, Selection of orientation and thickness and Design examples, Stiffened composite plates. Design of joints: Introduction, Types of joints, Mechanically fastened joints, Failure modes in mechanically fastened joints, Design guidelines for mechanically fastened joints, Adhesively bonded joints, Failure modes in bonded joints, Stress distribution in adhesive joints, Types of bonded joints, Selection of type of adhesive joints, Design guidelines for adhesively bonded joints and Decision on the type of joint. Damage tolerance in composites: Introduction, Sources of damage, Types of damage, FAR requirements and advisory circulars, Building block approach, Impact damages: Damage growth under fatigue loads, Residual strength: Tests and analytical methods. Detailed design: Basics of projections, Drawing standards and conventions, Introduction to CADD, Design of composite parts and Assembly design. Optimization: Fundamentals of optimization, Mathematical concepts in optimization, Optimization of composite plates. Testing of composite structures: Factors influencing testing, Test environment, Test methods and standards, Introduction to static testing of composite structures and Examples. Repair of composite aircraft structures: Introduction to repair, Repair philosophy, Repair sequence, Repair criteria, Damage assessment, Classification of repair, Selection of repair joints, Repair procedures, Certification of repair

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3525**			
Course Title	**Analysis of Composite Structures**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: Definition, Classification, Tailoring composites, Mechanical properties of composite lamina, Prediction of strength and stiffness. Elements of micromechanics. Macromechanics: Analysis of lamina, Constitutive classical laminate theory, Thermal stresses. Analysis of composite plates, Analysis ofcomposite shells, Vibration of beams and plates, Examples of applications

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-2-3526**			
Course Title	**Processing & Characterization of Composite Materials**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to composites, classification of composites (based on matriices-PMC, MMC &CMC, based on reinforcement – particulate,continuous reinforcements,special class of composites – hybrid, bio composites, Nano composites), PMC for aerospace application (thermoset/ thermoplastic based composites), Polymer matrix composite processing technologies, characterisation / testing of composites (physical/ thermal/ mechanical/thermomechanical/hygrothermal), hygrothermal effects on the properties of composites(hotwet degradation & certification aspects)

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3501**			
Course Title	**Grid generation techniques for CFD**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Introduction various grid generation techniques, structured grid generation, Algebraic grid generation methods, introduction to PDE based grid generation techniques, concept of grid control and grid control functions, examples of simple grid generation methods in 2D and 3D, multi-block approach for complex configurations. Introduction to unstructured grid generation, Delaunay triangulation method, 2D and 3D unstructured meshes, concept of isotropic and un-isotropic tetrahedral meshes, concept of hybrid grids. Unconventional methods, the Cartesian Grid and Mesh free approach. A brief hands-on training on the POINTWISE software for grid generation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3502**			
Course Title	**Kinetic schemes for the computation of compressible flows**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

An introduction to kinetic schemes for CFD, The moment method strategy for computation of in-viscid flows. Concept of up-winding at the kinetic level, introduction to 1-D FDM,FVM kinetic upwind schemes, stability and consistency studies for kinetic schemes, introduction to multi-dimensional problems, variants of kinetic schemes, the kinetic mesh free methods.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3503**			
Course Title	**Turbulent Flows**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Characteristics of turbulent flows, RANS equations, vortex dynamics, concepts of equilibrium and similarity, Free shear layers, wall bounded flows, Stability of fluid flows, laminar-turbulent transition, statistical aspects of turbulence, scales in turbulence, spectrum of turbulence, basics of turbulence modelling, turbulent measurement techniques.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3504**			
Course Title	**Experimental Aerodynamics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to aerodynamic testing in various speed regimes; requirements of aerodynamic testing; Design aspects of low speed wind tunnels; flow visualization methods; Measurement methods for flow variables. Wind tunnel balances; Elements of computer based instrumentation ; measurements and analyses methods; Model Design, Pressure, Flow, and Shear Stress measurements; Forces and moments from balance measurements, Sources of error in wind tunnel data, scale effects in data usage, general test procedures for aircraft. Introduction to advanced optic based flow diagnostics.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3505**			
Course Title	**Mechanical aspects of Turbo Machinery**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to Mechanical Aspect of Turbo machinery: Engine Configurations, Compressor, Turbine, Combustor, Materials. Mechanical Design of Rotor Components: Compressor Blade, Turbine Blade, Disk, Blade Disk Attachment, Impeller, Bladed Disk. Rotor Systems and Dynamics: Rotor Configurations, Support System,Lubrication, Critical Speed Analysis, Unbalance Response, Balancing. Vibration aspects: Blade Vibration, Disk Vibration, Bladed Disk. Advanced Bearings: Foil Bearings, Active Magnetic Bearings.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3506**			
Course Title	**Propulsion Systems for Light Aero Vehicles**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction & IC engine basic theory: Engine types- Operating cycles of SI and CI Engines - Calculation of performance parameters - Typical Performance curves - Components of the SI and CI engines- Fuel supply system - carburettor, fuel injection - ignition system - Engine cooling and lubrication system - Turbo charging and Super charging - Effects on engine performance - Aero diesel and gasoline engines – Small gas turbines. Fuels: Introduction - Structure of petroleum, Refining process, Products of refining process. Fuels for SI & CI engines: Properties of fuels for S.I. and C.I. Engines - Potential alternative fuels for S.I. and CI Engines and their properties - Alcohols & Gasoline blends - Fuel additives - DEE/DME - Biodiesels - Biodiesel blends with diesel - Dual fuel systems. Fuels for Gas Turbine engines: Specific requirement for Gas turbine engines and standards - Properties of liquid fuels & Gaseous fuels - Fuel handling systems, safety and additives. Hydrogen - Properties - Use in C.I Engines - Use in S.I Engines - Production methods- Storage methods - Safety precautions. IC engine combustion: Combustion Chemistry - Combustion in SI engines- Initiation of combustion - Flame velocities - Normal and abnormal combustion - Combustion chambers - Combustion in CI engines - Vaporization of fuel droplets and spray formation - Air motion - swirl, squish, tumble flow - Diesel knock and engine variables, features and design considerations of combustion chambers. Engine emissions: Introduction, concerns, regulations - Mechanisms of pollution formation - Carbon monoxide, unburned hydrocarbons, oxides of nitrogen and smoke/Particulate emission - Effects of pollutions on environment – Methods of measurement - Methods of controlling emissions for SI, CI and gas turbine engines - Correlations. Wankel rotary engines: Basics - Working principle - Merits and demerits - Comparison with reciprocatingengine - Applications - Engine Design aspects - Geometrical equations, P-V diagram, V-theta diagram, Torque fluctuation - Engine components - Coating requirements - Testing of engines - Airworthiness certification - Aero Wankel engines. Recent trends: Homogenous charge compression ignition (HCCI) - CRDI in CI engines - VVTi - Lean burn engines - Stratified combustion engines - Fuel cell - Use of light weight materials for engine components - Flexible fuel vehicles, Small UAV & MAVs power plants - Introduction - Electric motors with high specific energy batteries - Mini I.C.Engines - Merits and demerits.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3507**			
Course Title	**Experimental techniques in Propulsion**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Introduction: Introduction to Propulsion Systems, High Speed Combustor Test Facility, Combustion and Gas Dynamics, Heat Transfer in Propulsion Systems, Turbo machinery, Mechanical Aspects of propulsion systems Measurement Techniques: Measurement techniques in propulsion systems, The study of temperature, pressure and mass flow measurement, The study of Data acquisition & controls. High Speed Combustor Test Facility: The experimental study of Nitrogen gas command/purging system, The study of Oxygen gas system, The study of Hydrogen gas system, The experimental study of air flow system, The experimental study of kerosene fuel system, The experimental study of high pressure air compressor system, The experimental study of pre-heater01 up to 500 K temperature. Combustion and Gas Dynamics Lab: The study of lean blow out prediction in swirl stabilized combustor, The study of atomization performance prediction of simplex atomizer. Heat Transfer lab: The study of convection heat transfer coefficient measurement: Turbo machinery Lab: The study of wake flow measurement in a linear cascade. Mechanical Aspects of Propulsion Systems: Rotor dynamics analysis of typical geeffot rotor system, The study of advance bearing system.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3508**			
Course Title	**Flight Vehicle Identification – Tools & Techniques**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: Motivation, Measurements, Methods, Models, Validation. Data gathering: Optimal Input Design, Maneuvers, Instrumentation, Calibration. Aircraft Mathematical Modeling: Reference frame, Equations of Motion, Navigation Equations, Aerodynamic Modeling. Estimation and Optimization: Properties of Estimator, State Estimation, Parameter Estimation, Optimization Methods. Regression, Ordinary Least Squares, Generalized Least Squares, Nonlinear Least Squares, Model Structure Determination, Maximum Likelihood Method, Output Error and Equation Error Methods, Kalman Filtering. Model Validation: Statistical Accuracy, Residual Analysis, and Simulation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3509**			
Course Title	**Digital Image Processing and Applications**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Digital image fundamentals, intensity transformations and spatial filtering, frequency domain processing, image enhancement, image restoration, color image processing, morphological image processing, image segmentation, stereo visionand correspondence problem, image registration, image fusion, matlab examples, and case studies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3510**			
Course Title	**Multi Sensor Data Fusion**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Multi sensor data fusion introduction, algorithms for data fusion, Multi sensor estimation, Decentralized data fusion, Multi sensor multi target tracking, Fundamentals of image processing, Image registration, Image fusion, Flight vision, Matlab examples and case studies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3511**			
Course Title	**INS/GPS Multi-sensor Kalman Filter for Navigation**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Inertial sensing principles and technology, Simple low cost INS implementations, Inertial mechanization / Error models, GPS principles, signals, receivers, Simple multi-sensor Kalman Filter, Error modeling applications, INS/ GPS multi-sensor integration.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3512**			
Course Title	**Vision based Guidance and Control**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: Background, requirements and issues, human vision. Image formation: geometry and photometry: Geometry, brightness, quantization, camera calibration, photometry (brightness and color). Image segmentation: Region segmentation, Edge and line finding. Multi-view Geometry: Shape from stereo and motion, feature matching, surface fitting, Active ranging. Image classification: Pixel classifications, region classification, face detection and identification. Object Recognition: Alignment methods, Shape descriptions. Motion Analysis: Motion detection and tracking, Inference of human activity from image sequences. Applications survey, Review: Industrial, navigation, mapping, multimedia. Course Intro and Demos of Working Computer and Robot Vision Systems, World 2D: Representing and Manipulating Points, Lines And Conics Using Homogeneous Coordinates. World 2D: Projective Transformations and Transformation Groups. Characterization of Distortions Caused by Projective Imaging and the Principle of Point/Line Duality, Estimating a Plane-to-Plane Homography with Angle-to-Angle and Point-to-Point Correspondences, World 3D: Representing Points, Planes, and Lines. World 3D: Quadrics, Transformation Groups, and the Absolute Conic. Visual Perception and Edge Detection (Sobel, LoG, Canny), Extracting Interest Points and Their Descriptors (with Harris, SIFT, and SURF) in Image Pairs and Establishing Point-to-Point Correspondences Between the Images. Estimating Homographies with Linear Least-Squares Minimization, Robust Homography Estimation with the RANSAC Algorithm, Refining Homographies with Nonlinear Least-Squares Minimization (Gradient-Descent, Levenberg-Marquardt, and DogLeg), Image Segmentation. Binary Image Processing Algorithms, Measuring Texture and Color, Camera Models: The Pinhole Model. Camera Models: The Finite Projective and the General Projective Cameras. Image of the Absolute Conic (orHow to Make a Camera Figure Out Its Internal Parameters from a Couple of Images). Camera Calibration (Zhang's Algorithm), Extracting Features by Bin Counting in Parameter Space -- The Hough Transform. Epipolar Geometry and the Fundamental Matrix, PCA for Dimensionality Reduction and Data Decorrelation, LDA (Linear Discriminant Analysis) for Image Recognition, Face Recognition Studies with PCA, LDA, etc., and Nearest-Neighbor Classification, Automatically Learning the Most Discriminating Features through Class Entropy Minimization, Image Segmentation using Graph Partitioning Algorithms.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3513**			
Course Title	**Advanced Experimental Techniques in Materials Science**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Metallographic techniques: Resolution, depth of focus, polarized light, phase contrast, interference microscopy, quantitative metallographic techniques and Image Analysis. X-ray diffraction techniques: Bragg's law, Diffraction methods, Stereographic projection. Cameras- Laue,Debye-Scherer cameras, Seeman- Bohlin focusingcameras, GIXRD. Application of xray diffraction: Indexing space group identification, intensity calculation, lattice parameter measurement, stress analysis, phase analysis. Electron microscopy: Construction and operation of electron microscope –specimen preparation techniques. Image formation methods in scanning electron microscope, composition analysis, EDX, WDX. Basics of TEM and STEM. Scanning probe microscopes: Scanning Tunneling Microscope, Atomic Force Microscope etc. Advanced chemical and thermal analysis: Basic principles, practice and applications of surface analytical techniques such as X-ray spectrometry, XPS, AES, SIMS, Thermal analysis methods – DTA, DSC, TGA. Nanomechanical characterization: Dynamic Indentation Technqiues, NHT, Tribology at Nanoscale, Nanotribology and Nanoscratch Testing. Spectroscopic techniques: IR, FTIR and Raman spectroscopies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3514**			
Course Title	**Materials for Energy Conversion**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Fundamental of electrochemical energy conversion – Thermo dynamical and kinetic aspects– Relevance in aerospace applications- Principles of Batteries and Fuel cell operations – Types of batteries and fuel cells - Components of batteries and fuel cells and their material aspects - Experimental techniques. Introduction to solar radiation and heat transfer, various types of solar collectors, solar water heating, solar cooling, solar industrial process heat and types of solar thermal power systems, photovoltaics, Hydrogen energy - production and storage.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3515**			
Course Title	**Nano-Dimensional Magnetic Thin Films**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Introduction: Magnetism, Magnetostatics, Magnetism of electron, Ferromagnetism, Antiferromagnetism and other ferromagnetic order, Micromagnetism, domain and hysteresis, Nanoscale magnetism, Experimental methods, Application of soft magnetic materials and its application, hard magnetic materials and it's applications, Spin electronics, Magnetic sensor, Principle of magnetic sensing, Signal and noise, Different type of magnetic sensor, field mapping, Applications of magnetic sensors.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3516**			
Course Title	**Computational Structural Dynamics and Aeroelasticity**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Variational Principles, Hamilton's Least Action Principle, Lagrange's equations; Vibration of multi-degree of freedom systems; Finite element formulation for elasto-dynamics of continuous systems; bar, beam and plates; Normal mode expansions and direct integration; Static/dynamic condensation and sub-structuring techniques; Torsion and bending of an aircraft wing; Static aeroelasticity and divergence of a wing; Dynamic aeroelasticity and bending-torsion flutter of a wing; Dynamic response of a wing to gust and atmospheric turbulence; Introduction to system identification based flutter prediction; Concepts of nonlinear vibrations.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3517**			
Course Title	**Computational Nonlinear Structural Mechanics and Vulnerability**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Review of linear FEM. FEM for one one-dimensional plasticity: Perfect plasticity, Isotropic and Kinematic strain hardening, finite element formulation, Newton-Raphson solution technique, one-dimensional viscoplasticity, integration algorithms. Continuum theory of plasticity: Yield condition, Flow and hardening rules, loading and unloading conditions, stability, convexity and normality, J2 plasticity /viscoplasticity. FEM for two-dimensional and three-dimensional plasticity: Rate independent plasticity, Explicit and Implicit techniques, Return methods for J2 plasticity, finite element formulation, NR technique. FEM for large deformation elasticity: Continuum Mechanics - Description of motion of body, deformation gradient, Green-Lagrange strain, Rate of deformation, principal stresses, polar decomposition, Cauchy stress and P-K stresses, balance of mass and momentum, Principal of objectivity, Constitutive equation for hyper elasticity, New Hookerion elastic model, finite element formulation for finite strain elasticity, Total Lagrangian and updated lagrangian. Introduction to nonlinear FEM for structural dynamics, Nonlinear FEM for composites, Concepts of structural damage and vulnerability.

Faculty	ENGINEERING SCIENCES			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3518**			
Course Title	**Computational Stochastic Structural Mechanics and Reliability**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Introduction to probability, random variables, different probability distributions; Random process theory, stationarity, ergodicity, non-stationarity, power spectral density; Random field theory, homogeneity, non-homogeneity; Vibration of S.D.O.F. system under random inputs; Input output relation, Extension to M.D.O.F. system; Failure of randomly vibrating systems; Formulation of reliability for structural problems; Exact solution methods – first order and second order reliability methods, transformations; Simulation methods – Direct Monte Carlo and Importance sampling methods; Systemreliability methods; Introduction to Reliability based design concepts; Concepts of stochastic finite element methods.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3519**			
Course Title	**Applied Aeroelasticity**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Aerodynamic-structural coupling, static aeroelasticity (divergence, control reversal etc), dynamic aeroelasticity (Flutter, Buffet, Gust), flexible loads, introduction to numerical and experimental techniques in Aeroelasticity. Aerodynamic theories (subsonic/supersonic), basics in active controls, aeroservoelasticity (modeling, analysis) & its applications: active flutter control technique, gust load alleviation etc.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3520**			
Course Title	**Smart Materials and Structures**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to smart materials, constitutive modelling, smart & adaptive structures concepts, numerical & experimental methods for adaptive structures (sensing, actuation, monitoring), active-passive vibration controls, shape control ofstructures, optimal placement techniques for sensor & actuators.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3521**			
Course Title	**Vibration Control Techniques for Aerospace Structures**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to vibration, sources of vibration, passive vibration control approaches, modelling different vibratory loads & structural system, system identification techniques, introduction to active control system, feedforward & feedback controls, modelling of different actuators and sensors, control system design and analysis, experimental techniques in vibration control.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3522**			
Course Title	**Finite Element Methods for Aircraft Structures**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to thin walled structures, Isotropic &composite materials, beam, plate & shell theories, R-R method and displacement based FE procedure, novelty in FE coding, numerical experimentation with FE analysis, static & dynamic solutions using numerical approaches.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3523**			
Course Title	**Fatigue and Fracture Mechanics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to fatigue of materials; Mechanisms of fatigue failures; HCF and LCF; Fatigue design concepts; Fatigue testing; S-N curves, factors influencing S-N behavior; Strain-life approach; cyclic stress-strain behavior; Fatigue life estimation under block and spectrum loads. LEFM concepts; crack tip plastic zone; FCGR;crack growth life estimation; statistical aspects of fatigue; variable amplitude fatigue; load sequence effects. Introduction to SIF, SERR, J-integral values, Irwin's theory, 2D and 3D VCCI and MVCCI methods, MVCCI method, methods of crack growth analysis in metals/composites using FEA.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3524**			
Course Title	**Mechanical Design and CAD/CAM**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Fundamentals - Introduction to Design: Design, Design Process, Problem Formulation, Factor of Safety and Design codes. Load analysis: Equilibrium equations, Free-Body diagrams, Load analysis case studies. Materials and Processes: Material-property definitions, stress-strain relationships, Heat treatment, coatings and surface treatment, material selection. Stress, strain and deflection: Principal stresses, strains, Mohr's circle, types of stresses, stress concentration, combined stresses, thick and thin cylinders, columns, case studies. Static failure theories: Selection and use of failure theories, factors in the selection of safety factor, General guidelines for adopting factor of safety. Applications - Introduction to the Design of Material handling equipments winches, wire ropes, shackles, hoists, tackles etc, IS standards. Basics of Mechanical Design, Design of Gears & Power Screws, Design of Keys and Shafts, Design of Springs, Brakes, Coupling and Clutches, Design of Flexible Mechanical Elements (Belts & Chains), Selection of the Rolling Bearings & Sealing Elements, fasteners & Joints. Case studies, Geometric Dimensioning and tolerance practices, standards etc. CAD/CAM - Introduction to CAD, Solid Modeling, Feature Modeling, Parametric Modeling, Boundary Representation and Constructive Solid Geometry, Transformations and Projections, Computer Aided Manufacturing.

Faculty	ENGINEERING SCIENCES			
Lab Name	CSIR-NAL, BANGALORE			
Course Nomenclature	ENG-NAL-3-3525			
Course Title	Mechanical Systems Design and Aircraft Systems			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: Review of fundamentals of kinematics-Mobility analysis -Formation of one D.O.F. multiloop kinematics chains, Network formula - Gross motion concepts. Kinematic Analysis: Position analysis -Vectorloop equations for four bar, slider crank, inverted slider crank - Geared five bar and six bar linkages. Analytical method for velociy and acceleration analysis - Four bar linkage jerk analysis - Plane complex mechanism. Path Curvature Theory: Fixed and Moving centrodes, inflection points and inflection circle. Euler Savary equation, Graphical constructions - Cubic of stationary curvature. Synthesis Of Mechanisms: Type synthesis - Number sythesis - Assosiated linkage concept. Dimensional systhesis - Function generation , path generation, motion generation. Graphical methods. Cognate linkage - Coupler curve synthesis, design of six bar mechanisms .Algebraic methods. Application of instant centre in linkage design. Cam mechanism - Determination of optimum size of Cams. Dynamics Of Mechanisms: Static forceanalysis with friction - Inertia force analysis - combined static and inertia force analysis. Shaking force, Kinetostactic analysis. Introduction to force and moment balancing of linkages. Spatial Mechanism And Robotics: Kinematic analysis of spatial RSSR mechanism - Denavit - Hartenberg parameters. Forward and inverse Kinematics of robotic manipulators. Aircraft Systems: Hydraulics Systems, Hydraulics (Theory and application), a) Pumps - Different types of pumps, Pump characteristics & Theory, Aerospace applications b) Valves- Different kinds of valves, flow and pressure loss calculations,Flow through pipes, Control systems , c) Landing Gear system- Architecture, subsystems, Load calculationsd) Fuel system- Architecture,design etc. e) Thermal Systems Thermal engineering (Theory) Thermodynamic principles, Refrigeration and air conditioning, Heat exchangers, Compressors & Turbines, Environmental control system-Architecture , subsystems , Load calculations d) Simulation methods applied to Systems using Bond Graph techniques etc

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3526**			
Course Title	**Optimization Techniques in Engineering Design**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to Optimization, Classical Optimization Techniques, Unconstrained Optimization, Constrained Optimization, Linear Programming, Multi-objective Optimization, Finite Element Based Optimization, Structural Design Optimization, Introduction to Multidisciplinary Design Optimization, Evolutionary Optimization and Optimization of Composites.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3527**			
Course Title	**Impact and Crashworthiness**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Classification of Impact, High velocity and low velocity impacts, Stereo-mechanical Impact, Central Impact, Rotational Impact and Eccentric impact. Vibration aspects, Wave transmission in Elastic solids, Impact of two rods,Impact of rigid mass on a rod, Transverse impact of a mass on a beam. Contact phenomena, Forces and deformations at the contact point, the hertz law of contact, other contact deformation relations, examples. Soft body impact at high velocities, shock waves, bird hit, hail impact. Energy absorption concepts, airbags, foams, gelatine, Crashworthiness of vehicles, Calculation of energy absorbed during low velocity impact. Experimental aspects ofimpact, measurement of accelerations, velocities of impact, low velocity, high velocity impact, high speed photography. Computational methods for impact analysis, explicitanalysis, examples.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3528**			
Course Title	**Finite Element Methods for Composites**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to finite element methods: Discussion on mathematical modeling, weighted integral and weighted residual methods, Rayleigh-Ritz methods, principle of minimum potential energy, weak formulation, FE solutions of one and two dimensional problems, convergence analysis. Mechanics of composite laminates: Introduction to composites, micromechanical analysis of composites, homogenization theory, macromechanical analysis of lamina, properties of laminates and their constitutive equations, classical laminate and shear deformation theories, interlaminar stresses, failure theories, environmental effects. Finite element modeling and analysis of composites:One dimensional modeling of laminated beams and plate strips by CLPT and Timoshenko beam theory, two dimensional modeling of laminated plates using CLPT, FSDT and HSDT, layerwise theories, 3D modeling of laminated plates, cutout in composites, statics, free-vibration and buckling analysis, first ply and progressive failure analysis, modeling of delamination, intra-ply and inter-ply damage, nonlinear and post-buckling response analysis.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3529**			
Course Title	**Digital Signal Processing and Applications**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Introduction to Signals and signal processing: Characterization and classification of signals, signal processing operations and applications. Fundamentals of Discrete time systems: Introduction, Basic Definitions, Important discrete-time signals, Discrete-Time systems,Sampling of continuous time signals, Digital filter with A/D and D/A, MATLAB Exercises. Transform –domain representation of Signals: Discrete-Time Fourier Transform, Discre Fourier Transform (DFT) and its properties, Computation of the DFT of real sequences, inverse DFT, The z-Transform, MATLAB Exercises. The Fast Fourier Transform and its applications: Introduction, Computation of FFT, Convolution of two sequences using DFT, MATLAB Exercises. Analog filter Design: Introduction, Filter types and Transformations, Implementation of second order Filters, Component requirements, Filter approximations, Filter design procedures and design examples, MATLAB Exercies. Digital Filter Design: Introduction, Filter specifications, Magnitude and phase response of Digital Filters, Filter Design considerations and Realization, MATLAB Exercises. Time-Frequency Analysis: Theoretical background, Fourier transforms short comings, interpretations difficulties, Spectrogram, Time-scale analysis, Wigner-Ville distribution, MATLAB Exercises. Digital signal processing Applications: Vibration data processing, System Fault diagnosis and Health monitoring, Case study using MATLAB simulation exercises.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3530**			
Course Title	**Manufacturing Techniques for Composites**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Introduction to course/Why Composites, Health and Safety Issues, Glass / Carbon / Organic Reinforcements /Thermoset / Thermoplastic matrices,Ceramic / Metal matrix Composites, Hand layup/Wet Layup / Spray up/Vacuum Bagging, Prepreg and Autoclave moulding, Tool Design & Manufacturing, Matched die / Compression molding / SMC, Pultrusion / Filament winding, Cocuring and Integral Construction, Sandwich composites, Liquid Composite Molding, Joining Composites, Thermoplastic processing techniques, Machining of Composites, Repair of Composites, Recycling, Quality inspection / Testing, Natural Fiber Composites.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3531**			
Course Title	**Repair Technology for Aircraft Structures using Composites**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Introduction to aircraft materials, classification of metallic materials, basic material structures and properties, mechanical behaviour of materials and manufacturing process, Introduction to composite materials and their processing, Mechanical testing of composites. Adhesively Bonded Joints & Mechanically Fastened Joints. General Engineering Applications of FRP composites. Introduction to repair; Repair philosophy, Repair sequence, repair criteria, sources of damages, Types of damages, Damage assessment. Classification of repair, Design of repair joints, Design of damage tolerant repair joints, Selection of repair joints, Repair procedures, Repair schemes for damaged composite aircraft parts. Why composites for repair of aged metallic structures, crack patching, repair qualification and certification procedures.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3532**			
Course Title	**Experimental Techniques for Composites**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Introduction to composites, Manufacturing processesfor polymer matrix composites, Micro and Macro mechanics, Classical laminate theory, Introduction to Fracture Mechanics, types of damages in composites and damage propogation. Fundamental Strain Gage Technology, Strain Gages on Composites, Normal-Stress and ShearStress Gages and Rosettes, Strain Gage Reinforcement Effects on Low-Modulus Materials. Experimental characterization of composites, Mechanics of materials approach to stiffness Determination of E1, E2, v12 etc, Mechanical Test Fixtures. Instrumentation Practices for Tension & Shear Testing of Composite Materials, Creep and fatigue testing of Composites. Non destructive testing of composites- Ultrasonics, Acoustic Emission, X-ray, Infra red thermography. Advances in composites testing- Digital image correlation system, laser Doppler vibrometerVibrothermography, laser ultrasonics, Embedded Fiber Optic Strain Sensors for damage detection.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3533**			
Course Title	**Non-Destructive Testing and Evaluation**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Introduction to NDT : Explain : Selection of NDT methods. Visual Inspection (Optical method), Liquid Penetration Inspection, its advantages and limitations. Magnetic Particle Inspection : Methods of generating magnetic field, types of magnetic particle and suspension liquids.Eddy Current Inspection : Principle, operation variable, procedure, inspection coils. Microwave Inspection : Microwave holography. Ultrasonic Inspection : Basic equipment characteristic of ultrasonic waves, variables inspection, inspection methods pulse echo A,B,C scans transmission. Radiography Inspection: Principles, radiation source – Rays and gamma rays – rays tubes, radio graphic films, scenes and filters, image intensifiers, Industrial Computer Tomography. Optical Holography: Basic of holography, recording and Acoustical Holography : system and techniques applications. Advanced Techniques: Acoustic Emission, Laser ultrasonics, Acousto ultrasonic, infrared thermography.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3534**			
Course Title	**Introduction to Continuum mechanics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Vectors and tensors: Introduction, Vectors: vector addition and scalar components. Indicial notations, finite roations. Scalar products, vector products. Change of orthogonal basis. Tensors: Rectangular Cartesian tensor components, tensor properties. Vector and tensor calculus: gradient, divergence and curl. Stress: body forces, surface forces, traction vectors, stress components. Principle axes, principle stressand invariants. Strain and deformation: small strains and rotations in two and three dimensions, kinematics of a continuous medium, rate of deformation tensor, spin tensor. Finite strain and deformation, Eulerian and Lagrangian formulation, rotation and stretch tensors. Compatability conditions. Basic principles: Integral transformation, conservation equations (mass, engergy, angular momentum and linear momentum). Entropy and the second law of thermodynamics, clausius Duhem inquality. Engergy potentials. Constitutive relations: Introduction to ideal materials, classical elasticity, visoelastic behavior, introduction to plasticity.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-3-3535**			
Course Title	**Textile Reinforcements for Composites**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Introduction to textile structures, weaves, knits and braids, Introduction to basic weaves and weaving machinery, yarn and fabric mechanics, woven cloth construction and design, glass and carbon weaving, 3D preforming technologies such as stitching, tufting, multilayer weaving, orthogonal weaving and 3D weaving, woven fabric geometry, weaving calculations, testing and evaluation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-4-0001**			
Course Title	**Project Proposal**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Formulation of a project proposal by selecting topics of high relevance and novelty and will have state-of-the art review, methodologies, recommendations etc. in specified format in a holistic manner preferably candidate's own research work suitable for submission to appropriate funding agencies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-4-0002**			
Course Title	**Review Article**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Preparation of one review article on specific research area of the student.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NAL, BANGALORE**			
Course Nomenclature	**ENG-NAL-4-0003**			
Course Title	**CSIR-800 Project**			
Credit Distribution (L-T-P-C)	0	0	8	**4**

Course Content:

The students have to undertake a project in rural area for 6-8 weeks in line with CSIR-800 programme which is primarily prepared at empowering 800 million Indians by way of S & T inventions. The theme for the project may be chosen from CSIR-800 document and as per expertise available at individual laboratory. Students will choose the topics in consultation with Doctoral Advisory Committee (DAC).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-1-3701**			
Course Title	**Research Methodology**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

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Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-1-3702**			
Course Title	**Numerical Methods and Programming**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Course Objective To understand the algorithms involved in the numerical methods used for computer simulation, have the ability to choose an appropriate algorithm and be aware of the advantages and pitfalls expected in a particular algorithm. Computer implementation of algorithms and use of Matlab or other subroutines. Modules · Introduction to Programming, linux, introduction to Matlab/Scilab/Octave · Matrix operations · Function approximations, solutions of system of nonlinear equations · Numerical methods for ODEs · Finite-difference/volume methods for PDE · Optimization approaches

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-1-3703**			
Course Title	**Mathematical fundamentals**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Course Objective To review mathematical fundamentals, teach common mathematics prerequisites of other courses, and to impart perspective on modeling and simulation. Modules · Analysis basics · Linear Algebra · Ordinary and partial differential equations · Optimisation

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-2-3701 to 2-3704**			
Course Title	**Lab courses**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Course Objective Training in planning, executing, analyzing and reporting results from an experimental study in several disciplines, ranging from introductory experiments to advanced training in use of sophisticated equipment.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-2-3705**			
Course Title	**Reaction and ReactorEngineering**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Course Objective To develop the understanding of the reactions from molecular scale to the reactor scale, and to equip the student to model different reactor configurations and non-idealities in reactor systems. Modules · Chemical kinetics · Homogeneous reactor analysis and design · Heterogeneous reactor analysis and design · Special reactors

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-2-3706**			
Course Title	**Transport phenomena**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Course Objective To develop a good physical understanding of the processes of momentum, heat and mass transfer at the continuum level; to develop the mathematical tools to solve problems in transport phenomena Modules · Linear algebra and calculus relevant to transport phenomena · Conservation equations · Examples in transport phenomena

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-2-3707**			
Course Title	**Thermodynamics and Statistical Mechanics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Course Objective To develop the understanding of thermodynamics principles as applicable to chemical systems. Modules · Classical Thermodynamics, ideal gases · Solution thermodynamics · Equilibrium thermodynamics · Non-equilibrium thermodynamics · Ensemble methods

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-2-3708**			
Course Title	**Advanced Mathematics**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Objective A very detailed study of specialized topics not covered in textbooks. The syllabus may cater to a discussion of most recent research papers and projects based on the published work

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-2-3709**			
Course Title	**Advanced Numerical Methods**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Objective An in-depth study of very advanced numerical techniques not covered in textbooks and not taught at the graduate level course. Envisaged as a discussion of recent papers on the newer techniques being implemented for very complicated problems.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-2-3710**			
Course Title	**Seminar Participation**			
Credit Distribution (L-T-P-C)	0	1	0	**1**

Course Content:

Course Objective Provide exposure to current research and societal activities through talks by eminent scientists and other speakers. Students will be required to attend approximately 10 talks every semester.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-2-3711**			
Course Title	**Seminar Participation**			
Credit Distribution (L-T-P-C)	0	1	0	**1**

Course Content:

Course Objective Provide exposure to current research and societal activities through talks by eminent scientists and other speakers. Students will be required to attend approximately 10 talks every semester.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-2-3712**			
Course Title	**Seminar Participation**			
Credit Distribution (L-T-P-C)	0	1	0	**1**

Course Content:

Course Objective Provide exposure to current research and societal activities through talks by eminent scientists and other speakers. Students will be required to attend approximately 10 talks every semester.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-2-3713**			
Course Title	**Seminar Participation**			
Credit Distribution (L-T-P-C)	0	1	0	**1**

Course Content:

Course Objective Provide exposure to current research and societal activities through talks by eminent scientists and other speakers. Students will be required to attend approximately 10 talks every semester.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-2-3714**			
Course Title	**Symposium participation**			
Credit Distribution (L-T-P-C)	0	0	2	**1**

Course Content:

Course Objective Provide exposure to current topics through scientific talks and poster session, and an opportunity to showcase research ability and results to potential employers. Students are expected to present posters and interact with participants from industry and academia.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-2-3715**			
Course Title	**Statistical Analysis**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Course Objective To ensure students develop competence in statistical analysis required for their research. Modules • Basics: Introduction to probability, Bayesian probability, distributions • Inferential statistics: tests of hypotheses, analysis of varia

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-2-3716**			
Course Title	**Fundamentals of Biology**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Course Objective To review biology fundamentals, provide an introduction to students with a non-biology background. Course will focus on core concepts and a quantitative view of biology. Modules • Biomolecules/biochemistry: DNA and RNA composition, struct

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3701**			
Course Title	**Advanced topics in materials and processes**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Objective An in-depth study of specific topics well beyond material available in textbooks. As appropriate, it may include specialized training on high -end equipment that is not normally part of a MTech level lab course.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3702**			
Course Title	**Advanced topics in chemical engineering**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Objective An in-depth study of specific topics well beyond material available in textbooks. Envisaged as a discussion of recent papers and projects on areas extending the currently published work.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3703**			
Course Title	**Multiscale simulations in materials**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Course Objective To be familiar with simulations at the molecular and sub-molecular scale, including quantum chemistry based and classical mechanics based methods. Modules · Introduction to molecular modeling · Quantum-chemistry driven modeling · Classical mechanics based modeling · Example problems at multiple scales

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3704**			
Course Title	**Industrial flow modeling**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Course Objective To teach students the basic equations of fluid dynamics and computational methods to solve these equations as applied to flows in industrial processes. At t he conclusion of the course students will be able to analyze complex flow situations, develop a simple model for complex flow and solve it numerically, and simulate the actual complex flow using available CFD software. Modules · Introduction to CFD · Solution techniques for solving CFD equations · Introduction to CFD Software · Turbulence modeling · Multiphase flows

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3705**			
Course Title	**Data driven modeling**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Objective The course will emphasize the conceptual understanding of methods along with their implementation in real world scenarios. At the end of the course, the student is expected to be able to identify and implement appropriate conventional, machine learning or AI based methods for linear/non linear data fitting, data reduction, and classification. Modules · Statistics basics · Supervised learning · Unsupervised learning · Artificial intelligence based methods · Model validation · Practical applications in data reduction, feature selection, classification

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3706**			
Course Title	**Non-linear dynamics**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Objective Introduce methodologies for analyzing complex nonlinear behavior with examples from reaction engineering, chemical, and physical systems. Students will learn (1) how nonlinear systems differ from linear systems regarding their dynamical properties; (2) how to analyze the stability of complex systems ; (3) how sensitivity of system dynamics is related to predictability and control; (4) to explore dynamical systems analytically and with computer simulations Modules · Introduction to the dynamics of nonlinear systems · Preliminary analysis of time-series data: · Toy "Nonlinear models" and the role of parameters · Stability of solutions to ODEs · Properties of chaos: · Self organizing properties of nonlinear systems · Phase space analysis

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3707**			
Course Title	**Modeling of biological systems**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Course Objective Provide a brief background of biological systems for model development. Bioreactor design and analysis. Metabolic network modeling using constraint based approaches and signaling pathway modeling using deterministic and stochastic modeling techniques. Modules · Biological fundamentals · Bioreactor models · Metabolic pathways · Signaling pathways · Pharmacokinetics and pharmacodynamics

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3708**			
Course Title	**Advanced separation processes**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Objective Provide understanding of the principles underlying various separation processes. Modules · Mass transfer and thermodynamics applications to separations · Unit operations in separation: adsorption, distillation etc · Fundamentals of separation equipment design

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3709**			
Course Title	**Envirinmental Pollution Control**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Course Objective Industrial Pollution Control course is devised to understand the pollution scenario in chemical and allied industries that include both Air and Water Pollution. It details various technologies that are used for pollution control and include- Absorption, Adsorption, Ion Exchange, Coagulation, Extraction, Membrane separations, Biological methods of treatmentaerobic and anaerobic, advanced oxidation processes and cavitation, in isolation and or process integration. Devising pollution control strategy has been discussed with the help of real life examples in air pollution and industrial waste water treatment. Modules Pollution abatement systems for particulates and gases Industrial waste water treatment processes Biological methods for waste water treatment Water recycle and reuse Solid waste and hazardous waste management 73

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3710**			
Course Title	**Statistical Analysis**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Objective The intended audience is the graduate student needing competence in statistical analysis for their research. Prior knowledge of statistics is not required. Course will cover methods for describing sets of data, random variables, sampling distributions, tests of hypotheses, non-parametric statistics, analysis of variance, and an introduction to concepts of supervised and non-supervised learning

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3711**			
Course Title	**Advanced Algorithms**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Course Objective The aim is to introduce students to the theory behind computing. This should help them in two ways: (1) design better code and (2) identify which computational problems in their research provably can or cannot be solved e ciently. Modules Asymptotic notation, recurrences Sorting, divide and conquer Elementary data structures Dynamics programming and greedy algorithms NP completeness

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3712**			
Course Title	**Advanced Reaction Engineering**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Objective A very detailed study of material not covered in textbooks and well beyond that taught at the M.Tech. level. The course can focus on design concepts of industry problems handling complicated reactor designs for wider range of reactions.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3713**			
Course Title	**Advanced Transport Phenomena**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Objective An in-depth study of very advanced research based topics not available in textbooks and well beyond that covered in M.Tech.level course. It may include specialized training on high-end equipment like rheometers etc

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3714**			
Course Title	**Advanced Thermodynamics**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Objective Focused study of material not covered in most textbooks. Can include discussions of recent papers focusing on various aspects accompanied by small projects based on the published papers.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3715**			
Course Title	**Advance Topics in Bioengineering**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Objectives This course is designed to focus on the advanced computational and mathematical concepts in bioengineering. The course material will include discussion about topics not available in standard textbooks and well beyond that covered in M.Tech. level course.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3716**			
Course Title	**Pharmokinetics for Chemical Engineers**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Objectives This course will introduce chemical engineering students basic pharmacokinetic and pharmacodynamic concepts and models and illustrates the use of these concepts in the drug discovery and formulation process. Further, through practical examples, it will help students to understand the connection between drug formulation and pharmacokinetic.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3717**			
Course Title	**Modelling of Drug Formulation Process**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

A typical process to produce drug dosage forms has many complex steps which includes mixing and transport of powders and slurries, granulation/enlargement of powders, particle size reductions, spray drying, tablet lm coating, melt spray congeal process, among many others. In order to achieve nal quality attributes, it is critical to understand the basic chemical engineering principles which drives these processes. This course will introduce the basics of drug formulation processes and simple mathematical model used for design and scale-up.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3718**			
Course Title	**Critical survey**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Course Objective State-of-the art review, methodologies, recommendations etc. for topic related to thesis research.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3719**			
Course Title	**Kinetics of Biological Reactions and Reactors**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Objective To introduce students to reaction engineering as applied to biology: phenomenological and other rate laws, and bioreactor modelling and analysis Modules • Kinetics of enzymatic reactions: chemical kinetics, enzymes, enzyme kinetics, non-

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3720**			
Course Title	**Systems Biology**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Course Objective To introduce the concept of systems approach applied to biological systems. The course will allow understanding of how components in the cell interact and build networks that eventually lead to living organisms. This would open the way fo

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3721**			
Course Title	**Epidemiology and Ecology**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Course Objective To provide understanding of large scale biological systems: epidemiology and ecology. The course will introduce different modeling methods and simulation techniques used to study ecosystems and spread of infectious diseases in populations

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3722**			
Course Title	**Chemoinformatics**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Objective To help students understand the fundamentals of chemoinformatics , appreciate complementary aspects of chemoinformatics for design of bioactive molecules and materials, understand the chemical reactivity at atomic level (Industry and biol

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3723**			
Course Title	**Computational Functional Genomics**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Objective   To introduce students to current problems in functional genomics and present them with   computational tools and methods to solve them.   Modules   • Genome sequencing: assembly and annotation   • Algorithms for sequence alignment   • Probabilistic

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3724**			
Course Title	**Biochemistry and Structural biology: Computational Techniques Techniques**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course objective To introduce students to the computational aspects of modern molecular biology. The course aims to explain the molecular basis of cellular processes, thus acting as a bridge to fill the gap between systemic and reductionist approaches emp

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3725**			
Course Title	**Biochemistry and Structural Biology: Biomolecular Dynamics**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Objective   Introducing the concepts of biomolecular dynamics and computational approaches to elucidate   structural transitions and dynamics.   Modules   • Molecular dynamics   o Basics of molecular dynamics: time scales, equations of motion, introduction t

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3726**			
Course Title	**Independent Study**			
Credit Distribution (L-T-P-C)	4	0	0	**4**

Course Content:

A semester-long research project (~130 hours work). Projects will be offered by scientists and students can choose topics/problems.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-3-3727**			
Course Title	**Systems Pharmacology**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Objective To introduce students to the mathematical modeling of drug delivery, distribution and action Modules • Drug delivery modes and models • Basic pharmacokinetics – compartment models • Physiology-based pharmacokinetics • Systems pharmacology

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-4-0001**			
Course Title	**Project Proposal**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Formulation of a project proposal by selecting topics of high relevance and novelty and will have state-of-the art review, methodologies, recommendations etc. in specified format in a holistic manner preferably candidate's own research work suitable for submission to appropriate funding agencies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-4-0002**			
Course Title	**Review Article**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Preparation of one review article on specific research area of the student.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NCL, PUNE**			
Course Nomenclature	**ENG-NCL-4-0003**			
Course Title	**CSIR-800 Project**			
Credit Distribution (L-T-P-C)	0	0	8	**4**

Course Content:

The students have to undertake a project in rural area for 6-8 weeks in line with CSIR-800 programme which is primarily prepared at empowering 800 million Indians by way of S & T inventions. The theme for the project may be chosen from CSIR-800 document and as per expertise available at individual laboratory. Students will choose the topics in consultation with Doctoral Advisory Committee (DAC).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**PHY/ENG-CSIO-1-0001**			
Course Title	**Research Methodology**			
Credit Distribution (L-T-P-C)	1	1	0	**2**

Course Content:

Introduction to Research: Importance, study of literature, defining research problem, hypothesis formulation, experimental design Data Collection and Measurement: Methods and techniques, probability and probability distributions, sampling and sampling designs Data Analysis: Testing of hypothesis, statistical tests and analysis, data interpretation, multivariate analysis, model building, forecasting methods Report writing and Presentation: Ethics in research, Plagiarism, substance of reports, formats, referencing, oral presentation skills General practices followed in Research – literature and data management, Safety practices in the laboratory, Intellectual property rights (IPR)

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**ENG-CSIO-1-2402**			
Course Title	**Mathematics for Engineers and Scientists**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Ordinary Differential Equations (ODEs): First order & Second order; Partial Differential Equations (PDEs); Fourier Transform: Discrete and Fast Fourier Transforms; Numeric Analysis: Solution of Equations by Iteration, Numeric Integration and Differentiation, Basic Concepts of Optimisation. Unconstrained Optimization: Method of Steepest Descent, Linear Programming, Simplex Method. Determinants and Matrices, Probability, Bayes Theorem, Random variables, Continuous and discrete distribution function, Probability distribution function, Binomial Distribution, Poisson distribution

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**ENG-CSIO-1-2403**			
Course Title	**Circuit Theory and Electronic Devices**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Electric circuits and components: Introduction, basic electrical elements – resistor, capacitor, inductor, Kirchhoff's laws, voltage and current sources and meters, network theorems, AC/DC circuit analysis, transformer, impedance matching, grounding and electrical interference. Semiconductor electronics: Junction diode, Zener diode, analysis of diode circuit, three terminal devices - BJT, JFET, MOSFET, photo devices - photo diodes, photo transistors, LED, LCD, opto-isolator and opto-couplers, amplifiers: BJT, FET amplifier, single stage, multistage power amplifiers – class A, B, C and D amplifiers. Introduction, differential amplifiers, OPAMPs: specifications, characteristics and applications, practical OPAMP, interpretation of data sheets of an OPAMP, active filters and oscillators. Number system and code conversion, logic gates, Boolean algebra, combinational logic circuits, sequential logic circuits-latch, RS, JK, T, D flip flops, shift registers, counters, digital building blocks: decoder, encoder, MUX, DMUX, A/D, D/A converters, memories, programmable logic devices, microprocessors, microcontrollers, display devices. Four terminal devices: SCR, DIAC, TRIAC, construction, rating characteristics and applications of SCR, DIAC, TRIAC, IGBT

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**ENG-CSIO-1-2404**			
Course Title	**Material Science and Engineering**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

INTRODUCTION: Materials Science and Engineering, Classification of Engineering Materials, Levels of Structure, Structure-Property Relationships in Materials, Geometry of Crystals, The 90 Space Lattices, Crystal Structures, Crystallographic Directions, Crystallographic Planes, Linear and Planar Densities, Structure Determination by X-Ray Diffraction, The Bragg law of X ray Diffraction, The power method, Imperfections in Solids, Mechanical Properties of Metals. PHASE DIAGRAMS: The phase rule, single-component systems, Binary phase diagrams, Microstructural changes during cooling, The Lever rule, The Iron–Iron Carbide (Fe–Fe3C) Phase FAILURE: Fundamentals of Fracture, Types of fracture, Theoretical fracture strength of brittle materials, Griffith theory of brittle fractures, Ductile fracture, Fracture toughness, Prevention of fractures, Fatigue, Creep. MAGNETIC AND DIELECTRIC MATERIALS: Diamagnetism and Paramagnetism, Ferromagnetism, Anti-ferromagnetism and Ferrimagnetism, The Influence of Temperature on Magnetic Behaviour, Domains and Hysteresis, Magnetic Anisotropy, Soft magnetic materials, Hard magnetic materials, Superconductivity, Polarization, Electric breakdown, Ferroelectric materials, Frequency Dependence of the Dielectric Constant, Dielectric Strength, Dielectric Materials.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**ENG-CSIO-2-2401**			
Course Title	**Signal Processing**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Signals and Systems, Continuous time signals, sampling theorem, discrete time signals and systems, classification; Transforms, Analysis and Filters, Analysis of linear systems, correlation of discrete time signals, frequency domain analysis, DFT, FFT, z-transform, IIR/FIR digital filter design, basics of DSP processors; Signal processing in instrumentation, case studies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**ENG-CSIO-2-2402**			
Course Title	**Computer Aided Design and Simulation**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to Optics Software for Layout & Optimisation (OSLO), Paraxial Optics, Third order aberrations; Design & Evaluation of Optical Systems Consisting of One, two & three elements using OSLO. Introduction to drawings 2D, 3D and Projection, Drawing view of components & assembly. Modelling Approaches: Geometric modelling, Wire-frame modelling, part modelling, assembly modelling, Sheet Metal modelling. Rendering of Visualization. Introduction to Finite Element Analysis: Static, Frequency, Thermal & Dynamic analysis. Analog, Digital & Mixed signals, Ground and Power Supply requirements; Active and Passive components behaviour; Mixed signal simulation. Environmental Parameters, Thermal analysis and EMI Fundamentals, Schematic & PCB layout design.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**ENG-CSIO-2-2403**			
Course Title	**Human Physiology**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Cell and Tissue: Introduction to cell, multicellular organization, basic structure and organization of cell, cell organelles, tissue structure, types of tissue. Cardiovascular system: Anatomy of cardiovascular system, cardiac muscle, electrical conduction in heart, brief introduction to ECG/EKG, types of circulation, working of heart and cardiac cycle. Respiratory system: Anatomy of respiratory system, gas exchange, physiology of respiration, spirometry, respiratory volumes and capacities. Digestive system: Anatomy of digestive system, process of digestion, absorption and excretion, role of digestive enzymes and juices, hepatobiliary system. Nervous and endocrine system: Anatomy of nervous system and endocrine system, action potential, division of nervous system, nerve tissue, transmission across synapse, reflexes, neural control of different major body stems, sleep cycle, special senses (eye, ear, smell), role of hypothalamus, pituitary, different hormones and their role. Musculoskeletal system: Types of muscles, muscle contraction physiology, types of bones, bone macro and micro anatomy, bones in body, cartilage types, joints types, movement at joints, fracture types and healing. Urinary system: Anatomy of renal system, working of the kidneys, process of urine concentration and bladder control, maintenance of acid-base balance. Immune system: Immunity, Types of immunity, components of Immune system, antibodies, antigen, blood groups, detection of antigen/antibody as basis of disease diagnostics.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**PHY/ENG-CSIO-3-2401**			
Course Title	**Advanced Self Study**			
Credit Distribution (L-T-P-C)	0	2	4	**4**

Course Content:

The main focus of this course is to encourage self-learning in the niche areas of the candidate's interest. The candidate is expected to do an extensive literature survey in the chosen research area and submit an written report of the work and present the work to group of experts in the form of a seminar.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**ENG-CSIO-3-2402**			
Course Title	**Digital Image Processing**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Introduction: Elements of visual perceptions, digital Image sensing, sampling and quantization, digital image representation, basic relationship between pixels, elements of digital image processing system. Image transforms: Discrete Fourier transform and properties, separable image transforms, image enhancement. Wavelet transforms. Restoration and Reconstruction: Image restoration, image segmentation, image reconstruction from projections. Statistical pattern recognition: Cluster analysis, feature selection & extraction, syntactic pattern recognition: stochastic languages, problem solving methods for pattern recognition. Case studies: Medical image processing, colour image processing, thermal image processing.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**ENG-CSIO-3-2403**			
Course Title	**Statistical Analysis & Machine Intelligence**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Statistical Analysis: Statistics In Research, Common Terms in Statistics, Constraints in Research, Population and Sample, Choosing Appropriate Sample Size, Sampling, Errors in Sampling, Data Collection, Bias in Statistics, Data representation, Types of Data, Data Analysis, Measures of Central Tendency, Standard deviation, Variance, Standard Error of Means, Gaussian Distribution, Normal Distribution Curve, Skewness, Tests of Significance – t/z/ANOVA, chi square test, correlation and regression analysis. Applied Machine Learning: Linear algebra revisited, ML Tools, Introduction to Machine Learning –Supervised Vs. Unsupervised Learning, Linear regression, Logistic regression, Regularization, Neural networks- Representation and Learning, Machine Learning System Design, Support Vector Machines, Clustering, Dimensionality reduction, Anomaly detection, Recommender systems, Large scale machine learning, Applications- enose, iTongue, cancer, Iris, Boston housing, sonar, wine etc . Hybrid systems: Uncertainty and imprecision, fuzzy systems, linguistic rules, approximate reasons, neuro-fuzzy systems, genetic algorithms and evolving neural networks, applications in control, inspection, monitoring, forecasting, recognition and diagnosis, Applications/Case Studies: Engineering design optimisation, optimiser behaviour evaluation through stochastic analysis, performance analysis, optical design and engineering, mechatronic products, agro applications.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**ENG-CSIO-3-2404**			
Course Title	**Biological Control Systems**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Introduction: Control systems, transfer functions, mathematical approaches, system stability, feedback concept and stability analysis, Biological control system, comparison with engineering control, transfer of various bio-chemicals between compartments, biological receptors and actuators, characteristics, transfer function model, bio-feedback mechanism. Regulation: Regulation of acid-base balance, regulation of extra cellular water and electrolytes, process controls-cardiac rate, blood pressure, respiratory rate and blood glucose regulation. Endocrine control, Pharmaco modelling-drug distribution system, regulation of interstitial fluid volume. CO_2 regulations. Modelling of Human Systems: Modelling of human cardiovascular system, respiratory system, thermal regulatory system, etc, parameters involved, control system models etc, heat loss from the body, model of heat transfer between subsystems of human body like skin, core, body in relation to environment. Bio-mechanics: Muscle behaviour to excitation & EMG analysis, stiff leg gait model, Gait pattern in terms of step size, Step frequency, Comfortable walking & gait behaviour during exercise. Heat-lung information pathways under normal and exercise conditions in terms of O_2 and CO_2 balance. Hearing and Vision System: Information pathways for various sensory organs such as hearing, vision, smell, etc. Skull position & velocity sensing, auditory cupila dynamics, time & frequency response characteristics, papillary dynamics for optimum flux density as retina, cilliary muscles control, transient response, eye tracking problem and various information pathways, etc.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**ENG-CSIO-3-2405**			
Course Title	**Bio Instrumentation**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Introduction - Cellular organization: Cell, Action potential of cell, Transport of substances across biological membrane. Cardiovascular system: heart, arterial and venous system, blood, cardiac cycle. Basics of ECG, PCG. Measurement of blood pressure by direct and indirect methods. Plethysmography. Defibrillators: DC defibrillators, AC defibrillators of capacitance discharge and delay line capacitance discharge with basic circuit diagrams. Types of electrodes and their features. Cardiac pacemakers: Asynchronous and Synchronous (demand) Mode of operation. External and Implantable Asynchronous pace makers. Working Principles, modes of triggering. Respiratory system: Trachea and Lungs. Respiratory Physiology. Spirometry, Ventilators. Nervous system and special senses: Nerve physiology. Basics of EEG. Electrodes used for measurement of EEG. Skeletal system: Classification of Bones, Joints and Muscles- Structure and function. Basics of EMG. Bipotential Electrodes: Electrode electrolyte interface, half cell potential polarization , electrode skin interface and motion artefact. Types of electrodes. Micro electrodes. Miscellaneous: Hearing aids, Heamodialysers- types of exchangers. Lasers in Surgery, Principles and applications of Endoscopes. Electrical hazards in hospitals: Patient electrical safety, types of hazards, patient isolation, physical effects of current, let – go – current, Micro shocks, different ways for electrical accident to occur, safety instruction circuits, electrical grounding & effects.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**ENG-CSIO-3-2406**			
Course Title	**Agri-Physics and Agro Control Systems**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Measurement techniques and instruments for various agri-parameters such as pH, electrical conductivity, moisture content, temperature, relative humidity, viscosity/ consistency, rheology, heat transfer coefficient, visco-elastic behaviour, etc. Modelling of key agri-processes such as material carrier, extraction, clarification, concentration, crystallisation, drying etc. Typical case studies of level control, consistency control, biochemical reactions based on material balance, heat balance, population balance, etc. Instrumentation & control for various unit processes such as precision farming, cultivation under controlled atmosphere, photosynthesis, crop health monitoring, pesticide estimation, soil mapping, light flux density, etc. Case studies of some key agro-based industries in terms of instrumentation & control : automatic grading & sorting of fruits / vegetables, controlled environment storage system (seed potatoes), Juice clarification, evaporation and crystallisation process in cane sugar industry, instrumentation in tea processing such as withering, rolling/CTC, fermentation, drying, etc. Mushroom cultivation in environmentally controlled cropping houses, control system realisation, algorithm development (PID, PD 2T2), tuning of controller, performance evaluation, identification techniques.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**ENG-CSIO-3-2407**			
Course Title	**Agro Mechanical Systems**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Agriculture Parametric Study: Field measurements, Soil dynamics & water resources, Agriculture field engineering, Pre & Post harvesting Agriculture Engineering: Elements of machine design, Computer aided design, simulation & analysis, instrumentation & process control Farm Machinery: Tractor system & control, Production technology for agriculture machinery, Tractor mounted gadgets for pre & post harvesting, Resources of Irrigation, Conveyor systems, Grading & Sorting of fruits & vegetables, Storage chambers, Chilling, Humidification & Aeration units, Processing system (solar drying, juice extraction , clarification , filtration), Control valves & actuators, Material characterization Agriculture Economics: Agro environmental science, Principle of ergonomics & safety, Human engineering & safety, Precision farming & natural resource farming

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**ENG-CSIO-3-2408**			
Course Title	**Optical Instrumentation**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Geometrical Optics: Optical Components: Lenses, Mirrors, Prisms; Diffraction Gratings, Optical System Layout, Basics of Lens Design, Zoom Lenses, Mirror and Catadioptric Systems, Optical Specifications and Tolerances Physical Optics: Apertures and Diffraction, Wave Aberrations and MTF, Fourier Optics & Optical Signal Processing; Diffractive Optics, Quantum Optics Optical Materials & Coatings: Optical Glass, Plastics, IR Materials, Anti Reflection Coatings, Reflection Coatings, Interference Filters Radiometry and Photometry: The Inverse Square Law; Intensity; Radiance and Lambert's Law; the Radiometry of Images, Blackbody Radiation, Photometry, Illumination Devices

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**ENG-CSIO-3-2409**			
Course Title	**Opto-Mechanical Systems**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Module – i: Optical fabrication & metrology Optical materials, optical shop supplies, tools & fixtures, optical processors, optical processing, optical shop testing. Module – ii : Opto-mechanics: design, fabrication & metrology Opto-mechanical design process, environmental influences, mounting individual lenses, mounting multiple lenses. Module –iii : Display technology Principles, Emergent Technologies, Application Areas for Display Devices Including CRT, LCDs, Reflective Displays, Emissive Devices (OLEDs), Plasma Displays, Scanned Laser Displays, Digital Micro-mirror Devices. Fundamentals of Light & Vision, Display Electronics & Calibration; Display Measurement: Concepts, Techniques, And Instrumentation; Commercial, Industrial & Military Standards For Testing of SW & HW; Environmental & Performance Testing Parameters & Standards For Display Systems

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**ENG-CSIO-3-2410**			
Course Title	**Embedded System**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Introduction to embedded system: Single purpose hardware and software. Architectural Issues: CISC, RISC, DSP Architectures. Microcontroller and Interfacing: Keyboard, Touch Screen, LCD, Serial Port, RTC, Timer/counter, ADC/DAC, Stepper motors, Watchdog timer, JTAG, Interrupt, I/O Devices, Memory and it Characteristics FPGA, I 2 C, Bus Architecture, Modelling concepts, Testing, Simulation and Debugging Techniques and Tools, Introduction to advanced microcontrollers- AIC, 8051, AVR, ARM. Introduction to Real Time Operating System (RTOS) – Features, Components, Resource Management/ Scheduling, Design consideration, Challenges. Examples of Real-time embedded systems, sensors and interfacing techniques.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**ENG-CSIO-4-0001**			
Course Title	**Project proposal writing**			
Credit Distribution (L-T-P-C)	1	1	0	**2**

Course Content:

Formulation of a project proposal by selecting topics of high relevance and novelty and will have state-of-the art review, methodologies, recommendations etc. in specified format in a holistic manner preferably candidate's own research work suitable for submission to appropriate funding agencies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**ENG-CSIO-4-0002**			
Course Title	**Review Article**			
Credit Distribution (L-T-P-C)	1	1	0	**2**

Course Content:

Preparation of one review article on specific research area of the student.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CSIO, CHANDIGARH**			
Course Nomenclature	**ENG-CSIO-4-0003**			
Course Title	**CSIR-800 Societal Program**			
Credit Distribution (L-T-P-C)	0	0	8	**4**

Course Content:

The students have to undertake a project in rural area for 6-8 weeks in line with CSIR-800 program which is primarily prepared at empowering 800 million Indians by way of S & T interventions. The theme for the project may be chosen from CSIR-800 document and as per expertise available at individual laboratory. Students will choose the topics in consultation with Doctoral Advisory Committee (DAC). This needs to be completed before submission of thesis. Detailed guidelines are on AcSIR website.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 1-2901**			
Course Title	**Research Methodology & Technical Communication Skills**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Literature review Effective scientific writing & presentation Intellectual property management Research planning Effective written and oral communication Ethical issues

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 2-2901**			
Course Title	**Numerical methods and Process Modeling**			
Credit Distribution (L-T-P-C)	2	1	0	**3**

Course Content:

Fundamentals of mathematical modeling Chemical Process Modeling Numerical methods Process optimization Process simulation using Software Packages

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 2-2902**			
Course Title	**Advanced Separation Processes**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Fundamentals of Separation Processes Binary Separation Processes Multi-component Separation Processes Rate Based Separations Hybrid Separations Reactive Separations

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 2-2903**			
Course Title	**Reaction Technology**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Homogeneous reactor design and analysis: Non-ideal reactors Heterogeneous reactors for fluid-fluid systems: Kinetic evaluation and design Heterogeneous reactors for fluid-solid systems: Kinetic evaluation and design Novel Reactor Configurations

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 2-2904**			
Course Title	**Advanced Chemical Engineering Thermodynamics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Basic concepts of thermodynamics Solution thermodynamics: Properties of mixtures Phase equilibria: VLE, LLE, VLLE, SLE Chemical reaction equilibria: Multi-reaction equilibria Introduction to molecular and statistical thermodynamics

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 2-2905**			
Course Title	**Advanced Process Design**			
Credit Distribution (L-T-P-C)	2	1	0	**3**

Course Content:

Heat transfer equipment design Mass transfer Equipment design Reactor design Process Instrumentation Process Safety and Hazard analysis Computer Aided Process Design

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 2-2906**			
Course Title	**Advanced Process Optimization**			
Credit Distribution (L-T-P-C)	2	1	0	**3**

Course Content:

Unconstrained Optimization – single variable and multivariable   Linear programming   Nonlinear programming with constraints   Mixed Integer Programming   Global optimization   Optimization of heat transfer applications   Optimization of separation processes   Optimization for Chemical Reactor Design and Operation

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 2-2907**			
Course Title	**Membrane Technology**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to membrane separation processes Membrane transport theories Membrane preparation techniques Design and analysis and industrial applications of membrane processes Membrane reactors and membrane contactors

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 2-2908**			
Course Title	**Advanced Process Monitoring and Control**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to Advanced control systems Controllability, Observability and Stability Analysis State estimation and inferential control Adaptive Control Nonlinear Model based Control Model predictive control with linear, nonlinear and data-driven models Plant wide control Fault detection and diagnosis

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 3-2901**			
Course Title	**Process Engineering**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Process Route Selection Process Flow sheeting Process optimization Process Equipment Design Advanced Process Engineering Concepts

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 3-2902**			
Course Title	**Process Integration and Intensification**			
Credit Distribution (L-T-P-C)	4	0	0	**4**

Course Content:

Introduction to process integration and intensification Heat Exchange Network Synthesis Mass Exchange Network Synthesis Reactor Network Synthesis Equipment based Process Intensification Method based Process Intensification

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 3-2903**			
Course Title	**Artificial Intelligence in Process Engineering**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to Artificial Intelligence (AI) Data reduction and classification methods Expert systems Evolutionary optimization methods Neural Networks - Concepts and Applications

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 3-2904**			
Course Title	**Biochemical Engineering**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to Biochemical Engineering   Fermentation processes – microbial & enzymatic   Bioprocess Modeling   Bioreactor design   Downstream processing operations

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 1-2951**			
Course Title	**Research Methodology**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Introduction to Research: Definition and objectives of Research – Building blocks of science in research – Literature review, critical analysis & evaluation, interpretation, Research Purposes, Ethics in research. Quantitative and qualitative research techniques: Probabilistic and non–probabilistic samples – Hypothesis development – Hypothesis testing with quantitative data – Sample Size – Sampling Techniques – Determination of Optimal sample size – design of experiments. Problem solving methods: Probability distributions, Fundamentals of statistical analysis and inference – Multivariate methods – Concepts of correlation and regression – Fundamentals of time series analysis and spectral analysis, error analysis – Applications of Spectral Analysis. Data collection: Interviewing and questionnaires – Secondary sources of data collection – Guidelines for questionnaire design – Electronic questionnaire design & surveys – Special data sources: focus Groups – Static & dynamic panels – Review of advantages & disadvantages of various data – Collection methods and their utility. Research report: Purpose of the written report – Concept of audience – Basics of written reports – Integral parts of a report – Experimental, results and discussion – Conclusions & future work.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 2-2951**			
Course Title	**Wireless Sensor Networks**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Sensing mechanism: Sensor characteristics – electric, magnetic, electromagnetic, piezoelectric – pyroelectric – Hall effect, optical, chemical and bio sensors – noise in sensors and circuits – calibration – low power sensors – Data Acquisition dynamic models of sensors. Wireless characteristics: Wireless characteristics – Radio energy considerations, SINR capture model for interference – Medium access and sleep scheduling -– Traditional MAC protocols – Energy efficiency in MAC protocols – Asynchronous sleep techniques – Sleep scheduled techniques – Contention free protocols - topologies for connectivity and coverage. Ad–Hoc wireless network and wireless sensor network: Routing, multicasting, medium access, transport layer protocol, QoS, self–organization, security, addressing, service discovery, energy management, ad–hoc wireless internet. Routing: Metric based approaches – Multi-path routing – energy-aware routing techniques – Geographic routing – Routing to mobile sinks – Data-centric routing – Data gathering with compression – Data–centric storage and retrieval – database perspective on sensor networks – Reliability guarantees – Congestion control. Applications: Applications of sensor network – design and architecture of layered & clustered data dissemination – data gathering – Mac protocols – location discovery – ZigBee standard

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 2-2952**			
Course Title	**Simulation of Computer Systems and Networks**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Simulation of random variables and random process: Univariate and multivaraiate models – Transformation of random variables – Bounds and approximation – Random process models – Markov and ARMA Sequences – Sampling rate for simulation – Computer generation and testing of random numbers. Estimation of performance measures: Quality of an estimator – estimator for SNR – Probability density functions of analog communication system – Monte Carlo method and Importance sampling method – estimation of power spectral density of a process. Introduction to NS-2: Introduction – NS-2 Simulator preliminaries, Work with trace files – description and Simulation of TCP/IP Queuing models – M/M/I and M/M/I/N queues – Little’s formula, Burke's theorem – M/G/I queue. Simulation of network routing protocol using NS–2: Routing Network Dynamics – Routing Network Dynamics – Differentiated Services, Simulation of LAN – Classical Queuing Model.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 2-2953**			
Course Title	**Mobile and Pervasive Computing**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Introduction: Mobile communication v/s mobile computing – Applications & services – Mobile enabled legacy applications – Pervasive computing – Pervasive Devices. 3G and 4G Cellular networks

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 3-2951**			
Course Title	**Real Time Systems**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Introduction: Real–time systems – Applications – Basic models – Characteristics – Safety and reliability – Real–time tasks – Timing constraints – Soft and hard Real time systems. Scheduling real–time tasks: Concepts – RT tasks and their characteristics – Task scheduling – Clock-driven scheduling – Hybrid schedulers – Event-driven scheduling – EDF scheduling – RMA: RT resource sharing: Resource sharing – Priority inversion – Resource sharing protocols – Task dependencies – Task allocation: static & dynamic – Fault-tolerant scheduling – Clock synchronization. RT operating systems: Time services – Features of RTOS – UNIX based RTOS – Windows as a RTOS – POSIX – Benching RT systems. RT communication & databases: RT communication – RT communication in a LAN – Performance comparison – QoS frame work – routing – resource reservation – rate control – QoS models – Characteristics of temporal data Applications of RT databases –– Concurrency control in RT databases.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 3-2952**			
Course Title	**Network Protocols**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Architecture: Hardware components & Design constraints, OS and execution environments, Network architecture, Sensor network scenarios, Service interfaces of WSNs, Gateway Concepts. Localization: Localization and positioning, Coverage and connectivity, Single–hop and multi–hop localization, Self configuring localization systems, Sensor management network protocols: Classification of MAC protocols, S–MAC protocol, B–MAC protocol. Routing: Routing Protocols – Energy-efficient routing – Unicast, broadcast, multicast geographic routing – Data centric and content based routing, Storage and retrieval in network, Compression technologies for WSN – Data aggregation. Security: Security principles – Authentication – Access control and authorization – Non–repudiation privacy and confidentiality – Integrity and auditing – Security analysis process – Overview of wireless security – Legislation & policy – Attacks and vulnerabilities – Zigbee Security. Standards and policy solutions: Network Solutions – Physical hardware security – Wireless security – Securing WLAN – VPN – Intrusion detection system – Wireless public key infrastructure tools – Auditing tools

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IICT, HYDERABAD**			
Course Nomenclature	**ENG-IICT- 2-2909**			
Course Title	**Software Applications in Chemical Engineering Problem Solving**			
Credit Distribution (L-T-P-C)	2	2	0	**4**

Course Content:

Problem formulation, Simulation, Evaluation of effect of parameters, Process Simulation Case Study – using ASPEN PLUS, Flow dynamics Case Study – using FLUENT / COMSOL Reports on the case studies, Presentations on the salient features of the case studies and results

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-4PI, BANGALORE**			
Course Nomenclature	**ENG-4PI-1-2201**			
Course Title	**Research Methodology**			
Credit Distribution (L-T-P-C)	1	1	0	**2**

Course Content:

Migration to 3G Networks – UMTS architecture – UTRAN – RNC functions – USIM – Protocol stack – CS and PS domains – IMS architecture – Handover – 4G LAN and cellular networks – WiMax IEEE 802.16d/e – WiMax internetworking with 3GPP. Context aware computing & wearable computing

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-4PI, BANGALORE**			
Course Nomenclature	**ENG-4PI-2-2202**			
Course Title	**Statistical and Computational Methods**			
Credit Distribution (L-T-P-C)	2	1	0	**3**

Course Content:

Adaptability – Functionality and data – Transcoding – Location aware computing – Location representation – Localization techniques – Triangulation and scene analysis – Types of context – Role of mobile middleware – Adaptation and agents – Service discovery – Wearable Sensors. Applications: Three-tier architecture – Model view controller architecture – Memory management – information access devices – PDAs & smart phones – Smart cards & embedded controls.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-4PI, BANGALORE**			
Course Nomenclature	**ENG-4PI-2-2203**			
Course Title	**Global Navigation Satellite System (GNSS) theory and it applications**			
Credit Distribution (L-T-P-C)	2	1	0	**3**

Course Content:

Introduction to GNSS geodesy, GNSS theory, GNSS reference frames, sources of errors and correction, positioning using GNSS observables, GNSS data collection, data processing and analysis, GNSS applications for Geoscience, Modelling of GNSS derived surface deformation. Introduction to GNSS geodesy covers the state of art on Global Navigation Satellite systems, its components, geodesy, Military and Civil applications. GNSS reference frames: Introduction to celestial and terrestrial reference frames, Earth Centered Earth fixed reference frame and earths pole of rotation. Sources of errors and corrections: Introduction of positioning using GNSS satellites, errors involved covering orbit, clock errors, troposphere and ionosphere errors, miscellaneous errors. Positioning using GNSS observables: To determine the precise position and time, error correction, different types of positioning. GNSS data and processing theory: Models involved in data processing and analysis. GNSS applications to Geoscience: Surveying, continental deformation studies, landslide hazard mapping, Glacier dynamics, Volcano deformation, troposphere and ionosphere modeling, InSAR (Interferometric Synthetic Aperture Radar), GIS (Geographical Information System) etc. Modelling of GNSS deformation: brief introduction of different kind of modeling techniques that are currently being used.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-4PI, BANGALORE**			
Course Nomenclature	**ENG-4PI-2-2204**			
Course Title	**Principles and Techniques of Mathematical Modelling**			
Credit Distribution (L-T-P-C)	2	1	0	**3**

Course Content:

This course will provide an overview of principles and techniques of mathematical modelling used by engineers and scientists with a bias to fluid mechanics. The following topics will be discussed: 1. Mathematical modelling. What is modelling? Properties of a model. Why do we model? Some examples. The four paradigms and relevance of modelling. 2. Order of magnitude analysis. Dimensional arguments. 3. Complex variable. Power series. Branch points. 4. Vectors and tensors. Linear vector spaces. Matrix theory. 5. Vector fields, their Divergence and Curl. Classification and representation of vector fields. 6. Numerical methods. Numerical differentiation and integration. Interpolation. Initial and boundary value problems. Euler and Runge-Kutta methods. Multi-step methods. 7. Dynamics: Geometric ideas. 8. Model equations in fluid mechanics.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-4PI, BANGALORE**			
Course Nomenclature	**ENG-4PI-2-2205**			
Course Title	**High Performance Scientific Computing**			
Credit Distribution (L-T-P-C)	2	1	0	**3**

Course Content:

Modern computer architectures, Programming and Tuning Software, Shared-Memory Parallel Processors, Scalable Parallel Processing, Scientific data formats, Open source application software Basic concepts in parallel computing, parallel algorithms, Introduction to message passing and MPI programming, embarrassingly parallel problems, Problem decomposition, graph partitioning, and load balancing, introduction to shared memory and OpenMP programming techniques, parallel direct and iterative methods, programming on different parallel architectures, applications relevant fields, Debuggers HPC best practices, Linux shell programming, sequential programming, compiler optimization, Multi-processor parallel programming, benchmarking and performance evaluation on different architecture, Visualization of different data formats.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-4PI, BANGALORE**			
Course Nomenclature	**ENG-4PI-2-2206**			
Course Title	**Nonlinear Dynamics**			
Credit Distribution (L-T-P-C)	2	1	0	**3**

Course Content:

Introduction/Phase Space, Plane and Portraits : Linear Systems and their classification;Existence and uniqueness of solutions; Fixed points and linearization; Stablility of equilibria; Pendulum Oscillator,Dufing oscillator,Lindstedt`s method; Conservative and reversible systems. Limit cycles: The Van der Pol oscillator, Method of averaging; Relaxation oscillators; Weakly Nonlinear Oscillators; Forced Duffing oscillator, method of multiple scales; Forced Van der Pol oscillator,entrainment, Mathieu`s equation, Floquet Theory, Harmonic Balance. Bifurcations: Saddle-node,transcritical,and pitchfork bifurcations; Center manifold theory; Hopf bifurcation; Global bifurcations; and Poincare maps. Chaotic Dynamics : Lorentz equations; Lorentz map ; Logistic map; Lyanpunov Exponents; Fractal sets and their dimensions; Box ,point wise and correlation dimensions; Strange attractors; Forced two-well oscillators Time Series Analysis: State space approach

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-4PI, BANGALORE**			
Course Nomenclature	**ENG-4PI-2-2207**			
Course Title	**Applied Computational Methods**			
Credit Distribution (L-T-P-C)	2	1	0	**3**

Course Content:

Ordinary Differential Equations: Initial Value Problems: Single step methods, Multi step methods Boundary Value Problems: Shooting Method, Finite Difference Methods, Finite Element Method Partial Differential Equations:Finite Difference Discretization, Finite difference treatment of 2nd order nonlinear PDE of parabolic, elliptic types, Hyperbolic problems Higher Order Methods: Spectral Method, Pesudospectral Method

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-4PI, BANGALORE**			
Course Nomenclature	**ENG-4PI-2-2208**			
Course Title	**Numerical Analysis and Fortran Programming**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

This is a programming-intensive course which will make the students write Fortran codes for numerical analysis topics. There is no separate lab component. Programming assignments will be integral to the course and not considered as lab assignments. The topics covered will include: Basics of computer floating point arithmetic, Fortran programming and debugging, Taylor series, solution of algebraic equation, linear systems – direct and iterative methods, eigen value problems, least squares and singular value decomposition, interpolation and extrapolation, numerical differentiation and integration, numerical solution of ordinary differential equations

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-4PI, BANGALORE**			
Course Nomenclature	**ENG-4PI-2-2209**			
Course Title	**Finite Element Method**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Approximate solution of linear differential equations -- Weighted residual techniques. Collocation, Least Squares and Galerkin methods. Use of piecewise continuous approximation functions. Basis of Finite Element Method. Formulation of element level equations and assembly into system level equations. One dimensional example problems. Elements of Variational calculus. Minimisation of a functional. Principle of minimum total potential. Piecewise Rayleigh - Ritz method and FEM. Comparison with weighted residual method. Two dimensional finite element formulation. Isoparametry and numerical integration. Finite element formulation for transient dynamic problems. Algorithms for solution of equations.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-4PI, BANGALORE**			
Course Nomenclature	**ENG-4PI-2-2210**			
Course Title	**Qualitative and Quantitative Aspects of Water Cycle**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

The course deals with basic elements of hydrological cycle, fundamental principles of river water quality modeling and water resource management. Hydrology and Ground Water, Hydrological Cycle, engineering perspective of hydrological cycle, the global water budget. Hydrological measurements and networks. Analysis of discrete and continuous hydrological data, urban hydrology, Non-point source pollution, ground water management. Water wells and artificial recharge. Impact of land use change on hydrological cycle. Application of mesoscale models in studying hydrological cycle and regional water budgets. River Water System Mathematical models as tools of water quality management, point and diffused source of pollution. Deterministic and stochastic water quality models. Concepts of BOD, DO and COD. State-of-the art river water quality models. Lake and river water quality assessment.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-4PI, BANGALORE**			
Course Nomenclature	**ENG-4PI-3-2201**			
Course Title	**Advanced Self Study**			
Credit Distribution (L-T-P-C)	0	2	4	**4**

Course Content:

Aims to train the student on learning, on one's own, topics that are not formally taught in a course. This would involve primarily three components - collection of relevant literature on a chosen topic, organization of relevant material into a written report based on candidate's own critical understanding and finally presentation of the findings in front of wide audience in the form of a seminar. Thus communication skills are also expected to be honed up (4 credits)

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-4PI, BANGALORE**			
Course Nomenclature	**ENG-4PI-4-0001**			
Course Title	**Project proposal writing**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Formulation of a project proposal by selecting topics of high relevance and novelty and will have state-of-the art review, methodologies, recommendations etc. in specified format in a holistic manner preferably candidate's own research work suitable for submission to appropriate funding agencies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-4PI, BANGALORE**			
Course Nomenclature	**ENG-4PI-4-0002**			
Course Title	**Review Article**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Preparation of one review article on specific research area of the student.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-4PI, BANGALORE**			
Course Nomenclature	**ENG-4PI-4-0003**			
Course Title	**CSIR-800 Societal Programme**			
Credit Distribution (L-T-P-C)	0	0	8	**4**

Course Content:

The students have to undertake a project in rural area for 6-8 weeks in line with CSIR-800 programme which is primarily prepared at empowering 800 million Indians by way of S & T inventions. The theme for the project may be chosen from CSIR-800 document and as per expertise available at individual laboratory. Students will choose the topics in consultation with Doctoral Advisory Committee (DAC).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG(CIMFR)-1-1901**			
Course Title	**Mathematics For Engineers**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Linear Algebra: Linear independence; Orthogonality; Vector Spaces and their bases and dimensions; GramSchmidt method for orthogonal basis set; Orthogonal projections; Matrices; Solution methods for linear simultaneous equations; Eigenvalue problem. Vector Analysis: Vector differentiation, Applications; Vector operators: Grad, Div and Curl. Vector integration and related Integral Theorems, Applications; Cylindrical and Spherical Co-ordinate Systems. Differential Equations: Linear ODEs of first and second orders; Linear second order equations, Applications; The Laplace Transform, Applications; Fourier Series and Applications; Partial differential equations of first and second orders; The Laplace and Wave Equations.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG(CIMFR)-1-1902**			
Course Title	**Rock Mechanics And Ground control In Mining**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Rocks and rock structures; Rock mass classification; Rock mass properties; Rock failure criteria; Stresses in elastic and plastic ground conditions; Effect of anisotropy and inhomogeneity on rock properties; In situ stresses and its measurements; Different types of ground excavations and effects of their instability; Design of roadways and pillars; Approaches of ground behaviour evaluation; Different types of rock reinforcement and support; Ground Control measures during different methods of mining; Rock bursts and bumps; Slope stability evaluation: Discontinuities and geomechanical properties of slope mass; Groundwater condition and its measurement; Mechanics of slope stability; Slope stability in weathered slopes; Case studies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG(CIMFR)-1-1903**			
Course Title	**Engineering Geology**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Depositional textures and structures; Physics of deformation with surroundings, time and material; Planar and linear structures; Faults, folds, cleavages, dip, strike, contour, stratification, lamination, bedding; Unconformity & joints - their classification and Recognition in the field ; Major structures and tectonics; Structures in igneous rocks and igneous intrusions; Geomorphology and structure morphotectonics; Mineral Exploration: Geological, Geophysical and Geochemical Prospecting; Study of geological structures; Management and utilisation of geological data; Coal geology; Hydrogeology.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG(CIMFR)-1-1904**			
Course Title	**Mine Safety Legislations And Safety Management**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Mine Safety Legislations: Mines Act; Mine Rules; Coal Mines Regulations; Metalliferous Mines Regulations; Mines and Minerals (Development and Regulations) Act; Mines Rescue Rules; Circulars; Other related industrial legislations, circulars, documents related to mine safety. Mine Safety Management: Requirements for effective safety management; Mine safety management system – background, objectives and structure; Different levels of safety management; Processes of safety management; Hazard identification and risk assessment; Risk management, case studies; Concept of mine safety monitoring. Purpose and classification of safety monitoring. Mine safety monitoring techniques ; Preparation of safety monitoring plan; Measurement of safety efficiency; safety audit; safety records.

Faculty	ENGINEERING SCIENCES			
Lab Name	CSIR-CIMFR, DHANBAD			
Course Nomenclature	ENG(CIMFR)-1-1905			
Course Title	Rock Mechanics Instrumentation And Monitoring			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Ground behaviour and instability in ground excavations; Methods of studying ground behaviours; Monitoring of ground behaviour in underground mines; Different types of field instruments used for rock mechanics instrumentation and monitoring – sensors and transducers, readout units, data acquisition systems, etc.; Rock mechanics testing equipment; Acoustic emission equipment; Monitoring of reinforcement and support system; Rock bolt pull tester; GPR based monitoring of underground structures; Field instrumentation and monitoring of slopes; Conventional and GPS based monitoring; Real-time monitoring; Communications/storage of data; Analysis of data and evaluation of ground stability.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG(CIMFR)-1-1906**			
Course Title	**Methods Of Mining**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Methods of exploration; Evaluation of mineral deposits; Mine planning; Surface and underground mining; Opening of mineral deposits; Shaft sinking; Methods of excavations; Explosive and Blasting; Conventional and special methods of mining; Mining Machinery and its applications.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-1-1907**			
Course Title	**Rock Excavation Engineering**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Rock Excavation by drilling and blasting; Study of the theories of rock penetration including percussion, rotary, and rotary percussion drilling; Rock fragmentation including explosives and the theories of blasting rock; Application of theory to drilling and blasting practice at mines, pits, and quarries; Mechanised Excavation of Rock; Classification and construction of extraction machineries; Different types of machineries and their suitability; Selection of equipments and machineries; Operational conditions; Safety measures; Performance monitoring; Condition monitoring and maintenance; Study of excavation stability; Excavation support design.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-1-1908**			
Course Title	**Reliability And Maintenance Engineering In Mining Systems**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Statistical methods in reliability: Basic statistics and probability theory; Reliability concepts: Reliability function, failure rate, MTTF, MTTR, mortality curve, useful life, availability, mainta inability, system effectiveness; Reliability analysis and prediction: Time to failure distribution, exponential, normal, gamma, weibull distribution, system reliability evaluation, standby systems; Design for reliability: Design theory, design for reliability, design for maintainability, reliability improvement techniques; Maintenance engineering: Introduction, maintenance policies, failure, diagnosis, Markov maintenance, process maintenance support and lo gistics, maintenance management; Reliability and maintenance in mining: Failures in mining systems, reliability testing, machine maintenance management, human reliability, mine systems reliability improvement, reliability optimization.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-1-1909**			
Course Title	**Environmental Management In Mining Industry**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Concept of sustainable and eco-friendly mining; Impacts of mineral exploration, mining, processing and utilization on environment; Air quality standards, air pollutant sources and health effects; Source and occurrence of waters in mines; Mine water contaminants and their natural attenuation; Acid mine drainage and mine water treatment; Soil conservation and erosion control, restoration of soils, Importance, threats, approaches for conservation and management of biodiversity; Methods of collection and analyses of water, soil, gaseous and particulate pollutants; Bio-monitoring and analytical techniques; EIA/EMP, Environmental clearance; Environmental Law, Legislation and Policies; Principles of mine closure plan; Environmental Hazard and Risk Assessment.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-2-1901**			
Course Title	**Numerical Simulation And Stability Evaluation Of Mining Structures**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Different numerical methods; Inputs of numerical methods; Model generation; Application of Finite difference method; Finite element method; Distinct element method; Boundary elements method; Hybrid methods; Application of different numerical modelling methods and software for ground stability evaluation of mining structures; Validation of models; Design optimisation through numerical modelling; Case studies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-2-1902**			
Course Title	**Advanced Mine Ventilation And Environment**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Mine Ventilation systems; Mine thermodynamics and computation of psychometric properties; Modes of heat transfer; Designing of climatic conditions in panels; Computation of volume flow; Application of Kirchoff's second law to solve field problems; Hardy Cross Iterative method and its application to solve ventilation network problems; Thermodynamic principles applied to ventilation network analysis; Air Leakage; Recirculation and reversal of air flow; Pressure behavior of sealed-off area; Dynamic balancing of pressure technique; Ventilation survey and planning; Air conditioning; Environmental monitoring; Network analysis; Ventilation survey instruments; Simulations of mine ventilation network; Design of coal dust control plan; Noise and Vibrations; Mine Illumination.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-2-1903**			
Course Title	**Advanced Mine Surveying And Subsidence Engineering**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Concepts of Surveying; Automatic Level; Digital Level & Optical Theodolites; Data collection procedures; GIS:GIS Data Models; Data Acquisition; Maps and Map Projections; Surveying using EDM; Total Station and its application in Mine Subsidence and Ground Movement Monitoring of Opencast Mine Slopes ; 3D Scanning; 3D Ground/Mine Surface Modelling using Total Station; Section extraction and excavation volume computation in civil and mining application; Mapping. Subsidence: Causes and types of subsidence; Subsidence measurement methodologies and prediction; Environmental impacts of subsidence on land, buildings, ground water, forest cover, etc.; Safe limits of subsidence for different surface features and structures; Subsidence control measures.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-2-1904**			
Course Title	**Mine Fire, Accidents And Disasters - Analysis And Prevention**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Causes and types of mine fire; Fire risk assessment; Detection and Assessment of spontaneous heating/fire; Gas hazards; Methods of sampling of gases from fire area; Mine gas Analysis; Thermo-compositional Investigation; Environmental affects due to fire; Fire prevention and combating; Fire combat methods; Dealing with long standing fires; Fire fighting equipment. Types and Causes of mine accidents; Dangerous occurrences in mines; Study of mine accidents and its analysis; Mine accidents and disasters; Analysis of mine accidents and preventive measures. Types and causes of mine disaster; Mine inundation; Design of underground dams; Mine explosion; Mine rescue; Mine disaster control and mitigation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-2-1905**			
Course Title	**Mine Safety Equipment: Design, Testing And Evaluation**			
Credit Distribution (L-T-P-C)	1	0	2	**2**

Course Content:

Types of mine safety equipment; Safety parameters in mine equipment; Legislations related to safety equipment; Principles of design of safety equipment; Different types of testing procedures; Testing and evaluation of safety equipment, machines, electrical cables, wire ropes and other accessories ; Electrical hazards; Flame proof and intrinsically safe electrical equipment.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-2-1906**			
Course Title	**Advanced Mining Methods**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Design of mine layouts for underground and surface mining; Design of coal and hard rock pillars; Advanced and special mining methods; Review of various experimental mining methods/procedures; Assessment of caving characteristics; performance and application of backfill; Coal bump and rock burst and their alleviation. Thick, thin and complex seams mining; Underground Coal Gasification and Coal Bed Methane; Choice of stoping method; Stope design; Production planning; Special underground excavations in metal mines; Consolidated and unconsolidated hydraulic & dry filling, paste filling stopes, preparation, transportation and filling operation; Solution Mining: in-situ leaching, chemical, bio-chemical and thermal leaching; Novel mining methods.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-2-1907**			
Course Title	**Mechanisation And Automation For Mine Safety**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Selection, procurement and replacement of mine equipment; State-of-the-art and future trends in mine mechanization and mine automation systems for both surface and underground mining; infrastructure required to support mine automation; Application of robotics and intelligent systems for safer mining; Potential economic, health and safety benefits of mine mechanisation and automation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-2-1908**			
Course Title	**Rock Blasting And Fragmentation**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Advanced study of the theories of rock penetration; Explosives: Chemistry and physics of explosives; Properties of explosives; Explosive and blasting accessories; Initiation and priming systems; Bulk explosives; Heavy ANFO, ANFO with Sawdust & Rice-Husk; Criteria of explosive selection; Rock breakage by explosives: Theories, Rock breakage mechanism, Methods for prediction and assessment of fragmentation; Design of blasting rounds for surface and underground excavations; Special blasting techniques: Secondary breakage; Pre-split blasting; Smooth blasting; Cast blasting; Segregation blasting; Demolition blasting; Trench blasting and Induced caving by blasting. Environmental considerations: Control of Noise; Ground vibration; Air blast and Fly rock; Dust & Fumes.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-2-1909**			
Course Title	**Industrial Physiology And Ergonomics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Anthropometry for design and body composition; Design principles – work station and tool design. Human information processing: man -machine-environment system. Environmental ergonomics and climatic factors: illumination, noise and vibration; Occupational health; Physiological factors. Fatigue-shift works. Control and display. Work posture. Selection of work force and training. Industrial and personal safety

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-3-1901**			
Course Title	**Advanced Self Study**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Specialised advanced courses would be offered in consultation with the thesis supervisors and Doctoral Advisory Committee (DAC).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-3-1902**			
Course Title	**Advanced Numerical Simulation For Design Of Underground Mining Structures**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

General principles of design of underground mining structure; Design process for excavation in rocks; Influence of geological structures on design; Collections, preparation, and evaluation of in situ and laboratory data for underground excavation design; Use of rock mass rating systems for site characterization and excavation design; Design of support and reinforcement systems; Design methods of different openings in massive, stratified and jointed rock; Analysis of stress and rock mass deformations around excavations using numeri-cal method; Application of different numerical modelling methods and software for design of underground mining structures; Demonstration of concepts using various case studies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-3-1903**			
Course Title	**Open Pit Slope Design Engineering**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Physical Characterization of discontinuities; Geomechanical Properties of slope mass; Groundwater condition and its measurement; Basic Mechanics of slope stability; Slope stability in rock slopes: Plane, wedge and toppling failures; Slope stability in soil and weathered slopes: Circular failure; Influence of blasting and damage control; Slope monitoring; Remedial measures: Influence of shape of slope face, slope water depressurization, Surface protection of slopes, control of rock falls.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-3-1904**			
Course Title	**Mine Fire And Mitigations**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Types of Fire; Spontaneous combustion; Mechanism of spontaneous heating of coal; Categorisation of Coal in respect of susceptibility of spontaneous combustion; Role of moisture and V.M.; Fire risk assessment; Detection and assessment of spontaneous heating/fire; Gas hazards; Methods of sampling of gases from fire area; Mine gas Analysis; Thermo-compositional Investigation; Environmental affects due to fire; Fire prevention and combating in underground coal mines; Fire combat methods; Dealing with long standing fires. Surface Fire: Fire in virgin coal bench, developed pillars worked by opencast method, Coal Stock, Overburden dump fire, Causes and techniques for prevention and control; Fire fighting equipment.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-3-1905**			
Course Title	**Mine Closure**			
Credit Distribution (L-T-P-C)	3	2	0	**4**

Course Content:

Purpose of mine closure; Designing, planning and financing closure; Stakeholder engagement and community development; Mine site reclamation and rehabilitation; Phytostabilisation and phytoremediation; Soil ecology and biodiversity; Cover design; Construction and monitoring; Tailings deposit closure; Mining legacies and relinquishment; Mining for Closure: Policies, practises and guidelines for sustainable mining and closure of mines; Mine closure case studies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-3-1906**			
Course Title	**Communication Technologies For Underground Mines**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Difficulties of underground mine communication; Wired Communication: Types of Wired Communication, Carrier Current System, Optical fibre Communication; Semi-Wireless Communication: Leaky Feeder Based System, Location and Monitoring for Personal Safety, Digital Enhanced Cordless Telecommunications (DECT), Ethernet; Wireless Communication: Pocket Pagers, Walkie-Talkie System, Bluetooth, Wireless Fidelity (Wi-Fi), World Interoperability for Microwave Access (WiMAX), Radio Frequency Identification Technique, Ultra Wideband Communication, Through-the-Earth Communication System, Very Low frequency and Low Frequency Propagation, Hybrid communication systems; Installation techniques of different communication system; Maintenance.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-3-1907**			
Course Title	**In Situ Gasification And CBM**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Concept and methodologies of coal gasification; Underground coal gasification - definition, concept and methods, Characterization and correlation of properties of coal for CBM and UCG; Coal bed methane - definition, origin of coal bed methane; Geological controls of methane generation from coal; Global coal bed methane potentials, UCG and CBM exploration, reserve estimation and exploitation; Methodologies for extraction of coal mine methane, CBM policy/ regulations; Clean development mechanisms.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-3-1908**			
Course Title	**Geology, Remote Sensing And GIS**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Origin of earth and its internal structure; Different geological discontinuities; Maps and cross sections; Concept of plate tectonics and its role in hydrocarbon exploration; Principles and techniques of remote sensing; Application of remote sensing for exploration in coal basins; Micro wave Remote Sensing; Thermal and hyper spectral remote sensing and its applications to earth resources and mines management; LIDAR application in mining; GIS and its application in mineral and mining sector; GPS: concept, satellite systems, differential GPS and Global Navigation Satellite Systems; Application of remote sensing in earth resource assessment in mining and mine management related studies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-3-1909**			
Course Title	**Clean Development Mechanisms**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Clean Development Mechanism (CDM) background, definition, goals, GHGs, sectors eligible for CDM; National authority CDM India; financial issues and carbon market; benefits. The Kyoto Protocol: Article 12; CO2 equivalent calculation; CDM operationalization, modalities and procedures for CDM project, project cycle, scope for CDM in coal industries, case studies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-3-1910**			
Course Title	**Environmental Risk Assessment In Mines**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Environmental behaviour of chemicals, Stressor characteristics, Ecosystem potentially at risk, Ecological effects; Characterization of exposure, exposure analyses, exposure profile, ecosystem characterization; Hazards & its effect assessment; Toxicity of chemical pollutants in organisms, dose-response relationships, toxicity of mixtures of chemicals, ecotoxicity, carcinogenesis; Risk Characterization and risk management; Summary and interpretation of ecological significance and remedial action goals. Case studies. Occupational diseases, their effects and prevention; recognition, evaluation and control of physical hazards. Industrial toxicology – local and systemic and chronic effects temporary and cumulative effects; exposure to carcinogens. Industrial hygiene.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-3-1911**			
Course Title	**Fly Ash Management**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Fly ash generation, characterisation, physical and chemical properties; mineralogy; potentially toxic inorganic and organic substances; liming equivalent, and engineering properties; Ash collection, ammonia dozing; handling and transportation in TPPs; Ash utilisation polices; Ash pond: structure; management; abandoned ash pond reclamation. Environmental health hazards from fly ash; Leaching characteristics of fly ash; Utilisation of fly ash in agriculture; forestry; wasteland reclamation; reclamation of low-lying area; Fly ash in mine stowing; cement industry, clay, tiles, brick making, embankment; land filling; Value added products from fly ash.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-3-1912**			
Course Title	**Mining Land Reclamation And Biodiversity Conservation**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Biotic and abiotic components; land use and land cover classification; Causes of damage to land, landscape planning and visual impact; waste disposal, overburden dumps and tailings impoundment; land use categories; pre-mining investigations; Deposit, topography and equipment; top soil characteristics, removal, storage; Reclamation of mined land and coal waste dumps; planning and monitoring; Afforestation programmes, application of mulches, stabilizing agents and fertilizers; plant species establishment, soil characteristics, soil amendment, selection of species, economics of reclamation, Bioremediation practices and application, factors influencing bioremediation, bioremediation system and process; EIA / EMP; Policies, guidelines and legislation related to ecology and biodiversity conservation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-3-1913**			
Course Title	**Environmental Monitoring And Instrumentation**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Environmental sampling, need, scope and approaches; concentration units, precision, accuracy and recovery, detection and quantization limits, standard calibration curves. Fundamentals, purpose and types of sample preparation for trace elements and organics; principles of gravimetry, titrimetry, colorimetry, spectroscopy, electrophoresis, XRF, XRD, flame photometry, TLC, GC, ICP-OES, GC-MS; AAF/ICP-MS and Chromatograph; Analysis and interpretation of environmentakl, case stdies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-3-1914**			
Course Title	**Mine Air Emissions Monitoring And Control Engineering**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Mining and fugitive emission and control system: Techniques of identification and assessment of Quantum of emissions in mining operations and suitable control devices like condensers, spray systems, scrubbers, cyclones, ESP(s) bag filters etc.; Design techniques of air pollution control systems, International treaties related to air emissions and preparation of cost estimates; Air Quality Modelling in prediction of dispersion of pollutants in mining operations and related techniques for point, area and line sources.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-3-1915**			
Course Title	**Water Resource Management In Mining Areas**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Source and occurrence of waters in mines; water problems, mine inundation and preventive measures; mine water chemistry, source of mine water contaminants and their natural attenuation; acid mine drainage its cause and effects; mine water treatment processes; water makeup, mine dewatering processes and environmental impacts of dewatering and their mitigation; water problems and legislation in mines; Water use and demand in coal industries. Water pollution monitoring and management. Techniques of analysis and description of hydrological data related to mining, aquifer characteristics like permeability, transmissivity estimation of ground water potential and impact of withdrawal of ground water in mining.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-3-1916**			
Course Title	**Paleontology, Stratigraphy And Geophysical Exploration**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Palaeontology:branches and applications; important groups of mega and microfossils; Palaeobotany in relation to coal basins; Concepts in stratigraphy, basic principles of stratigraphy, stratigraphic classification, sequence stratigraphy; Stratigraphy of Indian coal basins; Different techniques of geophysical exploration of Indian coal basins; Case studies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-4-0001**			
Course Title	**Project Proposal**			
Credit Distribution (L-T-P-C)	0	1	2	**2**

Course Content:

Formulation of a project proposal by selecting topics of high relevance and novelty and will have state-of-the art review, methodologies, recommendations etc. in specified format in a holistic manner preferably candidate's own research work suitable for submission to appropriate funding agencies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-4-0002**			
Course Title	**Review Article**			
Credit Distribution (L-T-P-C)	0	1	2	**2**

Course Content:

Preparation of one review article on specific research area of the student.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CIMFR, DHANBAD**			
Course Nomenclature	**ENG-CIMFR-4-0003**			
Course Title	**CSIR-800 Societal Programme**			
Credit Distribution (L-T-P-C)	0	0	8	**4**

Course Content:

The students have to undertake a project in rural areas for 6-8 weeks in the line with CSIR-800 programme which is primarily prepared at empowering 800 million Indians by way of S&T inventions. The theme for the project may be chosen from CSIR-800 documents and as per expertise available in the laboratory. Students will select the topics in consultation with Doctoral Advisory Committee (DAC).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-1-2101**			
Course Title	**RESEARCH METHODOLOGY**			
Credit Distribution (L-T-P-C)	1	1	0	**2**

Course Content:

General Practices followed in Research – literature and data management; Communication skills – writing and presentation; Intellectual property rights; Scientific ethics & Safety practices.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-1-2102**			
Course Title	**MATHEMATICS FOR ENGINEERS**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Linear Algebra: Linear independence, Orthogonality, Vector Spaces and their bases and dimensions, GramSchmidt method for orthogonal basis set, Orthogonal projections. Matrices, solution methods for linear simultaneous equations, Eigenvalue problem. Vector Analysis : Vector differentiation, Applications, Vector operators: Grad, Div and Curl. Vector integration & related Integral Theorems, Applications. Cylindrical and Spherical Co-ordinate Systems. Differential Equations: Linear ODEs of first and second orders, Linear second order equations, Applications. The Laplace Transform, Applications. Fourier Series and Applications. Partial differential equations of first and second orders. The Laplace and Wave Equations.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-1-2103**			
Course Title	**INTRODUCTION TO MECHATRONICS SYSTEM**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Overview: What is Mechatronics? Instrumentation and Control System. Sensors & Transducers: Physical Principles & Basic mechanisms in sensor systems, performance characteristics, Different type of Sensors and transducers based on principles – Position and Speed Measurement, Stress and Strain Measurement, Temperature Measurement, Vibration and Acceleration Measurement; Actuators: Electromagnetic Principles, Motors – Electric, Hydraulics & Pneumatics; Mathematical Modeling: State space representation, Model Linearization, Sate model from linear graphs, Bond graphs, Modeling Electromechanical Systems. Structures and Materials, Modeling of Mechanical Systems for Mechatronics Applications, Fluid Power, Using MATLAB SIMULINK for modeling and simulation Mechatronics systems; Interfacing & Virtual Instrumentation..

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-1-2104**			
Course Title	**ADVANCED CONTROL SYSTEM**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction & Motivation: Role of Controls in Mechatronics, Mathematical Preliminaries, Review of classical control concepts, Root locus technique; Frequency response analysis, Bode Plot, Design of PID Controller, Controller tuning. State Space Design: Modeling of physical systems, Concepts of state, State-space, Representation of Linear system, Controllability and Observability, State Observers. Advance Controller Design: Kalman Filters as Dynamic System State Observers; Linear Quadratic Regulator (LQR) design, Nonlinear Control Design; Describing function, Phase-plane analysis, Fundamentals of Lyapunov Stability Theory (Autonomous Systems), Advanced Stability Theory (Non-autonomous Systems), Feedback Linearization (Input-state & Input-output linearization); Sliding Mode Control.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-1-2105**			
Course Title	**CAD & COMPUTER GRAPHICS**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Genesis of CAD, Simulation and Visualization, Concepts of CAE and Virtual Prototyping; Geometric Object Modeling – Analytical Representation of Curves & Surfaces, Various Curves and Surfaces (BSpline, Bezier, NURBS), Intersection calculations, AssemblyModeling Techniques; Computer Graphics: Linear algebra, Screen coordinates, Window coordinates, Graphics library, Rendering pipeline architecture, Homogeneous coordinates & Transformation Matrices, Quaternion, Projection matrices, Types of buffers, Display Interpolation techniques, Lightning, Wireframe, Shading models, Texture mapping, Ray casting, Ray tracing, Normal vectors, Evaluators & NURBS, Modeling of sculpture surface, selection and feedback, Concepts of scenes and scene graphics, Hierarchical Modeling Concepts, Kinematic Simulation of an Hierarchical model, Stereo Visualization.

Faculty	ENGINEERING SCIENCES			
Lab Name	CSIR-CMERI, DURGAPUR			
Course Nomenclature	ENG-CMERI-1-2106			
Course Title	ELECTRICAL AND ELECTRONIC CIRCUITS & DEVICES			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Electric Circuits and Components Network Theorems: Thevenin, Norton, Superposition, Maximum Power Transfer. Circuit Analysis, Transformer, Impedance Matching, Grounding and Electrical Interference, Electrical Safety. Semiconductor Electronics: Diodes and its' application; Operation, characteristics : Three terminal devices –- BJT, JFET, MOSFET; Four terminaldevices- SCR, Diac, Triac; Amplifiers using BJT, FET; Operational amplifiers Modern devices: CMOS, MESFET, MODFET, HBT. Computing: Number, system and code conversion, Logic gates, Boolean algebra, Combinational / Sequential Logic circuits – Latch,RS-, JK-, T-, D-, Flipflops, Buffer Register, Counters, Shift registers. Decoder, Encoder, MUX, DMUX, RAM, ROM, PROM, EPROM, EEPROM, Programmable logic devices

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-1-2107**			
Course Title	**MACHINES & MECHANISMS**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Rotation and Plane motion of a rigid body. Kinematic Pairs, Chains, Diagrams. Four Link Planar Mechanisms and their Inversions. Grubler's criterion and Grashof's criterion. Analysis of planar mechanisms – Graphical and Analytical methods Synthesis of planar mechanisms – Motion, Path and Function generation problems - Graphical and Analytical approaches Introduction to Machine Elements – Cams, Gears, Brakes, Clutches etc Cams – classification of cams and followers, nomenclature,description and analysis of follower motion, pressure angle. Determination of basic dimensions, Synthesis ofcam profiles – Graphical and Analytical methods. Gears – terminology, fundamental law of gearing, involute profile. Interference and undercutting, Simple, Compound and Epicyclic gear trains.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-1-2108**			
Course Title	**ROBOTICS**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Robotics introduction; Classification and Components; Rigid body transformation in R3; Homogeneous representation; Denavit-Hertenberg representation; Forward and Inverse kinematics; Redundant and Non-redundant robots; Differential kinematics, velocities, and their transformations; Geometric and analytical Jacobians; Manipulability, Isotropy and Workspace analysis; Manipulator statics; Velocity-force duality; Recursive computation of velocities and accelerations; Manipulator dynamics -Newton-Euler and Euler-Lagrange; Equation of motion; Path planning in joint and task space; Obstacle avoidance and optimal planning; Review of robot control methods; Optimization in robotics; Human-robot interaction; joint and link flexibilities; Walking machines and Exoskeletons; Robot hand and multifingered grasp, manipulation and control; Tendon driven manipulator.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-1-2109**			
Course Title	**MICROCONTROLLERS & EMBEDDED SYSTEM DESIGN**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Introduction to embedded systems and architecture, System design using specification and modeling tools Overview of embedded computing platforms; Microprocessors, Microcontrollers, DSP's and SoC's, Hardware – Software design and partitioning Design issues, consideration and trade–offs: Performance memory, power, timing, cost, and development time. Memory hierarchy, System Interfaces and Communication with peripheral units, timers counters, Introduction to Real-time system and Real-time Scheduling Real – time software development: High level languages and Programming issues, Systems performance: Networked embedded systems Future Trends, Applications, Tutorial & Laboratory .

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-1-2110**			
Course Title	**DIGITAL SIGNAL PROCESSING & APPLICATIONS**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Elements of Analog and Digital Signal Processing, Advantages of Digital over Analog, Sampling Theorem. Discrete Time Signals & Systems – Classification, Analysisof LT Systems, of LTI system Response to Arbitrary Inputs, Causality & Stability; Correlation, Convolution, Finite & Infinite Impulse Response, Recursive & NonRecursive Systems, Difference Equations. Z-Transform – Definition, Properties; Inverse-Z and Analysis in Z-domain. Fourier Analysis – Continuous & Discrete-Time Fourier Series, Power Density Spectrum, Fourier Transform, Frequency-Domain Characteristics of LTI Systems, DFT & Properties, Linear Filtering Using DFT, Frequency Analysis Using DFT,Understanding FFT. Digital Filter Design – Characteristics & Design of Filters. Future Trends, Applications, Tutorial & Hands-on

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-1-2111**			
Course Title	**ADVANCED MECHANICS OF SOLIDS**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Stress; Stress tensor, stress transformation, principal stresses. Equilibrium. Strain; Linear strain components, Compatibility. Constitutive Relations; Isotropic and orthotropic materials, Failure Theories. Two dimensional elasticity; Mohr's Circle. Polar co-ordinates. Airy's Stress Function for simple systems. Stress concentration factors. Stresses in pressure vessels and rotating discs. Torsion of bars of various sections. Beam bending; Deflections. Three Moment equation. Unsymmetric bending, bending stress and shear and shear center. Variational principles; Equilibrium- Virtual work and the Principle of Stationary Potential Energy, Compatibility- Principle of Stationary Complementary Energy, Castigliano's Theorems, Applications. Elastic Stability; Euler's Bucking Load for columns. Energy methods, Stability of simple frames.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-1-2112**			
Course Title	**ADVANCED MECHANICS OF FLUIDS**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Equations of fluid mechanics, Derivation of Navier-Stokes equations, Exact solutions of Navier-Stokes equations, Boundary layers, Exact solution of Boundary layer equations, Approximate methods for solving boundary layer equations, Boundary layer control, Axi-symmetric and three-dimensional boundary layers, Unsteady boundary layers, Stability Analysis, Transitional flows, Concepts of Turbulence, Introduction to Compressible Flows

Faculty	ENGINEERING SCIENCES			
Lab Name	CSIR-CMERI, DURGAPUR			
Course Nomenclature	ENG-CMERI-1-2113			
Course Title	MECHANICAL VIBRATIONS			
Credit Distribution (L-T-P-C)	3	0	0	3

Course Content:

Free vibrations and response of single-degree-of-freedom systems to harmonic, periodic and general excitations, Energy dissipation and damping, Duhamel's Convolution Integral for response to general time varying excitation. Multi-Degree-of-Freedom Systems; Lagrange's Equations. Free Vibration- The Eigenvalue Problem, Orthogonality of Modal Vectors, Dynamic response by Modal Analysis. Rayleigh's Quotient. Distributed Systems; Exact solutions of free and forced vibrations of bars and beams (axial, torsional and bending). Modal shapes and naturalfrequencies of continuous systems, Systems with lumped masses, Rayleigh's Principle Approximate Methods; Transfer Matrix Methods, Holzer's Method for Torsional Vibration, Myklestad's Method for bending vibration, Dunkerley's Method, Modal Superposition Methods

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-1-2114**			
Course Title	**COMPUTER LAB-I**			
Credit Distribution (L-T-P-C)	1	1	2	**3**

Course Content:

The Solution of Nonlinear Equations:Iterative Methods, Fixed-Point Iteration, Newton-Raphson and Secant Methods, Polynomial Equations Having Real Roots. Matrices and System of Linear Equations: The Solution of Linear Systems by Elimination, Pivoting, Triangular Factorization, Eigenvalue Problem. Approximation: Uniform Approximation by Polynomials,Data Fitting, Orthogonal Polynomials, Least-Squares Approximation by Polynomials. Differentiation and Integration: Numerical Differentiation, Numerical Integration and Associated Basic Rules, Gaussian Rules. The Solution of Differential Equations: Simple Difference Equations, Numerical Integration by Taylor Series, Runge-Kutta Methods, Multistep Formulae, PredictorCorrector Methods. Computer programming and code development of the algorithms taught in class.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-1-2115**			
Course Title	**FINITE ELEMENT METHODS**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Matrix methods review; Stationary Principles, Rayleigh-Ritz and Hellinger-Reissner Methods. Virtual Work, Governing Equations, Weighted Residual (Galerkin) Method and Weak Forms. Formulations of one-dimensional elements (axial bar, the Euler beam) using Direct and Variational Methods. Solutions to simple truss and frame problems. Interpolation, C0 and C1 elements. Convergence requirements. Isoparametric one and two-dimensional elements; Linear and Quadratic Timoshenko beam elements; shear locking. Linear 2D plane stress /plane strain element; parasitic shear. Reduced integration. Elementary theory of plates and plate elements; Mindlin and Kirchhoff element formulations, Concepts of locking. Full, reduced and selective integration techniques. Axisymmetric elements. The Best-fit paradigm of FEA.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-1-2116**			
Course Title	**ANALYSIS AND SYNTHESIS OF MECHANISMS**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Particle and Rigid Body Dynamics – Kinematics and Kinetics. Rigid body rotation, Velocity and Acceleration analysis using Instantaneous Centre (IC) of velocity, Corioli's component of acceleration, Plane motion of a rigid body. Kinematic Pairs, Kinematic Chains, Kinematic Diagrams, Four Link Planar Mechanisms and their Inversions Kutzbach and Grubler's criterion, Grashof's criterion, Analysis of plane mechanisms – Graphical and Analytical methods Dimensional synthesis of mechanism; Motion, Path and Function generation, precision point approach, Chebyshev spacing, three position synthesis, graphical and analytical approaches for four link mechanisms. Development of simple algorithms and computer programs for solving typical problems on analysis and synthesis of mechanisms.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-1-2117**			
Course Title	**COMPUTATIONAL FLUID FLOW & HEAT TRANSFER**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Discretization procedure in Finite-difference and Finite-volume methods. Fundamentals of Fluid Flow Modelling. Staggered and Collocated grids. Explicit methods: MAC,SMAC methods for solving Navier Stokes and Energy equations. Implicit Methods: SIMPLE and SIMPLER. Pressure Solvers: conjugate gradient method, strongly Implicit procedure. Grid-Generation: Algebraic, Transfinite, Poisson equation methods. Finite-volume based Navier-Stokes solution on arbitrary geometry using non-orthogonal grids. Introduction to Turbulence modelling (two equation models).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-1-2118**			
Course Title	**COMPUTER LAB -II**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Problem solving utilising application software like ANSYS, ADAMS, FLUENT etc.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2101**			
Course Title	**INTRODUCTION TO COMPUTER VISION**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Fundamentals of Computer Vision: Role of vision to achieve simple goals i.e. high level capabilities of vision using cognitive processes, geometric models and low level capability for object perception, representation of images. Computer Vision Research and Application on image formation, camera model and camera calibration, properties of projection, interaction of light and its modeling, perspective modeling, homogeneous coordinate, lens equation, types of image digitizers and image digitizing components. Feature Extraction, filtering and edge detection, fourier transform, texture primitives and texture as a pattern recognition problem, wavelets and multiresolution processing including image pyramids, subband coding, Harr Transform; multiresolution expansions and colour processing. Tutorial on Matlab platform & Project

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2102**			
Course Title	**ROBOTICS AND MACHINE INTELLIGENCE**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Artificial Intelligence, Computational Intelligence, Various Machine Learning Algorithms ,Pattern Reorganization, Computer Vision, Fuzzy Expert System, Fuzzy Automata. Fundamentals Of Robotics & Automation., Intelligent Robots, Control Systems and Components . Robot Motion Analysis and Control,Robot End Effectors,tactile and vision sensors in robotics Cognitive system for Human machine interaction. Future Trends, Applications, Tutorial & Laboratory.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2103**			
Course Title	**INTRODUCTION TO NAVIGATION & DATA FUSION**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Sensors, Sensing, Model of Sensors & Process uncertainties Introduction to estimation, estimation methods& relation between different estimators State space modeling, LTI Systems & Kalman Filter & Extended Kalman Filter Other Navigation Filters including Bayesian Filters,Information Filters, Particle Filter etc. Various Sensors used in Robotics: Accelerometer, Gyro, Compass, Encoder, Laser, Ultrasonic Sensor, Camera, Sonar, InfraRed Sensor, Tactile Sensor etc. Multisensor Data Fusion Fundamentals; INS, GPS Aided Navigation & Data Fusion Future Trends, Applications, Tutorial & Laboratory

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2104**			
Course Title	**MICRO SYSTEMS TECHNOLOGIES**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Introduction: precision engineering; multi-scale product manufacturing paradigms. Micro- Nano Manufacturing: MEMS foundry processes; micro-mechanical processes; regenerative techniques. Process Modelling: material removal mechanisms; FEA and molecular dynamics based simulations. Design of Micro Machines: sources of error; error mapping; precision drives and controls. Sensors for Precision Manufacturing: sensor systems for process monitoring, multi sensor approaches, signalprocessing and machine vision systems. Precision Metrology: definitions; laser interferometer; AFM; SEM; TEM. Micro Factory Concepts: micro assembly, composite molding, micro robotics, geometric analysis, decision systems, process planning and micro factory layout designs. Micro-nano systems engineering: module applications; micro-nano scale product design; case studies for biomedical, sensors, and nano technology applications. Tutorial and Laboratory practices

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2105**			
Course Title	**ADVANCED MATERIALS**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Basics: Mechanics of materials, mechanical properties, dislocation theory, mechanical testing methods, creep and relaxation behaviour of common engineering materials Advanced materials: Polymers, conductive polymers, ceramics, composites, nano-composites, smart materials, high temperature materials, bearing materials, materials for sensors and actuators Material characterization: Optical and X-ray spectroscopy, diffraction methods (X-ray diffraction, Crystallographic texture measurements, electron microscopy (SEM, TEM,EBSD, etc.), Atomic probe micro analysis (AFM), Thermo gravity analysis Future Trends, Applications, Tutorial & Laboratory

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2106**			
Course Title	**OPTIMAL CONTROL**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: Problem formulation, Mathematical model, Physical constraints, Form of optimal control, Performance measures, Static optimization techniques. Dynamic Programming and related topics: Introduction,Principle of optimality, Hamilton-Jacobi-Bellman equation, Continuous linear regulator problems, Pontryagin's maximum principle, Control with constraints, Time optimal control, Optimal tracking control problem. Variational Approaches: Calculus of variations, Fundamental concepts, Functionals, Euler's equation, Lagrangian, Variational approach, Optimal control law,Necessary conditions, Linear regulator & tracking problems, Multi-variable optimization problem, Linear Quadratic Regulator. Optimization Methods: Minimum time problems, Minimum control-effort problems, Kalman Filter, Non-linear system optimization, Gradient optimization techniques, Steepest ascent and decentmethod, Rosenbrock's conjugate gradient method, David-Fletcher-Power method.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2107**			
Course Title	**PRECISION MACHINE DESIGN**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Economics, project management and design philosophy, principles of accuracy, repeatability and resolution; error budgeting. Flexure design - linear and non-linear deflection, stiffness and strength, displacement vs force loads, material considerations, fatigue failure and its prevention. Bearings: rolling contact bearings, flexural bearings, gas bearings and magnetic bearings and design engineering surfaces. System design - manufacturing considerations, materials, structural design, joint design, support system and kinematic coupling design, sensors, actuators and transmissions and system integration driven by functional requirements and operating physics. Mini Project – application of theory and heuristics to the design of precision mechanical systems. Tutorial & Mini Project.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2108**			
Course Title	**NUMERICAL METHODS & COMPUTER PROGRAMMING**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Introduction, finite floating point arithmetic, catastrophic cancellation, chopping and rounding errors; Solution of nonlinear equations; bisection, , Newton's & Muller's method, fixed point iteration; Numerical optimization, Golden section search, Newton's method optimization; linear algebraic equations; forward Gaussian elimination, pivoting, scaling, back substitution, LU-decomposition, norms and errors, condition numbers, iterations, Newton's method for systems, computer implementation; Interpolation- Lagrange, Newton & inverse ; Numerical Integration; finite differences, Newton cotes, trapezoidal, Simpson's rule, extrapolation, Gaussian quadrature; Numerical solution of ODE; Euler's method, Runge-Kutta method, multi-step methods, predictor-corrector methods, rates of convergence, global errors, algebraic and shooting methods, boundary value problems, computer implementation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2109**			
Course Title	**ELECTRO-MECHANICAL SYSTEMS DESIGN**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: Electro-Mechanical systems and applications: designand analysis of micro-nano positioning systems; ultra precision screw drives; Dual drive positioning systems; flexural joints; design and kinematics analysis of parallel kinematics platforms. High Speed Power Sstems: Distributed loads in electro-mechanical motion drives; Design and dynamic analysis of high speed spindle. Analysis and Synthesis of Fluid Mechanical Systems: hydraulic actuators, micro fluidic flow problems, solving micro pump system design. Instrumentation: sensors, actuators, encoders, servo mechanisms, laser interferometery and other position calibration techniques. Future Trends: Tutorial & Laboratory practices.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2110**			
Course Title	**ANALYTICAL MECHANICS**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Optimum Path: Fermat's Principle, Brachistochrone Problem. Calculus of Variation in Mechanics for Conservative Systems. Degrees of Freedom and the Configuration Space. The Concept of Functionals and their Variations. Virtual work, the varied path. Hamilton's Principle of Stationary Action, Lagrange's Equations of Motion. Applications of Lagrange'sEquations: Equations of motion of multi-degree of freedom systems. Vibrations of discrete systems (of lumped masses) and continuous elastic systems. Lagrange Multipliers for Constrained Systems. Applications. Hamiltonian Mechanics: The Legendre Transformations, Hamilton's Cannonical Equations of Motion, Applications. Accelerating /rotating reference frames. Dynamics of rotation of rigid bodies. Central force systems; Motion of satellites.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2111**			
Course Title	**FINITE ELEMENT METHODS FOR FLUID DYNAMICS**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Fundamental concepts; strong form, weak form, Galerkinapproximation; matrix equations, element and global point of view; numerical integration – Gaussian quadrature; temporal discretization - generalized trapezoidal rule; compressible and incompressible flows; implementation of the methods; issues related to high performance computing.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2112**			
Course Title	**NONLINEAR DYNAMICS & CHAOS**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

One-Dimensional Flows; Flows on the line & circle: Fixed Points and Stability, LinearStability Analysis: UniformNonuniform Oscillator, Overdamped Pendulum. Two-Dimensional Flows; Linear Systems with classifications, Phase plane; Phase Portraits, Fixed points and Linearization, Conservative Systems, Reversible Systems. Limit Cycles, Poincare-Bendixson Theorem, Relaxation Oscillations, Weakly Nonlinear Oscillations. Bifurcations; Saddlenode, Transcritical, Pitchfork and Hopf Bifurcations. One-Dimensional Maps; Stability of Fixed Points, Periodic Points, Poincare Map, Logistic Map, Dependence on Initial Conditions. Two-Dimensional Maps; Sinks, Sources and Saddles, Linear Maps, Coordinate Changes, Nonlinear Maps and the Jacobian Matrix, Stable and Unstable Manifolds. Chaos in Two-Dimensional Maps; Lyapunov Exponents: Numerical Calculation. Chaos in Differential Equations; Lorenz Attractor, Lyapunov Exponents for Flows

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2113**			
Course Title	**MECHANICS OF COMPOSITE MATERIALS**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to Composite Materials, Classification of composites; Fibres and matrices; Manufacturing, mechanical properties and applications of composites. Stress-strain relationships for a unidirectional/bidirectional lamina; strengths, thermal and moisture expansion coefficients. Determination of physical and engineering properties of a unidirectional lamina from the individual properties of the fiber and the matrix, fiber volume fraction, and fiber packing. Determination of the elastic stiffnesses and mechanical loads on laminate based on the values of individual laminae and the stacking sequence. Failure Criteria for a unidirectional composite lamina and a laminate; Design of laminated composite and other issues.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2114**			
Course Title	**ROTOR DYNAMICS**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Introduction to rotor dynamics. Flexural vibration & Torsional vibration. Critical speeds of rotors and response to imbalance. Factors affecting them such as gyroscopic action, internal damping, fluid film bearing. Methods for analysis such as Transfer Matrix, FEM etc. Bearing and Seals rotor dynamics. Stability of rotor systems. Balancing of rotors. Concepts of condition monitoring and Signature analysis.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2115**			
Course Title	**COMPRESSIBLE FLOW**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Brief review of fluid mechanics and thermodynamics, Flow regimes, Governing equations of compressible fluid flow, 1-D inviscid flows, Flow through nozzles and intakes, Mathematical theory of characteristics, Acoustic waves, Normal and oblique shock waves, Unsteady wave motion, The shock tube and moving shock waves, shock tube relations, Flow past wedge and aerofoil, Shock- Boundary layer interaction, Numerical techniques for compressible flows.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2116**			
Course Title	**FLOW THROUGH TURBO MACHINES**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Basic thermodynamics and fluid mechanics of turbo machines, dimension less performance characteristics, cascade theory, concept of circulation, lift and drag, conformal transformation developing blade geometry, isentropic flow analysis, axial flow turbine, radial flowturbine, selection of degree of reaction and effect on efficiency, centrifugal compressor andpump, compressor surging,3-D through flow analysis of the combined stator and rotor, performance prediction, cause & effect of secondary flow on the performance, effect of turbo machine geometry and operation characteristics on the performance, off-design performance analysis

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2117**			
Course Title	**FLUIDIZED BED DRYING**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Principle of fluidization, advantages & limitations, Thermal physical properties/Geldart classification, Heat transfer in fludizied bed drying, Basic principles of drying/drying curves, effects of operating parameters, batch/continuous/mechanically assisted fluidized bed dryer, Spouted bed dryer, Diffusion/kinetic/1-2-3 phase models and design procedures.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2118**			
Course Title	**FLUIDIZED BED COMBUSTION & GASIFICATION**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Introduction - Fluidized bed equipment, Features of fluidized bed; Gasification and combustion - Theory, Effect of operating parameters and feed properties. Gas cleaning, Design consideration, Application; Hydrodynamics – Regimes of fluidization, Bubbling and fast fluidized beds, gas-solid flow structure, gas-solid mixing, Gas-solid separators; Heat and mass transfer between fluid and solid; Modeling – equilibrium modeling, kinetic modeling, CFD modeling in bubbling and circulating fluidized systems.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2119**			
Course Title	**THERMODYNAMICS**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

State of Equilibrium, First Law of Thermodynamics,Second Law and Entropy, Availability and Exergy, Postulatory (Gibbsian)Thermodynamics, General Thermodynamic Relationships, Equations of State, Thermodynamic Properties of Pure Fluids and Mixtures, Stability, Chemically Reacting Systems, Reaction Direction and Chemical Equilibrium, Availability Analysis for Reacting Systems, Chemical Kinetics

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2120**			
Course Title	**PRINCIPLES OF CASTING SOLIDIFICATION**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Thermodynamics of solidification; Single phase and alloy solidification; Cellular and Dendritic growth; Mathematical analysis of redistribution of solute during solidification; mechanism of dendritic arm fragmentation, dendritic to equiaxed globular grain transformation, alloying effect on solidification; Solidification of metallic composite materials; diffusion kinetics; Fick's Law of diffusion, diffusion and phase transformation; Multiphase flow Modelling of alloy solidification, Case studies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2121**			
Course Title	**CONVECTIVE HEAT & MASS TRANSFER**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Conservation equations, boundary layers, free convection, forced convection. Heat transfer in laminar and turbulent, internal as well as external flows, mixed convection. Combined convection and radiation. Boiling and Condensation. Molecular diffusion in fluids, mass transfer coefficient. Simultaneous heat and mass transfer; Applications.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2122**			
Course Title	**TURBULENCE**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Origin of turbulence, Scales of turbulent motion, Correlation Functions, Kolmogorov Hypothesis and Probability Density Function; Statistical description of turbulence, Experimental techniques, Classical Idealization of Turbulent Flows; Vorticity Dynamics; Dynamics of Turbulent Kinetic Energy and Important Scaling Relations; Mean flow equations and Reynolds stresses; Closure problem; Free and wall bounded shear flows, Space-time correlations, Turbulent flows in pipes and channels, Laws of wall and fully developed turbulence; Spectral dynamics, Modeling Concepts; Direct and Large Eddy Simulation;

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2123**			
Course Title	**STATISTICAL METHODS FOR ENGINEERS**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Statistical Computing: Graphical representation, Frequency distribution, Measures of central tendency and dispersion, Random variable - it's expectation and variance, Probability models – Binomial-Poission-normal. Bivariate Frequency Distributions. Scatter Diagram, Product Moment, Correlation coefficient with properties, regression lines, correlation index and ratio, Spearman rank correlation. Multiple linear regression, multiple correlation, partial correlation. Random sampling, expectations and standard error of sampling mean (without derivation), expectation and standard error of sampling proportions. Point of estimation of parameters, Maximum likelihood estimation, interval estimate of parameters, test of significance based on t, F and CHI square distribution. Large sample tests, Tests based on Pearsonian frequency CHI-square.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2124**			
Course Title	**ADVANCED ELECTRICAL DRIVES**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

A.C. phase control circuits: Single phase AC voltage regulators and cycloconverters; Power Inverters: Single phase bridge, three phase bridge and PWM inverters Drives: Selection. Control and stability of electric drives. D.C. motor controllers: Armature voltage control of separately exited DC shunts Motor; single quadrant, two quadrant and four-quadrant operation; field current control, micro controller based control circuit for motor control; A.C motor controllers: Squirrel cage induction motor control, control-stator voltage control, V/F control, control of wound rotor motor, slip power recovery D.C and AC servo motor controller; stepper motor controller; Brushless DC motor controllers; Drives for Electric and hybrid Vehicles.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2125**			
Course Title	**MTech DISSERTATION PART-I**			
Credit Distribution (L-T-P-C)	0	8	16	**16**

Course Content:

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-2-2126**			
Course Title	**MTech DISSERTATION PART-II WITH VIVA VOCE**			
Credit Distribution (L-T-P-C)	0	8	16	**16**

Course Content:

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-3-2101**			
Course Title	**ADVANCED COMPUTER ORGANIZATION & ARCHITECTURE**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Introduction of different Computer generations. Design Methodology: Introduction, CPU, registers, BUS, memory. Processor Design: Processor organization, instruction sets, fixed point arithmetic. Control Design: Instruction sequencing, Hardware control, micro-programmed control, minimizing microinstruction size. Memory Organization: Memory technology, Virtual memory, high speed memories. I/O Systems: Programmed I/O, DMA and interrupt, I/O processor. Computer Network: Communication Protocols, Circuit Switch, Message Switch and Packed Switch, CDMA. LAN, WAN etc. communication devices, Cellular Network. Parallel processors, pipeline structures, Vector Processor etc. Pipelined instruction units, Arithmetic pipelined design, Multifunction and array pipelines, designing pipelined processor, Dynamic pipelined and re-configurability, Multiple vector task dispatching.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-3-2102**			
Course Title	**APPLIED SOFTCOMPUTING**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Artificial neural network (ANN), Supervised and unsupervised learning of ANN, fuzzy logic, fuzzy membership function distributions, fuzzy logic rules, fuzzy and neuro-fuzzy inference systems, Genetic-fuzzy system, rough sets, The Hopfield Network; Support Vector Machines;Evolutionary algorithms, differential evolution, simulated Annealing, antcolony optimisation, particle swarm optimisation, hybrid-system, engineering applications of modeling and optimisation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-3-2103**			
Course Title	**OPTIMIZATION TECHNIQUES IN ENGINEERING**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Classical optimization methods, unconstrained minimization; Univariate, conjugate direction, gradient and variable metric methods, constrained minimization, Feasible direction and projections. Integer and Geometric programming, multi-objective optimization, genetic algorithms (GAs), multi-objective GA, simulated annealing techniques, engineering applications

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-3-2104**			
Course Title	**LOW POWERED EMBEDDED SYSTEM DESIGN**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Hardware-software co-design, FSM and Timed automata, Modeling and design, Poware aware scheduling techniques, SDL, SpecChart etc. Architectural synthesis for DSP, Verification of digital systems - finite state automata, ù-automata, FSM; Sampling theorem and digital signal sequence, Frequency response and FIR,DFT and FFT, Tools for DSP Analysis and design, Decimation in time and frequency, FFT algorithms, discrete cosine transform; DSP ASIC Design, Configurable Logic, Design Methodology of power aware systems, VLSI Implementation of DSP Processors, Embedded systems Architecture and assembly instruction set; Adaptive Filters, The LMS Algorithm, Adaptive Lattice Ladder Filters, Recursive Least Squares Lattice Ladder Algorithms.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-3-2105**			
Course Title	**COMPUTER AIDED METROLOGY AND MACHINE VISION**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Precision, accuracy, repeatability, reproducibility, contact and noncontact measurements, challenges of temperature, probes and environment, uncertainty of measurements. Co-ordinate Measuring Machine: construction, process, probing and software, error compensation and alignment, prismatic component inspection, profile and surface measurement. Application of Laser interferometer: Basics, flatness testing, surface contour test, scales and gratings, Moire scales and Moire fringes, diffraction measurement technique. Computer Aided Measurement Techniques: data acquisition, automatic inspection machines, knowledge based system. Vision based inspection system: Basics of image acquisition, Basics of machine vision, morphological operation for shape analysis.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-3-2106**			
Course Title	**ADVANCED FLUID FILM BEARINGS**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Basic equations of lubrication, analytical solution –finite difference and finite element methods, and application to idealized hydrodynamic bearings. Hydrodynamic instability, mechanism of hydrodynamic instability, oil whirl and stability. Externally pressurized oil bearings – hydrostatic lubrication, fixed restrictors, circular step bearings, rectangular thrust bearings and numerical solution Gas lubricated bearings –governing equations, limiting solutions, slider bearings, externally pressurized gas bearings, porous bearings and whirl instability in journal bearings. Squeeze film bearing –parallel surface bearings, step bearings and some problems under squeeze film lubrication. Elastohydrodynamic lubrication, theoretical considerations, Grubin type solution, film thickness equations, different EHL regimes.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-3-2107**			
Course Title	**WEAR OF MATERIALS & SURFACE MODIFICATIONS TECHNOLOGIES**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Surfaces and Substrates: Surface topography, physico-chemical aspects of solid surfaces, surface interactions. elastic contacts, elastoplastic contacts and importance of substrate. Friction and Wear: Laws of friction, mechanisms of friction, friction space, stiction, stick slip, surface temperature. Abrasive wear, Adhesive wear, Erosion, Corrosive wear, Fatigue wear, Delamination of wear, and Fretting wear. Applications: Wear Behavior of Engineering Materials, Metallic materials, Ceramics, Polymers and Industrial applications. Surface Modifications Techniques: Electro deposition, Flame spraying, Plasma spray, Physical vapour deposition, Chemical vapour deposition, HIP surface treatments, Sol-gel coatings and Spin coating methods. Lab Works, Tutorials and Mini Project.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-3-2108**			
Course Title	**FUNCTIONALIZATION OF SURFACE AND INTERFACES OF BIOMATERIALS**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Introduction to biomaterials: Metallic, Ceramic, Polymeric, Composite, hydrogel, natural materials. Characterization of materials, mechanical properties, thermal properties, surface properties and adhesion. Biofunctionalization of Surfaces, Self-assembly, Polymer directed self-assembly of inorganic biomaterials – Biomimetics; surface and intermolecular forces. Surface modification, 2D and 3D scaffolds for tissue engineering; Materials for artificial blood vessels, mechanical heart valves, breast implants, orthopedic joints, dental fillings, chin augmentation, devices such as intravenous catheters and drug delivery vehicles, intra-ocular lenses, burn dressings, sutures, Biomaterials for tissue replacement; biologically functional biomaterials; testing and clearance of biomaterials; evaluation of biomaterials. Hip Joint Prosthesis Fixation: Problems and Possible Solutions, orthopedic implants

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-3-2109**			
Course Title	**NANOTRIBOLOGY AND ITS APPLICATION TO MICROSYSTEMS**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Introduction to Micro and Nanotribology. Overview of surface roughness, adhesion, friction, wear and lubrication. Mechanisms of solid-solid adhesion, liquid medicated contact, lubrication approaches. Characterization techniques – SFA, STM, AFM, Nanoindenter. Nanotribology, nanomechanics and material characterization using AFM. Overview of surface imaging,adhesion, friction, wear, indentation and lubrication. Metals, Ceramics, Self-Lubricating Films. Tribological Properties of Metallic and Ceramic Coatings. SelfAssembly for Controlling Hydrophobicity, Friction and Wear. Nanotribology of microsystems, examples with tribological issues. Nanotribological studies of Microsystems' materials and lubricants, superlubricity, Reversible adhesion etc. Nanomechanics of Nanostructure, measurement of mechanical properties of Nanostructure, FEM analysis of Nano-beams with roughness etc.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-3-2110**			
Course Title	**ADVANCED PASSIVE AND ACTIVE MAGNETIC BEARINGS**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Introduction to PMB, basic principles, configurations, merits and demerits, modeling and simulation of PMB. Electro-magnetics and mathematicl model of AMB, electromechanical structure and operating principles, stored magnetic energy and force, radial magnetic bearing, unbalance pull force. Basics of active control, introduction to magnetic bearing controls, active suspended machine, PID Control, adjustment of PID gains, interference in two perpendicular axes, unbalance force and elimination. Methodology for AMB suspended rotordynamics investigation,flexible rotor AMB characterization and control, two axes system, four-axis and five axis systems. Introduction to ferrofluid, principles, synthesis, characterization, ferrodydrodynamics, design of ferrofluid bearing.Mini Project / Lab Works,Tutorial.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-3-2111**			
Course Title	**LATTICE BOLTZMANN AUTOMATA**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Introduction and Kinetics of Particles: Kinetic theory,Particle dynamics, Distribution function, Boltzmann distribution. The Boltzmann Equation: Introduction to Micro, Macro and Mesoscopic Modeling, Lattice Gas Cellular Automata (LGCA), From LGCA to LBM (Lattice Boltzmann Model), Boltzmann Transport Equation (BTE), Derivation of LBM from BTE, Chapmann-Enskog Expansion, The BGK Approximation, One, Two and Three dimensional Lattice Arrangements, Equilibrium Distribution Function. The Diffusion Equation: Finite Difference Approximation, Lattice Boltzmann Method, Boundary Conditions, Two Dimensional Heat Diffusion. The Advection-Diffusion Problem, Implementation of LBM for basic fluid flow and heat transfer problems, Some advanced topics like turbulence, two phase flow, MHD etc.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-3-2112**			
Course Title	**ROBOTS WITH JOINT FLEXIBILITY: MECHANICS AND CONTROL**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

From Rigid to Flexible Robots, Joint flexibility, Stiffness/Impedance variability, Flexible Tendon Driven System, Tendon Routing, Manipulator Statics and Stiffness, Explicit and Antagonistic stiffness variability, Tendon manipulability, Stiffness Controllability, Dynamic model of flexible joint for serial robot, Singular perturbation technique, Control methods for flexible joint robots, Feedback linearization technique, Cartesian Impedance control, Simultaneous control of motion and stiffness in variable stiffness mechanisms. New generation of human friendly robots, Macro/Mini actuation approach, Antagonistic actuation approach, Variable stiffness in legged machines, exoskeletons and artificial prosthesis.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-3-2113**			
Course Title	**ARTIFICIAL INTELLIGENCE AND DATA MINING**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Foundation of AI and history of AI intelligent agents, Searching for solutions, uniformed search strategies, Local search for constrain satisfaction problems, Rule based deduction systems, Decision Support System, Data Prediction , Sequence Discovery , Fuzzy Sets and Fuzzy Logic, Game Playing DataMining, Knowledge Representation & Reasons logical Agents, Resolution, Decision Theory, Classical planning problem, Language of planning problems, planning with state – space search, Robot Motion Planning, Overview of machine learning, Decision tree learning, Two layer artificial neural networks, Multi-layer artificial neural networks, Inductive logic programming, Genetic algorithms, Genetic programming.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-3-2114**			
Course Title	**ADVANCED COMPUTER VISION**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Review of Computer Vision Fundamentals Model Fitting: Bilinear models, symmetricmodel, asymmetric model, classification, extrapolation,translation of the data set. Structure from Motion & Image Motion: Domain dependent & domain independent motion understanding, optical flow-adjacency, depth and collision, surface orientation and edge detection, egomotion, understanding of image sequences and probability theory for clustering. Review of Bayes Theorem: Statistical decision theory, Bayes Theorem, Classifier Types-parametric, nonparametric. Classifier training-supervised, unsupervised. Maximum likelihood estimation, Bayesian estimation. Object Recognition Pose Estimation using analytical or geometrical methods and learning based methods Object Tracking with adaptive background generation & shadow removal using single & multi camera tracking techniques with common algorithms for filtering and data Association Other topics include face recognition.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-3-2115**			
Course Title	**ADVANCED NAVIGATION & DATA FUSION**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Review of Navigation Sensors & Navigation methods Probabilistic modeling & its applications toNavigation & Data Fusion (Bayes Filter) Feature detection & Representation & Map building Data Association methods: Innovation Gate, Probabilistic Data Association, Joint Probabilistic Data Association, Multiple Tracking, Correlation based method Simultaneous Localization and Map Building: Theory & Application to Navigation, Multisensor data fusion application, sonar, vision, laser radar, INS, GPS etc. AI based Robotics, Qualitative Modeling Methods, Qualitative and Behavior based Navigation, Learning Systems, Perception Modeling and its application to Robotics.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-3-2116**			
Course Title	**MOBILE ROBOTICS**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Basic Components & Modelling: Introduction, Design considerations, Key issues, Locomotion, Configurations (Legged, Wheeled & Hybrid), Kinematics, Constraints, Dynamics. Sensing & Perception: Sensors, Levels of integration & advantages, Smart Sensors, Interoceptive & Exteroceptive sensors, Sensors for mobile robots (Dead reckoning, Heading, GPS, Vision, Motion sensors, Range finders etc.), Modeling (Allan Variance), Feature extraction. Navigation, Motion Planning & Control: The challenges of Navigation & Localization, Odometry and other dead reckoning methods, Active beacon navigation system, Land mark navigation, Occupancy grids, Path planning, Kalman Filter, SLAM Classical control methods (PID, FLC etc.), Obstacle Avoidance methods. Advanced Robotics paradigms: Behavioural & Probabilistic Robotics.

Faculty	ENGINEERING SCIENCES			
Lab Name	CSIR-CMERI, DURGAPUR			
Course Nomenclature	ENG-CMERI-3-2117			
Course Title	ADVANCED ROBOT DYNAMICS AND CONTROL			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Introduction to dynamics; Spatial velocity, acceleration and force; Transformations; Momentum and Inertia; Equations of motion of multibody system and constrained motion; Robot kinematics, serial and parallel manipulators, joint models; Forward and inverse dynamics of serial and parallel manipulators, Newton-Euler algorithm, Euler-Lagrange algorithm, Robot-environment contact and impact; Multifingered hand and cooperative multi-manipulator kinematics and dynamics, internal forces and internal motion; Lyapunov stability theory; Position control and trajectory tracking; Joint and task space control; Control of constrained manipulators; Force and Impedance control; Dynamics of manipulator on mobile platform; Modelling and dynamics of underwater robots/vehicles; Thrusters; Vehicle-manipulator dynamics; Control and stability of AUV.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-4-2101**			
Course Title	**ADVANCED SELF STUDY**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Specialised advanced courses would be offered in consultation with the thesis supervisors and Doctoral Advisory Committee (DAC).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-4-0001**			
Course Title	**PROJECT PROPOSAL**			
Credit Distribution (L-T-P-C)	0	1	2	**2**

Course Content:

Formulation of a project proposal by selecting topics of high relevance and novelty and will have state-of-the art review, methodologies, recommendations etc. in specified format in a holistic manner preferably candidate's own research work suitable for submission to appropriate funding agencies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-4-0002**			
Course Title	**REVIEW ARTICLE**			
Credit Distribution (L-T-P-C)	0	1	2	**2**

Course Content:

Preparation of one review article on specific research area of the student.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CMERI, DURGAPUR**			
Course Nomenclature	**ENG-CMERI-4-0003**			
Course Title	**CSIR-800 PROJECT**			
Credit Distribution (L-T-P-C)	0	0	8	**4**

Course Content:

The students have to undertake a project in rural areas for 6-8 weeks in the line with CSIR-800 programme which is primarily prepared at empowering 800 million Indians by way of S&T inventions. The theme for the project may be chosen from CSIR-800 documents and as per expertise available in the laboratory. Students will select the topics in consultation with Doctoral Advisory Committee (DAC).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-1-3301**			
Course Title	**Research Methodology**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Description Introduction; Research terminology and the scientific methods; Laboratory practices, discipline and safety practices; Types of Research; Research process and steps; Identifying a research problem; Literature survey and appreciation of existing literature; Conception of novel approach to solve the problem; Role of modelling and simulation; Design of experiment; Quantitative methods of data analysis; Qualitative analysis; Communicating Research results; Ethics in research. Case studies

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-2-3301**			
Course Title	**Computational Methods & Numerical Analysis**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Computation & Programming: Notions of syntax and semantics of programming languages, Concept of algorithm, Systematic development of programs, Computer Architecture & Memory management, Object Oriented Programming & Data structure, parameter passing mechanisms, Program design practices. Numerical Scientific Computing: Numerical differentiation & integration, Solving polynomial equations, Computational matrix, Transforms Computer Graphics: Input / Output devices, Raster & Vector Graphics, Drawing algorithms; Windowing and 2D/3D clipping. 2D & 3D Geometrical Transformations, Viewing Transformations, Animation Techniques Statistical Analysis: Statistical Concepts, Conditional Probability and independence, Regression Analysis, Design of Experiments, Support Vector Machine, Statistical Inference, Optimisation. Practical/ Lab Work: Statistical Analysis using standard statistical package, application modelling using MATLAB, application programming practices with standard graphics libraries like open GL.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-2-3302**			
Course Title	**Technologies for Mineral Resource Utilization**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Particulate technology, particle size distribution, sizing methodology, size-reduction and classification processes; Particulates in suspension, stability, Rheology and settling; Solidliquid separation methods; Physics, chemistry, and engineering design as applied to gravity, magnetic, electrostatic, and froth flotation processes

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-2-3303**			
Course Title	**Materials Characterization Technique**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Size and surface area analysis; Interaction of X-rays with matter, diffraction techniques and applications; Optical principles of microscopy; electron diffraction, imaging (various contrasts), determination of crystal structure, burgers vector, electron beam -specimen interactions and other applications of Transmission Electron Microscopy; Applications of Scanning Electron Microscopy and, Electron Probe Micro-Analyser; Principles of Quantitative Microscopy: Overview of other characterization techniques such as Auger electron spectroscopy, Scanning Tunneling Microscopy, Atomic Force Microscopy.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-2-3304**			
Course Title	**Recycling of Material Resources**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Mining and metallurgical wastes classification, investigation and evaluation of waste deposits, waste and circulatory management during recycling. Unit operations involving materials recycling processes such as pre-treatment (physical and chemical), roasting, calcination, sintering, leaching, solid-liquid separation; Solution, concentration and purification techniques—precipitation, cementation, solvent-extraction, evaporation, crystallization, electrowinning, electroremediation; Resources and recycling technologies across the major materials sectors, and case studies including wastes in steel and aluminium production; Recycling of E-wastes and secondaries; Economic evaluation and project implementation: Flow-sheet development, mass and energy balance, costing, technoeconomic feasibility report (TEFR) preparation, financial investment in waste recycling, project planning and implementation, work safety.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-2-3305**			
Course Title	**Process Instrumentation & Control**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Introduction to instrumentation in process industry, Different types of sensors and actuators, Computerized data acquisition, Monitoring and analysis of data (Time series and spectral analysis), Process control, PID Control, Introduction to PLC, SCADA & DCS, Networking and communication in industry, Artificial neural network & Fuzzy logic based control, Laboratory work.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-2-3306**			
Course Title	**Science for engineers**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Concepts of atomic and molecular energy levels leading to description of plasma state, plasma physics—thermal and non-equilibrium plasma, plasma diagnostics, methods of plasma processing of materials and minerals; Industrial plasmas, new concepts of resource utilization using plasma, Crystal structure and defects, electron and hole in lattices, Band gap module and tailoring : -optical and electrical, variable band gap. Structure and Bonding; Molecular basis of chemical reactions, reaction kinetics, structural effect on reactivity; Complexation concepts, Spectroscopy, Metals in biological domain, Molecular engineering; Computational approaches for structure-function correlation, Surfaces and interfaces, Chemical theories involved in solution, concentration and purification, Micelles, surfactants and their application for bulk processing of mineral resources. Cell types structure and function; Bio-molecules: composition and bonding; Overview of amino acids, proteins, carbohydrates, nucleic acids, lipids, enzymes, vitamins and minerals; DNA replication; Membranes, Introduction to bio-mineral processing

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-2-3307**			
Course Title	**Fundamentals of Engineering Analysis**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Fundamental concepts of fluid flow, heat and mass transfer; Shell balance approach for molecular and convective transport processes; Formulation and solution of ordinary and partial differential equations that describe physical systems of importance in engineering; some applications to minerals and materials processing Numerical methods: finite difference, numerical solution of ordinary and partial differential equations.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-2-3308**			
Course Title	**Process Design & Simulation**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Preliminary resource evaluation methods; Identification and development of process flow sheet; Elementary evaluation of plant performance; Spread-sheet development for plant data analysis; Introduction to simulation environment using MODSIM, simulator structure, numerical analysis of simulation, sequential method of simulation, practical application of plant simulation; Materials and energy balance, mass balance smoothing, data reconciliation in terms of grade and recovery, analysis of complex flowsheet for mass balancing, examples of material balance smoothing; Application of modeling and residence time distribution concepts for plant data interpretation; Parameter estimation: linear regression, one, two, and multi-linear regression; models nonlinear in parameters; Case studies of typical proces s plant design and operation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-2-3309**			
Course Title	**Advanced Topics in Materials Resource Engineering**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Plasma Processing Introduction, Basic plasma and gas discharge concepts, Glow discharge plasmas, Thermal plasmas, Plasma torches and sprays, Plasma chemistry, etching and polymerization, Plasma coatings, Diamond and diamond-like films, Diagnostics/Probes, Plasma Spraying, Preparation of nano powders, Plasma smelting, Plasma sintering Powder Metallurgy Production of metal and alloy powder, particle size & shape, microstructure, Powder compaction, Sintering (Solid state sintering & Liquid phase sintering), Hot pressing, Sintering furnaces & atmospheres, Applications of powder metallurgy. Corrosion Science & Engineering General introduction, Electrochemical reactions, Thermodynamic concepts, Eh-pH diagram, Prevention of corrosion Rheology Fundamentals, Types of viscometers and rheometers, Applications

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-2-3310**			
Course Title	**Energy & Environment**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Important Indian minerals & related environmental issues; Environmental impact due to mining in Orissa; Case study on graphite resources of Orissa and environmental management, Environmental issues related to mining, processing and products – solid wastes, Environmental impact analysis and management plan, Case studies related to environmental management of minerals and materials industries; Effluent treatment (nutrients removal) through microbial activity, Vulnerability and adaptation technologies for sustainable development, Pollution generation and management – Effluents, Environmental laws and global issues related to environment, Conservation of energy in different production and processing steps, Energy audit in mineral and material processing industries.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-2-3311**			
Course Title	**Comminution and Classification**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Crushing; Fundamentals of size reduction, comminution laws, drop shatter tests and shatter index, single particle breakage and packed bed breakage. Primary and secondary crushing - Jaw, Gyratory, Cone, Roll crushers, Hammer mills and Rotary breakers, High compression rolls; their design construction operation maintenance and performance aspects. Grinding; Grinding mill principles, design constructions and their operations, Mill liners. Open and closed circuit grinding, Ball mill, Rod mill, Pebble mill and Autogenous mills. Application of these mills for specific processing requirements, Effect of these process parameters on mill performance. Fluid energy mills, Effect of size on liberation, Different methods of particle size analysis and graphical representation. Modelling of communication process. Recent developments in comminution energy reduction. Classification; Industrial screening; design, selection, operation and maintenance of different types of industrial screens. Dry and wet screening, Pre-scrubbing and other processes to improve screening efficiency. Hydrocyclone Classification; construction, operation and maintenance application of different types of classifiers, efficiency, solid and water balance calculations.

Faculty	ENGINEERING SCIENCES			
Lab Name	CSIR-IMMT, BHUBANESHWAR			
Course Nomenclature	ENG-IMMT-2-3312			
Course Title	Separation Processes			
Credit Distribution (L-T-P-C)	3	0	2	4

Course Content:

Gravity Concentration Techniques: Basic principles, processes, ore characteristics required for applying gravity separation techniques, main applications and related problems. Concentration criteria for gravity process. Jigs: Basic principle of Jigging, types of jigs and their relative merits and demerits for beneficiation metallic and non metallic ores. Variables affecting Jigging, Jigging practice and operation. Spirals: Spiral concentration principles, types of spirals and their main applications. Shaking Tables: Principle, role of riffles, different types of tables and their applications. Heavy Media Separators: Principles of heavy media separation, dense medium, types of separators, laboratory heavy liquid test, efficiency of dense medium separator, Organic efficiency. Advanced Gravity Separators: Multi Gravity Separators (MGS), Floatex Density Separator, Knelson Concentrator, Falcon Concentrator - their mechanism of operation and circuit configurations. General flowsheets involving gravity separation for different minerals. Coal preparation techniques for both coking and non coking coals. Washability characteristics. Flowsheets for different coals. Magnetic and Electrostatic Separation Techniques: Magnetic Separators - principle of magnetic separation, dry magnetic separators, wet high intensity magnetic separators (WHIMS), high gradient magnetic separators (HGMS), super conducting magnetic separators and their applications in mineral industries. of green pellet formation and growth; Pelletization systems: equipments used in pelletizing plants, heating systems, design, technology selection, capacity limitation for different technologies and pellet production; Pelletization kinetics: Effect of water content, bentonite and degree of fineness on pelletization kinetics and physical properties of pellets produced, granulation time; Heating cycle: Calculation of heat consumption, mathematical calculation based on case studies. Hardening of green pellets: Drying, preheating, induration and cooling; Pellet properties: size, morphology, strength, variables affecting the strength of the pellets, shatter index, tumbler index, abrasion index, porosity and reducibility. Direct reduction of iron ore pellet: kinetic study at different conditions and quantity of reductants; characterization of metallization of pellets using different techniques. Mathematical calculation on energy consumption based on case studies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-2-3313**			
Course Title	**Mineralogy and Mineral chemistry**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Process mineralogy, Liberation Studies using QEMSCAN, Mineral chemistry using EPMA, Identification of mineral phases through XRD. Geochemistry :Chemical composition of the Earth, elementary statistics for geochemistry; major, minor and trace elements including rare earth elements; element partitioning between minerals and melts; petrogenesis, Geochemical Classification of elements, Geochemical differentiation, Isomorphism, Polymorphism, Atomic substitution and Geochemical cycle. Analytical Geochemistry: Chemical analysis of rocks and minerals, digestion techniques, preparation of standards, estimation of major oxide percentages using spectrophotometric /flame photometric and titrimetric methods. Preparation of calibration curves. Gravimetric estimation of silica and R2O3. Determination of noble metals. Introduction to Neutron Activation Analysis, principles of ICP, XRF & AAS analysis. Statistical Methods in Geosciences: Introduction to probability: random experiments, events, sample space, definitions of probability. Conditional probability and independence of events, Bayes theorm. Random variables, discrete and continuous probability distributions, joint probability distributions, conditional probability distributions. Mathematical expectation, moment generating and characteristic functions. Binomial, Poisson, Normal, Gamma, Exponential, Hypergeometric, Multinomial, Chi-square, t, and F distributions. Introduction to statistical inference, sampling distributions, point and interval estimation, hypothesis testing involving one and two univariate populations. Linear models ANOVA. Linear and multiple regression. Introduction to multivariate techniques PCA, factor analysis, linear discrimina nt analysis, classification

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-2-3314**			
Course Title	**Introduction to Optimization Methods**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: Variables, Constraints, Objective function, Variable bounds
Single variable optimization: Methods based on interval of uncertainty- Simultaneous search, Sequential search, Dichotomous search, Fibonacci search, Golden section search.
Multi-variable optimization: Direct Search method-Rosenbrock's method, Quadratic convergence, Powell's method, Nelder and Mead method.
Gradient methods: Newton-Raphson method, Method of Conjugate gradient, Davidson-Fletcher-Powell method, Marquardt's method
Constrained Optimization: Equality constraints, Inequality constraints, Simplex search method, Random search method, Variable elimination method, Generalized reduced gradient method.
Multi-objective optimization: Introduction to Genetic Algorithm, Fitness function, GA operators, Real-coded GA, Simulated Annealing.
Reference Books:
1) Asghar Husain & Kota Gangiah, Optimization Techniques for Chemical Engineers, Macmillan Co. of India.
2) Kalyanmoy Deb, Optimization for Engineering Design, Prentice-Hall of India
3) S. S. Rao, Engineering Optimization: Theory and Practice, Wiley-Interscience

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-3-3301**			
Course Title	**Computational Fluid Dynamics**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Introduction to Computational fluid dynamics; Conservation equations: momentum, energy and mass balance equations; Discretization methods: Finite difference method, Finite element method, Finite volume method; Structured and unstructured grid; Multiphase flows: fluid-fluid, fluid-solid; Turbulence modeling: Direct Numerical Simulation, Large Eddy Simulation, Reynolds Averaged Navier Stokes model; CFD modelling of some mineral and material processing unit operations; Introduction to CFD software.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-3-3302**			
Course Title	**Advanced Materials: Characterization and Processing**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Theory: Fundamentals of crystallography, crystal structure and structure determination by XRD, electron diffraction and neutron diffraction in polycrystalline materials, stereographic projection and pole figures, orientation and texture analysis, structure of metals, alloys, solid solution, concept of amorphous, glassy and nano materials and their characterization, defects in crystals, theory of dislocation, Burger vector, plastic deformation, stress measurement by XRD, strengthening mechanism, cold working and heat treatment of steel, hardness and tensile test of steel, concepts in fracture mechanics and fracture determination methods, S -N curve, low cycle fatigue, fatigue mechanism. Practical: Study of types of high temperature furnaces including plasma furnace, induction and vacuum induction furnace, study and determination of vacuum in rotary and diffusion pumps, high temperature determination by thermocouple and pyrometer, morphology and microstructure observation by various microscopy methods (SEM, TEM, AFM, optical), XRD, Raman spectroscopy and identification of impurities and precipitates in metals, microhardness and nanoindention measurements, tensile, fracture toughness and fatigue tests of steel

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-3-3303**			
Course Title	**Signal Processing for Intelligent Sensor**			
Credit Distribution (L-T-P-C)	4	0	0	**4**

Course Content:

Part I: Fundamentals of Digital Signal Processing Sampled Data Systems; Z-Transform; Digital Filtering; Digital Audio Processing; Linear Filter Applications; Part II: Frequency Domain Processing Fourier Transform; Spectral Density; Wave number Transforms; time-frequency analysis Part III: Adaptive System Identification and Filtering Linear Least-Squared Error Modeling; LMS; RLS and its variants; Block adaptive filters Part IV: Soft-computing based intelligent sensing Application of neural, fuzzy and evolutionary computing algorithms to intelligent sensor Part V: Signal Processing Applications Noise Reduction Techniques; Sensors and Transducers; Intelligent Sensor Systems; Sensor nonlinearity compensation; Making sensing independent of environment change; soft sensor Text Book:

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-3-3304**			
Course Title	**Soft and Evolutionary Computing**			
Credit Distribution (L-T-P-C)	4	0	0	**4**

Course Content:

Introduction: Computational intelligence, Neural network: Back-propagation, feed-forward, hybrid systems; Supervised learning: Perceptions, multilayer perceptions, basis function: Unsupervised Learning: Kohenen selforganizing networks, Hebbian learning, Hopfield Learning; Fuzzy Logic: Fuzzy set theory: Fuzzy sets, set-theoretic operations, membership functions; union, intersection and complement, fuzzy rules, reasoning and interference. Genetic Algorithm: GA-concept-encoding, fitness function, population size, selection, crossover and mutation operators, along with the methodologies of applying these operators; Binary GA and their operators, real subject coded GA and their operators. Hybrid System: Neuro-Fuzzy modelling, adaptive neuro-fuzzy interference systems (ANFIS), classification and regression trees, CART algorithm, data clustering, neuro fuzzy control, fuzzy logic and GAs, neural network weight update with GAs. Discrete optimization: Soft computing application: Case studies in the areas of sensors and instrumentation

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-3-3305**			
Course Title	**Digital Image Processing**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Digital Image fundamentals; Image enhancement, Grey level transformations, Histogram processing, spatial filtering, Image enhancement in frequency domain, edge detection, Image Restoration: Color image processing, Morphological image processing, Image segmentation, object recognition, computer tomography, and Triangulation method

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-3-3306**			
Course Title	**System Design for Process Control**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Measurement techniques and instruments for various processes; Functional elements of control system; Design and analysis of SISO/MIMO feedback control system; Feed forward and adaptive control strategies; Functional Analysis : fundamental and common non-linearities; Phase plane analysis, limit cycles and linearization; Stability concept, methods, disturbances and analysis; P, PI, PID control analysis, design, implementation, comparison and applications; Virtual instrument design approach for industrial control; Introduction to microcontrollers family architecture, programming; Interfacing techniques for memory, I/O devices, peripherals; Modern control concepts: static and dynamic optimization, self-tuning control, sliding mode control; Typical applications and project case studies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-3-3307**			
Course Title	**Intelligent Sensor Systems Laboratory**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Laboratory practices and safety considerations; Sensor interfacing; Signal conditioning of various sensors such as temperature, gases, pressure, humidity; Sensor calibration and excitation techniques; Virtual instrument and GUI design; Interfacing with dSpace 1104; Analog and digital I/O; File I/O; Integration of sensor, DAQ and GUI modules; Study of Matlab/Scilab; Implementation of Fuzzy systems and algorithms; Implementation of neural network algorithms; Implementation of neuro-fuzzy algorithms on real-world data sets; Implementation of signal processing algorithms; Implementation of dimensionality reduction algortithms; Implementation of classification algorithms.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-3-3308**			
Course Title	**Process control and Instrumentation Laboratory**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

1. Experimentation on Thermocouple and Temperature indicator and Temperature scanner; 2. Experimentation on Temperature sensor and its computer interfacing 3. Experimentation on Pressure sensor and pressure calibrator 4. Interfacing pressure sensor with PC using LabView 5. Experimentation with Load-cell 6. Position measurement with potentiometer 7. Accelerometer signal acquisition and analysis 8. Controlling Different types of valves and relays 9. Simulation for nonlinear compensation of LVDT 10.Simulation for Fuzzy control system 11.Genetic algorithm based optimization 12.Image acquisition and processing using Matlab 13.Image acquisition and processing using compact vision system 14.Experiment on long distance wired communication 4-20mA and RS485. 15.Experiment on wireless communication

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-3-3309**			
Course Title	**Image and Video Processing Laboratory**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Matlab and Labview based experiments on Image enhancement, Grey level transformations, Histogram processing, spatial filtering, Image enhancement in frequency domain, edge detection, Image Restoration: Color image processing, Morphological image processing, Image segmentation, object recognition using both offline and online images and videos.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-3-3310**			
Course Title	**Process Control Laboratory**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Laboratory practices and safety considerations; LabView usage and programming; Assembling/populating, PCBs for process control applications; microcontroller programming; Process parameters monitoring; Control of actuators, valves and pumps Flow monitoring and control; dSpace system usage; Active noise control; Mini-project.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-3-3311**			
Course Title	**Design, Simulation and Optimisation of Mineral Processing Plants**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Description of beneficiation processes of different types of ores like iron ore, coal, sulphide ores etc.; development of conceptual process flowsheet; material and energy balance. Design of mineral processing equipment: tumbling mill, hydrocyclone, vibrating screen, pump box, flotation cell, flotation column, thickener and filtration unit. Elementary discussion on simulation and modeling of processes; simulation of the processes using MODSIM, UCMAC simulators, numerical analysis of simulation, sequential method of simulation, practical application of plant optimization. Electrostatic Separators; Principle of electrostatic separation, types of separators and their application.

Faculty	ENGINEERING SCIENCES			
Lab Name	CSIR-IMMT, BHUBANESHWAR			
Course Nomenclature	ENG-IMMT-3-3312			
Course Title	Surface Phenomena and its Application			
Credit Distribution (L-T-P-C)	3	0	2	4

Course Content:

Flotation: Introduction, principle of flotation, history, flotation science and engineering. Surface chemistry, particle surface and its modification, surface energy of mineral and coal particles, surface activation, solubility of minerals in water, reaction between mineral surface and dissolved components, molecular adsorption, ionic adsorption, specific adsorption, surface wettability and contact angle, zeta potential, adsorption of reagents, floatability test of minerals, mineralization of air bubbles in flotation, formation of gas bubbles on a mineral particles, combined bubble attachment to a mineral surface, bubble-particle interaction, aeration and froth formation, types of froth and stability of froth. Flotation reagents for minerals and coal: Collector, frother, activator, depressant, dispersant, wetting reagents and pH regulator. Factors affecting flotation: Effect of mineralogical characteristics, effect of petrography constituents of coal, effect of particle size and shape, effect of pulp density, effect of pulp temperature, effect of composition of process water, effect of reagent dosage, effect of feed rate and effect of slimes. Flotation kinetics and release analysis. Flotation practice and machines: Flotation process, pulp preparation, conditioning, aeration, different types of flotation cells, factors affecting the size of the flotation cell, determination of number of cells and size, auxiliary flotation equipment and design of flotation circuit. Column flotation: Introduction, basic design and operation, effect of design and process variables, advantages over the flotation cell and hydrodynamics study by axial dispersion model. Rheology: Fundamentals, effect of surface properties, effect of particle and fluid properties, effect of chemical additives and its application. Flocculation: Mass flocculation, selective flocculation, sedimentation and design of thickener. Filtration: Principle of filtration, effect of surfactants in filtration process, types of filtration equipment.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-3-3313**			
Course Title	**Agglomeration and Direct Reduction of Iron Ore**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Brief introduction on characterisation, beneficiation of Indian iron ores, basic conceptual commercial process flowsheet development, Agglomeration process like briquetting, sintering and pelletisation, brief description on briquetting and sintering Introduction to pelletization: world scenario, resources and production, deposits, production and demand for iron and steel, Concept of pelletization process: raw materials and their preparation (iron ore, binder, additives, preparation), formation of green pellets, mechanisms

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-4-0001**			
Course Title	**PROJECT PROPOSAL**			
Credit Distribution (L-T-P-C)	0	1	2	**2**

Course Content:

Formulation of a project proposal by selecting topics of high relevance and novelty and will have state-of-the art review, methodologies, recommendations etc. in specified format in a holistic manner preferably candidate's own research work suitable for submission to appropriate funding agencies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-4-0002**			
Course Title	**REVIEW ARTICLE**			
Credit Distribution (L-T-P-C)	0	1	2	**2**

Course Content:

Preparation of one review article on specific research area of the student.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IMMT, BHUBANESHWAR**			
Course Nomenclature	**ENG-IMMT-4-0003**			
Course Title	**CSIR-800 PROJECT**			
Credit Distribution (L-T-P-C)	0	0	8	**4**

Course Content:

The students have to undertake a project in rural area for 6-8 weeks in line with CSIR-800 programme which is primarily prepared at empowering 800 million Indians by way of S & T inventions. The theme for the project may be chosen from CSIR-800 document and as per expertise available at individual laboratory. Students will choose the topics in consultation with Doctoral Advisory Committee (DAC).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-1-1601**			
Course Title	**Mathematical fundamentals**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Linear Algebra: Linear independence, Orthogonality, Vector Spaces and their bases and dimension. Matrices and Linear Mappings, Solution methods for Linear Simultaneous Equations, Eigenvalue problems. Statistics: Binomial distribution, Poisson distribution,Normal distribution, Test of significance, Chi-square test, t-test, Analysis of variance. Differential Equations: Linear ODEs of first and second orders, Systems of first order ODEs, Applications of homogeneous and non-homogeneous linearsecond order equations. Partial Differential Equations, Solving various ODEs, PDEs.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-1-1602**			
Course Title	**Heat and Mass Transfer Operations**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Heat transfer- conduction, convection and radiation withexamples; steady and unsteady heat transfer, overall heat transfer coefficient and its significance; Heat exchange equipments- types, relative merits and demerits; Radiation heating;Infra red and solar heating- principles, applications and equipments; Evaporation-classification and uses of evaporators, multiple effect evaporation, vapor recompression, basic calculations; Mass and momentum transfer operations: theory and applications in food processing

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-1-1603**			
Course Title	**Research Methodology**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Definition of research and its objectives, types of research, literature review and organization of effective communication, reference management, ethics, lab safety practices. Collection and interpretation of research data, documentation and presentation of research output as publication in peer reviewed journals. Good laboratory practices, guidance for Ph.D thesis writing and submission. Intellectual property rights, patents, and scientific documentation of research outputs.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-2-1601**			
Course Title	**Principles of Food Engineering**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Units, dimensions and conversions, material and energy balances, properties of steam, moist air, steam tables and psychometric charts, properties of solid food materials- shape, density and porosity, pressure drops and pressure head and energy relationships, flow properties of liquid foods, pulps and slurries, viscosity, consistency, simple rheological models, pumps, pipes and valves- classification and uses.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-2-1602**			
Course Title	**Instrumental Techniques**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Spectroscopy principle and applications in analysis of food constituents; Qualitative and quantitative analysis of food constituents; Chromatographic methods for separation of proteins and determination of molecular mass and homogeneity; Structural characterization of potent biomolecule by state of art instrumental methodologies such as HPLC, GC/GLC, LC-MS, NMR and others; Determination of additives and preservatives in food; Determination of shelf life of packaged foods; Sensory profile of food products- texture, aroma flavor, consistency and overall acceptability; Rheological characterization of dough and batter; Microscopic analysis of food material; Particle size analysis; Evaluation of food ingredients and products for microbial safety

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-2-1603**			
Course Title	**Innovative Food Processing Technologies**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Principles and applications of high pressure processing, Food irradiation – advantages and applications, Applications of ohmic heating, Pulsed electric field processing, Microwave and infra red processing, Smart packaging and supercritical fluid extraction.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-2-1604**			
Course Title	**Fermentation Technology**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Types of fermentation processes, kinetics of microbial growth and death, bioreactors for microbial culture, batch, fed batch and continuous bioreactor design and analysis; scale-up of bioprocess; downstream processing of biological materials; immobilized enzyme technology; effluent treatment; fermented foods and beverages.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-2-1605**			
Course Title	**Industrial Microbiology**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Developmental phases in the science of microbial fermentation, isolation and maintenance of microbial cultures, solid state and submerged fermentations, kinetics of microbial growth phases, operations of bioreactors and process control, design and analysis of batch, fed batch and continuous bioreactors. Microbial production processes for colours, flavours, enzymes, amino acids, vitamins and polysaccharides for foodapplications

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-2-1606**			
Course Title	**Significance of Food Preservation**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Objectives of food processing; Composition of foods; Degree of perishability of unprocessed foods; Causes of quality deterioration and spoilage of perishable foods; Intermediate moisture foods; Principles and methods of blanching; Test for adequacy of blanching; Conventional methods of preservation – Dehydration, Canning, Freezing, Fermentation, Smoking, Pickling, Chemical preservatives and others; Methods of drying and their application to fruits & vegetables; Procedures and technological applications relating to storage of foods at low, chilling and freezing temperatures

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-2-1607**			
Course Title	**Canning of Foods**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Basic principles of canning; pH classification of foods; Tin plate containers including coating methods; Can fabrication; Aluminum cans; Canning of fruits & vegetables / meat products

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-2-1608**			
Course Title	**Critical survey**			
Credit Distribution (L-T-P-C)	0	1	0	**1**

Course Content:

State-of-the art review, methodologies, recommendations etc. for topic related to thesis research.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-2-1609**			
Course Title	**Thermal processing of Foods**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Principle and types of retorts, thermal destruction of microorganism determination (D, z, & F0 values) and heat resistance in microorganism. Cooking, blanching, pasteurization and sterilization of foods, heat penetration and inoculation pack studies

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-2-1610**			
Course Title	**Hurdle Technology**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Principles and application; Intrinsic and extrinsic factors as effective hurdles; Behaviour of microbial contaminants in food system; Shelf life determination

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-3-1601**			
Course Title	**Seminars in topics of courses listed in level 300**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

N/A

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-3-1602**			
Course Title	**Food Process Engineering**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Drying- theory of drying, types of driers and their applications; Distillation- principles, applications and equipments-steam distillation and molecular distillation; Extraction and leaching- principles, equipment, types and applications; Separation methods- equipment and applications, sedimentation, centrifugation, filtration and membrane processing; Particulate solids, size reduction, size measurement, dry and wet grinders; Food emulsions, basics and examples; Homogenizers and colloid mills - principles and types; Mixing and kneading – equipment and applications

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-3-1603**			
Course Title	**Nano-Technology in Food Processing**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Introduction to nanostructured materials with thermodynamics and quantum mechanics for nano scale systems and engineering principles for nanotechnology. Fundamentals of food nano-technology - nano-encapsulation techniques, nano-emulsions, nano-particles, nanodevices and nano-sensors. Nano-materials characterizationand imaging techniques.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-3-1604**			
Course Title	**Packaging Technology**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Packaging technology and its importance to food processing and preservation. Packaging systems, chemical and physical testings for packaging materials. Types of packaging materials – paper boards, bags, pouches, plastic films, aluminum foils, metalized films, laminations and co-extruded films, tin plate, aluminum cans and composite cans, glass containers, rigid plastic containers, collapsible tubes, corrugated fiber board boxes and miscellaneous containers. Aseptic packaging and retort pouches.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-3-1605**			
Course Title	**Advanced Separations**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Mass transfer applications to separations, unit operations in separation: membrane separation, centrifugation, demixing, adsorption, distillation etc, fundamentals of separation equipment design.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-3-1606**			
Course Title	**Food Plant Management**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Definition and scope of food plant management with plant design and machineries along with regulatory requirement. System analysis-basic principles and methodologies, management and its role in planning and coordination. Market research and promotional avenues,financial aspects and inventory control. Demand and supply in food industry, computer applications in food processing sector.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-3-1607**			
Course Title	**Advances in drying technology**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Introduction to drying: theory of drying and principles, types of dryers and selection of drying methods, spray drying and its applications. Innovative drying methods in food processing: infrared drying, microwave drying, radio frequency drying, superheated steam drying and Spray-freeze-drying. Application of drying methods in micro and nanoencapsulation processes, Computational Fluid Dynamics and Finite ElementModelling of drying process.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-3-1608**			
Course Title	**Modelling in Food Processing**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Introduction to numerical methods - ODEs, PDE, FEM and FVM. Design and computational programming – ANN, AutoCAD, Matlab, ProE. Transport phenomena and examples in transport phenomena; Industrial flow modeling; Modeling of food and biological systems.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-3-1609**			
Course Title	**Technology of Cereals and Pulses**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Characteristics of wheat & its milled products – physical, chemical and rheological; Influence of ingredients, processing conditions and additives on quality attributes of bakery products; Physical & chemical characteristics of rice and rice-based processed products; Cooking quality of rice; Parboiling of paddy; Processed products ofmaize, sorghum and finger millet; Processing of pulses including cooking quality; Oilseeds as source of edible protein and oil; Extraction methods for edible oil – ghanni, expeller and solvent; Processing of oilseeds for protein concentrates and isolates

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-3-1610**			
Course Title	**Technology of Fruits and Vegetables**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Maturity indices in fruits and vegetables; Post-harvest spoilage – microbiological and physiological; wax coating; fruit ripening; Measurement of texture & colour in fruits and vegetables; Canning of fruits and vegetables; Preparation of fruit juices/beverages – RTS, squashes, syrups, lime juice cordial; Tomato-based juice, puree, paste, ketchup and soup; Fruit juice concentrates and powders; Fruit & vegetable-based pickles; Preserves and candies; commercial cold storages and supply chain management

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-3-1611**			
Course Title	**Food Safety**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Microbial contaminants – spoilage & pathogenic bacteria and fungi; Microbial toxins; Limiting factors for survival/growth of pathogenic and spoilage microorganisms; Other food contaminants – heavy metals and residues of pesticides & antibiotics; Food regulations – national and international; Quality systems in food chain – ISO 9001, 14001, 17025 and 22000

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-4-0001**			
Course Title	**Project Proposal**			
Credit Distribution (L-T-P-C)	0	1	1	**2**

Course Content:

Preparation of Project Proposal in non-Ph.D. research area of targeted focus. This would focus on the following: Identification of a research topic of relevance (non-Ph.D. programme) in the area of food science and technology; Status of literature as in public domain focusing on IPRs; Reason for selecting the topic;Questions to be asked; Proposed hypothesis as a solution finder; Gaps in existing knowledge base and answers therein; Cost/economic analysis and commercial viability.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-4-0002**			
Course Title	**Review Article**			
Credit Distribution (L-T-P-C)	0	1	1	**2**

Course Content:

Preparation of one review article on specific research area of the student. This would include the following: Preamble to the proposed topic of research; Review of literature taking into account contemporary aspects in prior art; Objectives; Programme of work including methodology; Relevance of proposed Ph.D. programme in the context of national and international scenario; Impact and benefits to CSIR and the Institute's knowledge base; Final submission as a project document

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CFTRI, MYSORE**			
Course Nomenclature	**ENG-CFTRI-4-0003**			
Course Title	**CSIR-800 Societal Programme**			
Credit Distribution (L-T-P-C)	0	2	2	**4**

Course Content:

Project to be undertaken in line with CSIR-800 focussed programme of CSIR; Theme of project to be selected from the objectives and commitments of respective Laboratory (CSIRCFTRI, Mysore) in CSIR-800, wherein the enrolled Ph.D. Scholar is pursuing Ph.D. programme

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-1-4501**			
Course Title	**Tools & techniques of materials characterization**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Basics of Materials Characterization,Principles of optics & optical microscopy and stereology, Electron microscopy (SEM & TEM), X-ray diffraction & crystallographic analysis, analytical electron microscopy, Advanced characterization techniques.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-1-4502**			
Course Title	**Advanced Metallurgical Thermodynamics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to thermodynamics, First law of thermodynamics and related thermodynamic laws, Second law of thermodynamic and related properties, Third law of thermodynamics and related issues, Concept of free energy, standard state etc, Fugacity, activity, concept of standard state, Equilibrium constant involving gas and condensed phases, Dependence of equilibrium constant and free energy on temperature, Thermodynamics of solution, Partial molar quantities, Roult's law, Henry's law, Alternative standard state, Seiverts law, mixing, excess function, Gibbs Duhem equation, regular solution involving multi-component systems, Ellingham diagram and its application in metallurgical system, Phase equilibria Construction of binary and ternary phase diagram, Concept of Computational thermodynamics, Application of Computational thermodynamics using thermocalc.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-1-4503**			
Course Title	**Kinetics of Metallurgical Processes**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to kinetics, Kinetics of homogenous and heterogeneous chemical reactions, Empirical and semi-empirical kinetics, Non-isothermal kinetics, Electro-chemical kinetics, Mass transfer in solid, fluid and at interface, Application of mass transfer to reaction kinetics in heterogeneous systems, Nucleation and growth.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-1-4504**			
Course Title	**Introduction to Materials**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Inter-atomic Interactions & Materials; Solid State of Material: Bonding in solids Atoms in a Solid Material : Basic Concepts of Crystallography : Symmetry Operations, Unit cell, Lattices, Planes, Directions, Bravais Lattices, Point Group Symmetry, Space Group Symmetry. Concept of commensurate, incommensurate and quasiperiodic structures. Structure of Solids: Packing of atoms in 3d-space, packing density. Defects in solids (point, lineand planner defects) Metallic Materials: Concept of phase, phase rule and phase diagram for single and binary systems. Invariant reactions in phase diagram. Concept of CCT and TTT diagram. Phase Transformation: Nucleation and Growth, Diffusion and Diffusion Equations. Diffusion LessTransformations. Mechanical Behaviour of Materials: Strength of a Material, Ductile Vs Brittle Material (Conceptof stress, strain and related aspacts). Basics of Polymers and Ceramics.

Faculty	ENGINEERING SCIENCES			
Lab Name	CSIR-NML, JAMSHEDPUR			
Course Nomenclature	ENG-NML-1-4505			
Course Title	Advanced Mathematics and Numerical Analysis			
Credit Distribution (L-T-P-C)	3	0	0	3

Course Content:

Matrix Algebra : Basic definition, Solution of linear systems- Matrix inversion method, Gauss Jordan elimination, , LU factorization, Solution of general Eigen value problem Solution of Algebraic and Transcendental Equations : Bisection method, Method of False position, Iteration method, NewtonRaphson method, Solution of systems of nonlinear equations, Gauss-Seidel method Interpolation: Finite Differences (Forward, Backward and Central differences), Newton's interpolation formulae. Lagrange Interpolation. Numerical Differentiation and Integration: Numerical integration by Trapezoidal rule, Simpson's rule and Gaussian quadrature. Numerical solution of Ordinary differential equation: Elementary stepping algorithms, First order differential equation by Picard's method, Euler's method. Runga-Kutta method, Predictor-Corrector method. Elementary numerical methods for partial differential equations: Introduction to partial differential equations and boundary conditions, Explicit and implicit finite difference equations, Crank-Nicolson method Elementary statistics and Linear least square analysis: Statistical description of data, Distribution functions, Least square fitting of a straight line, Least square fitting of polynomials

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-1-4506**			
Course Title	**Advanced Materials**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Structure and functional properties of advanced materials (theory and practice); synthesis and characterization; amorphous, nanocrystalline and nanostructured materials; crystalline alloys and oxide materials; shape memory alloys; carbon based materials; applications: energy, sensors and actuators.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-1-4507**			
Course Title	**Research Methodology & Technical Communication Skills**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

N/A

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4501**			
Course Title	**Principles and Advances in Iron Making**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Principles of Iron making, Techniques of agglomeration (sintering and pelletization), Raw materials characterization (RI, RDI, Swelling index, Tumbler, shatter), BF iron making process and modeling, Sponge iron making (coal base, gas base). Alternative routes of iron making (COREX, HISMELT).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4502**			
Course Title	**Principles and Advances in Non-ferrous Metallurgy**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

N/A

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4503**			
Course Title	**Transport Phenomena in Metallurgical Processes**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Fundamentals and applied aspects of transport phenomena with and without chemical reactions in metallurgical processes, Non-isothermal kinetics of heterogeneous chemical reactions accompanied by various transport processes in metal extraction, Principles of mathematical modeling and simulation and computational fluid dynamics and their application in metallurgical processes.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4504**			
Course Title	**Mineral Processing**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Mineral characterization, sampling, crushing and grinding, size classification, gravity concentration, magnetic and electrostatic separation and their application in mineral industries, surface chemistry and froth flotation principles, dewatering techniques, size enlargement processes, material balance and data reconciliation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4505**			
Course Title	**Advanced Minerology**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Fines partitioning – size and density, advanced gravity techniques – recent developments and applications in the processing of fines, selective flocculation, flotation – recent developments, plant practices and case studies in flotation, thickening, filtration, drying, agglomeration of fines - briquetting, pelletization and sintering, case studies and recent developments in agglomeration.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4506**			
Course Title	**Materials processing and manufacturing**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Non-metallic engineering materials, Functional materials, Nano-structured materials. Hot metal processing, Casting and solidification, Rapid quenching techniques, Thermomechanical processing techniques, Welding and joining technology, Machining and surface processing, Material evaluation and quality control

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4507**			
Course Title	**Materials Selection and Design**			
Credit Distribution (L-T-P-C)	2	1	0	**3**

Course Content:

Brief overview of bonding, crystal structure, defect structure; Light metal alloys, Cast irons and steels, Nickel base alloys, Non-metallic engineering materials, Relationship between processing-structure-properties of various engg materials Principles of alloy design; Tools used in designing materials- an Introduction: Processing constraints in design Materials selection criterion type, microstructural factors, performance criteria: in service and other strategic requirements of engineering components to be designed Economic consideration Technologically important material properties –physical, mechanical, thermal, optical, electrical properties, materials used in important engineering sectors Methodology for selection of materials for the component

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4508**			
Course Title	**Mechanical Behaviour of Materials**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Introduction to simple concepts of stress and strain tensor; Elastic stress-strain relationship; Strain energy; Mohr's circle; Plastic yielding of material; Yield point; Yield criteria; Yield locus; Flow curve, Concept of crystal geometry; Lattice defects; Modes of deformation: slip and twinning; Critical resolved shear stress for slip; Slip in a perfect lattice; Slip by dislocation movement; Stacking faults; Fundamentals of indentation hardness; Brinell, Meyer, Vicker, Rockwell hardness; Hardness conversion; Relationship between hardness and flow curve; Hardness at high temperature; Engineering stress-strain curve; True stress-strain curve; Strength and ductility measurement in a tension test; Effect of strain rate/temperature on tensile behaviour; Necking criteria; Notched bar and drop weight impact tests; Transition temperature curves; Instrumented impact testing; Introduction to fracture mechanics based design, creep and fatigue behavior of materials.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4509**			
Course Title	**Smart advanced materials for functional applications**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Theoretical approach to materials design & synthesis; bulk, nanostructured and multifunctional materials, materials for future technology, Advanced Magnetic materials for sensors, nanostructured ceramic materials for structural applications, damping materials, fine processing of advanced alloys, Foams, innovative processing of materials newer processes: biomimetic, SHS, severe plastic deformation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4510**			
Course Title	**Physical Metallurgy of Steels**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Effect of Alloying element in steel; Strengthening mechanism in steel; Hot rolling of structural steel; HSLA steel and controlled rolling; Heat treatment processes in steel; Alloy steels: DP steels, Stainless steels, Martensitic steels, Bainitic steels, TRIP/TWIP Steels; Tool steels, Hadfield steels, Maraging steels; Welding: sensitization, schafler diagram, intermetallic embrittlement, deformation induced phase transformation

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4511**			
Course Title	**Corrosion and Control**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Interaction of metals' with environments, formation of electrical double layer at metals - environments interface, mixed potential theory of corrosion, Stearn-Geary and Tafel equations, stress assisted corrosion and cracking , principles involved in controlling corrosion,Development of corrosion resistant alloys and materials, protective coatings, cathodic andanodic protection, passivity, Pourbaix diagram for metals and alloys, Corrosion inhibitors.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4512**			
Course Title	**Principles and Advances in Steel Making**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Principles of steel making, Different processes of steel making, Secondary steel making, Ingot casting and continuous casting, Electric processes (EAF and Induction furnace), Alloy steel making.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4513**			
Course Title	**Advances in Non-ferrous Metal Extraction**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Advances in extraction of: Base metals (Cu, Pb, Zn), Light metals (Al, Mg Ti, Na), Rare metals (Ga, Ge, Se, Te, W, Mo, Zr/Hf) and PGMs, Rare earth metals; Non-traditional resources of non-ferrous metals and metal extraction.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4514**			
Course Title	**Coal preparation technology**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Coal characterization, impurities in coal, washability curve and release analysis, coarse coal cleaning, processing of coal fines, dewatering and drying practices in coal preparation, current advances in coal cleaning, coal flotation, typical flow sheets for coal preparation plants and recent developments, dry beneficiation of coal.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4515**			
Course Title	**Advanced metal working techniques**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Metal working processes: Forging, rolling, extrusion, wire drawing; Powder forging, rolling and extrusion; Principles of advanced materials forming Introduction to deformation maps; Workability of materials; Effect of process and alloy composition; Introduction to sheet metal forming; Advanced sheet metal forming techniques; Forming limit criteria, Forming limit diagram, flow localization

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4516**			
Course Title	**Principles of Physical Metallurgy**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Crystal structures and defects in solid; Diffusion; Thermodynamics and kinetics of transformations; Equilibrium phase diagram; Solidification; Solid state phase transformations; Strengthening mechanism; Engineering Alloys.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4517**			
Course Title	**Creep, Fatigue and Fracture mechanics**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

High temperature material behaviour; Time dependent mechanical behaviour; The creep curve; Stress rupture tests; Mechanism of creep deformation; Creep resistant materials/components; Structural/microstructural changes during creep; Introduction to standard test practices; Fracture mechanics as a design concept; Strain energy and stress intensity factor; Linear elastic and elasto-plastic approach to fracture mechanics; Fracture toughness K, J-integral, CTOD; R-curve; Introduction to standard test practices; Stress and strain cycles; Different approaches to fatigue design: Total life approach and defect tolerant approach; High cycle fatigue; S-N curve and FCGR; Low cycle fatigue: cyclic stress-strain curve; Coffin-Manson relationship; Strain life equation; Fatigue deformation mechanisms: PSB, cell, lybrint; Introduction to standard test practices.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4518**			
Course Title	**NDE techniques for materials evaluation**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Basic Metallurgy for NDE: Metallurgical defects, Mechanical behaviour of materials, Fracture Mechanics, Modes of failure like fatigue, creep, corrosion, residual stress Surface NDE Techniques: Visual Testing, Liquid Penetrant Testing, Magnetic Particle Testing, Eddy Current Testing Acoustic Emission: Types of acoustic emissions - Basic concepts - instrumentation and signal description, background noise, inspection of pressure vessels, flaw location, inspection of composite materials. Ultrasonic Testing: Principles of Acoustics, Generation of ultrasonic waves, Ultrasonic Inspection Methods, Testing/Evaluation/interpretation, Recent advances in ultrasonic testing: Ultrasonic imaging, Synthetic Aperture Focussing Techniques (SAFT), Time of Flight Diffraction (TOFD), Phased Array Ultrasonic, Non-linear ultrasonic, Signal Analysis Magnetic NDE Techniques: Magnetic Barkhausen and magnetic hysteresis techniques, applications of MBE and MHL for damage evaluation Radiography & Thermography Techniques: Basic Principles of Radiography and Thermography, Film Radiography Radiographic Image Quality and Radiographic Techniques Special Radiographic Techniques, Applications of thermography for condition monitoring

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4519**			
Course Title	**Introduction to Magnetic Materials**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Magnetic properties & Measurement: Causes of Magnetism in Materials, Basic properties like permeability, remanance, coercivity, Hysteresis and core loss, Curie temperature, domain structure, magnetostriction. Different types of exchange interactions, Effect of external physical conditions like stress and temperature on Magnetic properties. Characterisation of soft and hard magnetic materials, domain observation, magnetic transport property, magnetic /atomic force microscopy (MFM), SQUID Magnetometer. Advanced Magnetic Materials: Advanced materials such as rare earth alloys used in permanent magnets, soft magnetic alloys used in flux density amplification. Nanostructured and amorphous materials, magnetic wires used in sensors, multilayers magnetic materials for spintronics and in data storage applications, Ferromagnetic shape memory alloy, giant magnetoimpedance & magnetoresistance materials. Magnetic Devices: Sensors and Actuators: Application of magnetic materials including the choice of materials for devices such as transducers, sensors and actuators. Magnetic devices used in medical, automotive, aerospace and power applications.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4520**			
Course Title	**Waste processing and recycling**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Introduction to waste processing and environmental management Waste generation, its recycling and and managenment (solid & Liquid): Wastes from mining and mineral industries, Wastes from iron and steel (including ferro-alloys) industries, Wastes from non-ferrous metal industries : such as Aluminum, Copper, Lead, Zinc, Titanium and Chromium. Waste generation from power plants and their recycling status, Bulk utilisation of slag and other wastes using eco-friendly processes. Metallic wastes from non-metallurgical sectors : home appliances and others such as E-waste, Spent batteries, Spent catalysts Toxological Characterization Toxicological characterization of liquid effluents, Toxicological characterization of solid wastes Values from wastes – High value material synthesis

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4521**			
Course Title	**Advanced Manufacturing**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Casting and solidification; Semi-solid processing (Rheocasting, thixo casting, spray forming, strain induced melt activation); Rapid quenching techniques. Welding and joining technology. Metal working processes; Forging, rolling, extrusion, wire drawing; Powder processing, Principles of metal forming; Deformation maps; Workability of materials; Sheet metal forming, Forming limit diagram; Thermomechanical processing.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-3-4501**			
Course Title	**Structural Integrity & Assessment**			
Credit Distribution (L-T-P-C)	2	2	0	**4**

Course Content:

Analysis of failures, Damage tolerance and fail-safety, Life assessment methodologies, Stress analysis of components, Software based life assessment Rejuvenation and refurbishment of degraded components, Reliability analysis and risk assessment of components, Fatigue performance of structures under variable amplitude loading, Structural integrity analysis of pressure vessel and pipelines.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-3-4502**			
Course Title	**Microstructural Engineering**			
Credit Distribution (L-T-P-C)	2	1	2	**4**

Course Content:

Evolution of microstructures, microstructural instability; Recovery, recrystallisation and graingrowth, Thermo-mechanical treatment and evolution of textures, Grain boundary Characterization; Heat treatment methodology; Structure-property-processing correlations.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-3-4503**			
Course Title	**Thermodynamics and kinetics of metal extraction processes**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Review of thermodynamic fundamentals [Gibbs energy, activity, and equilibrium constant; effects of temperature and pressure on equilibrium constant/composition; Ellingham Diagram and relative stability of oxides; Gibbs phase rule; construction of stability diagrams (predominance area diagram, phase diagram, and E-pH diagram); Thermochemistry; Alternative (Henrian) standard states; dilute solutions; interaction coefficients], Principles of thermodynamics and kinetics of Pyrometallurgy, Hydrometallurgy and Electrometallurgy processes of Ferrous and non Ferrous metal extraction including, Isothermal and non-isothermal kinetics of heterogeneous reactions.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-3-4504**			
Course Title	**Coating Technology**			
Credit Distribution (L-T-P-C)	2	0	4	**4**

Course Content:

Thin films: definition, nucleation and growth of thin films, Application of thin films. Processing of thin films: PVD, PECVD, electron beam evaporation, RF and DC sputtering, Magnetron sputtering, laser ablation. Plasma diagnostics by Langmuir probe and OES. Influence of thickness, power, pressure, substrate temperature, and substrate target distance on the growth and microstructure of thin films. Mechanical, adhesion behavior and measurement of thin films, magnetic, optical, texture properties of thin films method of evaluations of thin films. Surface chemistry and evaluation of thin film; Advanced Patterning techniques of thin films for devices: lithography, wet chemical, electron beam, laser; Problems and issues of thin films.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-3-4505**			
Course Title	**Advanced mechanical property characterization**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Multiaxial fatigue; High strain rate material testing practices; Indentation creep; Dynamic fracture toughness; Creep-fatigue interaction; Small specimen testing practices.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-3-4506**			
Course Title	**Integrated Computational Materials Engineering**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Atomic Scale Simulations: Density Functional Theory, Monte Carlo Simulations, Molecular Dynamics, Dislocation Statics and Dynamics, CALPHAD Modeling, Microstructural Simulation: Phase Field Modeling, Cellular Automata, Kinetic Monte Carlo, Finite Element and Difference Methods at Meso-Macro Scale, Polycrystal Elasticity and Plasticity Models, Integrated Materials Modeling and Simulation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-3-4507**			
Course Title	**Life Cycle Assessment**			
Credit Distribution (L-T-P-C)	2	2	0	**4**

Course Content:

Life Cycle Inventory Analysis, Life Cycle Thermodynamic and Kinetic Analysis, Life Cycle, Environmental Analysis, Life Cycle Cost Analysis, Life Cycle Impact assessment, Interpretation, Assessment Tools, Data Analysis, Application to some Materials, Application to Metallurgical Processes.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-3-4509**			
Course Title	**Science Management**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

1. Project Management Project Management Process, Project Integration Management, Project Time Management, Project Cost Management, Project Quality Management, Project Human Resource Management, Project Communication Management, Project Risk Management and Project Stakeholder Management 2. IP Management Overview of IPR Regime, Drafting of Patents,Patent filing procedures, International treaties and Convention on IPR, Patent legislations, Enforcement of Patents, Patent infringement, Patent Valuation, Exploitation of Patents, Patent Research and Analytics, Patinformatics Tools and Techniques, White Space Mapping

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-3-4510**			
Course Title	**Advanced Surface Characterization Techniques**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Relevance of advanced surface characterization to materials development, scientific understanding of phenomena in materials technology, Electronmaterials interactions, Physical principles of XPS, UPS, ARPES & AES, Spin orbital splitting, Chemical effect, Chemical shift, Depth profiling, Surface charging effect, Importance of CASA XPS software fitting parameters for quantitative analysis, UV-Visible spectroscopy, Infrared spectroscopy & Raman spectroscopy. XRD for thin films, Use of Rietveld method for XRD data analysis, AFM, and STM.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-4-4501**			
Course Title	**Project Proposal & Seminar**			
Credit Distribution (L-T-P-C)				**14**

Course Content:

mtech

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-4-4502**			
Course Title	**Dissertation Seminar Final Presentation & viva voce**			
Credit Distribution (L-T-P-C)				**14**

Course Content:

mtech

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-NML-2-4522**			
Course Title	**Dissertation Report**			
Credit Distribution (L-T-P-C)				**4**

Course Content:

mtech

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-IMMT-4-0001**			
Course Title	**PROJECT PROPOSAL**			
Credit Distribution (L-T-P-C)	0	1	2	**2**

Course Content:

Formulation of a project proposal by selecting topics of high relevance and novelty and will have state-of-the art review, methodologies, recommendations etc. in specified format in a holistic manner preferably candidate's own research work suitable for submission to appropriate funding agencies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-IMMT-4-0002**			
Course Title	**REVIEW ARTICLE**			
Credit Distribution (L-T-P-C)	0	1	2	**2**

Course Content:

Preparation of one review article on specific research area of the student.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NML, JAMSHEDPUR**			
Course Nomenclature	**ENG-IMMT-4-0003**			
Course Title	**CSIR-800 PROJECT**			
Credit Distribution (L-T-P-C)	0	0	8	**4**

Course Content:

The students have to undertake a project in rural area for 6-8 weeks in line with CSIR-800 programme which is primarily prepared at empowering 800 million Indians by way of S & T inventions. The theme for the project may be chosen from CSIR-800 document and as per expertise available at individual laboratory. Students will choose the topics in consultation with Doctoral Advisory Committee (DAC).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-1-1501**			
Course Title	**Research Methodology**			
Credit Distribution (L-T-P-C)	1	1	0	**2**

Course Content:

Introduction, terminology, and scientific methods; Types of research; Research process and steps; Identifying a research problem; Literature survey, appreciation of existing literature, identification of knowledge gaps; Conception of novel approach to solve the problem; Role of theory, modeling, and simulation; Design of experiments, testing and characterization strategies; Quantitative methods and data analysis; Qualitative analysis; Communicating research results; Thesis writing and oral presentation; Ethics in research.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-1-1502**			
Course Title	**Technical Communication**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Role and importance of technical communication; Effective written and oral communication; Ethical issues; Technical report writing; Technical / R&D proposals; Research paper writing; Letter writing and official correspondence; Emails; Oral communication in meetings and group discussions; Oral presentations; Use of modern aids.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1501**			
Course Title	**MTech Dissertation-I**			
Credit Distribution (L-T-P-C)	0	7	14	**14**

Course Content:

N/A

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1502**			
Course Title	**MTech Dissertation-II**			
Credit Distribution (L-T-P-C)	0	9	18	**18**

Course Content:

N/A

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1503**			
Course Title	**Project Management**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Introduction; Project formulation, evaluation and initiation; Project planning and scheduling; Risk management; Project execution and implementation; Project monitoring and control; Project closure; Project documentation; Leadership and teamwork issues; Complex projects; Advances and trends.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1504**			
Course Title	**Platforms and Techniques for Process Control**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Introduction to embedded systems for process control; 8- and 16-bit PIC microcontroller architecture, programming, I/O, Timer and interfaces, dsPIC architecture overview; ARM processor architecture and programming model; Functional Analysis : fundamental and common non-linearities; Phase plane analysis, limit cycles and linearization; Stability concept, methods, disturbances and analysis; P, PI, PID control analysis, Design, implementation, comparison and applications;

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1505**			
Course Title	**Digital Systems Engineering**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Overview of digital system specification, modeling and design methodologies; Timed, Untimed and Synchronous models of computation; Modeling of computation and memory interfaces; Basic concepts of system design specification, modeling and simulation using VHDL (or using SystemC); Transaction level Modeling (TLM) based methodologies; Trends in digital systems design

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1506**			
Course Title	**Intelligent Instrumentation**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Primary sensing principles and measurement variables; Sensor performance characteristics and terminology; Transducer measurement circuits; Signal conditioning circuits; Data conversion; Introduction of soft-computing techniques; Foundations of fuzzy approaches, fuzzy relationships and fuzzy numbers; Fuzzy rule-based systems; Fuzzy modelling; Fundamentals of neural networks; Back propogation and related training algorithms; Competitive, associative and other special neural networks; Practical aspects of neural networks; Fuzzy and neural control; Introduction to statistical pattern recognition; Dimensionality reduction and classification;Casestudy:“electronicnose”; Smartsensors; Future trends in intelligent sensor systems.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1507**			
Course Title	**Signal and Image Processing-I**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Linear time-invariant (LTI) discrete-time Systems (DTS) in time domain and transform domain; Discrete-time Fourier transform (DTFT), discrete Fourier transform (DFT), Z-transform; Transform analysis of LTI system : inverse system, all-pass system, minimum phase system, linear phase system; Image sensor models; Image representations and properties; Noise models, image de-noising; image pre-processing; Segmentation; Basics of morphological imageprocessing;Edgedetectionalgorithm

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1508**			
Course Title	**Power Electronics**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Introduction to power electronics; Power semiconductor devices, switching characteristics, driver circuits, loss and cooling requirements; AC-DC and DC-DC converters – steady-state analysis, modeling and simulation, converter transfer function; I/O filter design and analysis; Voltage-mode and current-mode control of converters;Basicmagnetictheory,Inductorandtransformerdesign

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1509**			
Course Title	**Real-time Embedded System Design**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Fundamentals of FPGA-based system design, Architecture of embedded processors, Advanced processor architecture concepts, architectures for digital signal processing and applications; Designing soft processors with FPGAs; Power/energy efficient embedded system design; Real-time programming and communication; Concurrent Programming, Synchronization and communication; Scheduling of uni-processor and multi-processors; Real-time operating systems (RTOS) organization, Concept of kernel design, RTOS scheduling, Case studies of VxWorks, QNX, TinyOS, and others; Programming with QNX or VxWorks; Embedded hardware building blocks, Embedded system level design, design space exploration and verification techniques.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1510**			
Course Title	**Lab : Process Control Techniques and Platforms**			
Credit Distribution (L-T-P-C)	0	0	2	**1**

Course Content:

Laboratory practices and safety considerations; Assembling/populating PCBs for process control applications; PIC and dsPIC platform programming exercises; Monitoring of process parameters in a RO plant; Control of actuators, valves and pumps in a RO plant; Flow monitoring and control for e-nose applications; Data analysis using e-nose and GC/MS system.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1511**			
Course Title	**Lab: Digital Systems Engineering**			
Credit Distribution (L-T-P-C)	0	0	2	**1**

Course Content:

Laboratory practices and safety considerations; Understanding Xilinx FPGA architecture; Designing with Xilinx FPGAs using Xilinx EDK, Core Generator; Architecture wizard and doing pin assignments; Using Xilinx ChipScope; Design of DSP sub-blocks using SysGen; Designing system blocks using synthesis tools.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1512**			
Course Title	**Lab: Intelligent Instrumentation**			
Credit Distribution (L-T-P-C)	0	0	2	**1**

Course Content:

Laboratory practices and safety considerations; Data acquisition (DAQ) techniques; Virtual instrument and GUI design; Analog and digital I/O; File I/O; Integration of sensor, DAQ and GUI modules; Experiments with modeling and use of sensors and strain gauges; Implementation of fuzzy systems and algorithms; Time series forecasting.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1513**			
Course Title	**Lab: Signal and Image Processing-I**			
Credit Distribution (L-T-P-C)	0	0	2	**1**

Course Content:

Laboratory practices and safety considerations; MATLAB experiments on LTI DT systems and their analysis in the transform domain with special focus on inverse system, linear phase system, all-pass system and minimum system analysis; MATLAB experiments on various color models, image pre-processing, de-noising, Segmentation and morphological image processing.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1514**			
Course Title	**Lab: Power Electronics**			
Credit Distribution (L-T-P-C)	0	0	2	**1**

Course Content:

Laboratory practices and safety considerations; Familiarization with power electronic devices and components, PCB design aspects; IGBT / Power MOSFET gate charge and switching times measurement; Estimating device loss; Design of gate driver circuit; Experiments with PWM controllers for buck and boost operations; Simulation of DC-DC converter using MATLAB and SPICE; Building forward and flyback controller for DC-DC conversion.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1515**			
Course Title	**Lab: Real-time Embedded System Design**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Laboratory practices and safety considerations; Understanding of developing a PowerPC and MicroBlaze based embedded system by using Xilinx Embedded Development Kit (EDK); Basic hardware design steps; Adding a processor system to a FPGA Design; Adding IP to a hardware design; Adding custom IP to the bus; writing software applications; System simulation with RTOS support; Multi-processor system design and implementation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1516**			
Course Title	**Physics of Semiconductor Materials and Devices**			
Credit Distribution (L-T-P-C)	4	0	0	**4**

Course Content:

Semiconductors; Inorganic and organic, single crystalline, polycrystalline, porous, amorphous crystal structures, and material properties; Si, GaAs, GaN, SiC; Energy band diagrams; Dielectric constant, permeability, permittivity, sheet resistance, resistivity, mobility, thermal conductivity and heat dissipation; Piezo -resistive and piezoelectric effects; Defects, dislocations and micro-plasma, phonon dynamics, ion-solid interactions; Electron transport in semiconductors, minority carrier life time, avalanc he breakdown phenomena, Hall effect; Theory of p-n junction, Schottky barrier, MOSFETs and MESFETs, IMPATTs and BARRITTs; Hetro-structures, strained semiconductors; Photovoltaics and solar cell; Solid state sensors and transducers; MOS analysis.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1517**			
Course Title	**Unit Processes in Semiconductor Technologies**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Crystal growth techniques, wafer preparation and shaping, chemical cleaning, thermal oxidation, photo-lithography, chemical etching (wet and dry), chemical vapor deposition techniques, thermal diffusion, ion implantation, metalization, chemical mechanical polishing, rapid thermal processing.

Faculty	ENGINEERING SCIENCES			
Lab Name	CSIR-CEERI, PILANI			
Course Nomenclature	ENG-CEERI-2-1518			
Course Title	CMOS Digital VLSI Design			
Credit Distribution (L-T-P-C)	3	0	0	3

Course Content:

Introduction to MOSFET from designer's viewpoint; MOS inverter : static and switching characteristics; MOS capacitor; Layers in VLSI design; Design rules and technology interface; Stick diagrams and Layout design; Propagation delay, Fan -out consideration; CMOS Latch-up; Scaling; Combinational MOS logic circuits : passtransistors/transmission gates, primitive logic gates, complex logic gates; Sequential MOS logic circuits : latches and flip-flops; Dynamic logic circuits; Clocking issues; CMOS subsystem design.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1519**			
Course Title	**Characterization Techniques for Semiconductor, Materials, Technologies and Devices**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Resistivity, Contact resistance, barrier height, carrier and doping concentration, mobility and carrier life time measurement techniques; Test structures for technology characterization; Analysis of surfaces, interfaces, thin films and devices; E-beam based techniques, Scanning Electron Microscopy and allied techniques; Material analysis techniques; Scanning probe Techniques; Ion-beam based techniques; Interferometry based techniques for materials and device characterization; Optical characterization.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1520**			
Course Title	**Lab: Semiconductor Processing Technologies**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Laboratory practices and safety considerations; Wafer preparation and shaping; Chemical cleaning; Thermal oxidation, photo-lithography; Wet chemical etching; Dry etching; Chemical vapor deposition; Thermal diffusion; Ion implantation; Metalization.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1521**			
Course Title	**Lab: CMOS-based Physical Design**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Laboratory practices and safety considerations; SPICE simulation; Schematic editor, Layout editor, DRC, LVS; Transfer and output characteristics NMOS transistor, parameter variations; CMOS inverter design, inverter threshold, noise margin, propagation delay; Layout of CMOS inverter, n-well design rules, LVS, static and transient characteristics, DRC; 2-input NAND/NOR gate; D latch and flip-flop; Postextract simulation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1522**			
Course Title	**Lab: Semiconductors Related Characterization and Measurement Techniques**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Laboratory practices and safety considerations; IV and CV Measurements; Resistivity, thickness, thin-film surface and bulk defects; grain size measurement; AFM/STM surface analysis; Stress and deformation measurements; Measurement of sheet resistance, junction depth, carrier mobility, doping profile estimation, minority carrier life time measurement; Model parameter extraction experiments.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1523**			
Course Title	**Lab: HDL-based Digital Design**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Laboratory practices and safety considerations; Introduction to HDLs; Simulation of behavioral, Architecture/RTL, data-flow and structural HDL code; Sub-system design using HDL : various adder architectures, BCD arithmetic, various counters, traffic-light controller, etc.; Mini-project. (SystemC, VHDL and/or SystemVerilog will be used as the HDL for the laboratory.)

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1524**			
Course Title	**Electromagnetic Theory and Transmission Lines**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Review of Maxwell's equations, wave equations and their solutions; Boundary conditions and their applications; Electromagnetic energy and power flow; Review of Poynting theorem; Transmission lines; Waveguide and coaxial components; Scattering matrix representation; Propagation of electromagnetic waves through homogeneous, in-homogeneous, and anisotropic media; Surface resistance and RF resistance; Ferrite devices; Waveguides and resonators; Characteristic and interaction impedances; Quality factor (loss and diffractive). Impedance matching; Measurement of "Q", power, noise figure, S-parameters, dielectric constant and loss Tangent, dispersion and impedance characteristics, and loss parameters.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1525**			
Course Title	**Microwave Communication**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Ground/surface wave, space-wave, and sky-wave modes of communication; Tropospehereic Communication; Line of sight communication and system performance; Active and passive repeaters and their design; Analog and digital communication; Mobile communication; Satellite communication system; Earth station design criteria and direct reception system; Satellite transponders and their design criteria; Phase-noise, intra-pulse and inter-pulse noises and their significance

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1526**			
Course Title	**Numerical Analysis and Techniques for Microwave Applications**			
Credit Distribution (L-T-P-C)	4	0	0	**4**

Course Content:

Numerical solution of linear and non-linear differential equations of higher orders; Analytical and numerical techniques to the solution of electromagnetic field problems; Using MATLAB for numerical analysis; Spent beam analysis for efficiency enhancement; Techniques for multi-beam electron guns; PIC simulation Techniques; Finite difference and finite element techniques; Method of moments applied to microwave devices.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1527**			
Course Title	**Microwave and Millimeter Wave Tube Technologies**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Fundamentals of vacuum technology. Vacuum generation and measurement, and leak detection. Ultra-high vacuum techniques. Surface physics and analysis in relation to electron Emitters. Electron-tube grade materials and their characteristics. Chemical processing. Heat treatment and special techniques: brazing, sintering, sputtering, TIG/electron beam/laser welding, glass-to-metal and ceramic-to-metal sealing, loss coating, and helix fitting. Vacuum processing of integrated devices. Design of tools, jigs, and fixtures. Engineering / mechanical design of components. Special machining techniques.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1528**			
Course Title	**Lab: Microwave Components Characterization and Tube Processing Techniques**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Laboratory practices and safety considerations; Scattering parameters; Measurement of impedance and characterization of cavities; Dispersion and impedance characterization of RF structures; RF loss measurements;UHVtechniques; Heat treatment inprotective atmosphere;Ceramic-to-metal sealing techniques; Chemical processing of components.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-2-1529**			
Course Title	**Lab: Microwave Devices Characterization and Tube Subassembly Fabrication**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Laboratory practices and safety considerations; Device characterization using spectrum analyzer, scalar/vector analyzer; Break-down tests; X-ray radiography; Hot RF characterization of devices; Metal-to-metal brazing techniques; Leak detection techniques; TIG/laser welding; Vacuum processing of devices; Cathode fabrication and testing; Cathode characterization using Auger and thermal emission microscope.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1501**			
Course Title	**Advanced Self-study (Special Topic)**			
Credit Distribution (L-T-P-C)	0	2	4	**4**

Course Content:

This will involve readings from published literature or books about new frontiers on a specific topic related to the field of electronics under guidance of senior scientist(s). A report needs to be submitted and a seminar on the special topic needs to be presented.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1502**			
Course Title	**Advances in Process Control**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Review of control system concepts; Issues in advanced process control design; State variable representation of continuous and discrete time systems; Concepts of observability and controllability; Design and analysis of SISO/MIMO feedback and feed-forward control systems; Steady state optimization, linear quadratic regulator control, stability using Lyapunov technique; Process applications of optimal control, adaptive control, model reference adaptive control; System analysis and design, process/plant uncertainty and robustness, sliding mode and robust control; Typical applications and case studies

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1503**			
Course Title	**Signal and Image Processing-II**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Continuous wavelet transform (CWT) and time-frequency resolution; Multi-resolution analysis and discrete wavelet transform (DWT); Fundamentals of multi-rate signal processing and perfect reconstruction; Spatial/2-D convolution and 2-D DWT; Applications of DWT; Histogram, histogram equalization and its applications; Motion detection algorithm; Applications of edge, face and motion detection algorithms; Circular Hough transform and its applications; Principle component analysis (PCA) and its application for gesture recognition; Introduction to neural networks and their application for human gesture recognition

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1504**			
Course Title	**Applications of Power Electronics**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Design and applications of buck, boost, half-bridge and full-bridge converters; Soft switching conversion techniques; Single-phase and three-phase DC-AC converters; PWM techniques for inverters; Design of singlephase inverters for UPS and photovoltaic applications; Design and applications of DC and AC drives; Unity Power factor conversion techniques and their applications.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1505**			
Course Title	**Lab: Advances in Process Control**			
Credit Distribution (L-T-P-C)	0	0	2	**1**

Course Content:

Laboratory practices and safety considerations; MATLAB exercises for control system design; LabView exercises for control system design; PID control design and simulation of inverted pendulum; Case studies – Design and simulation of motion control algorithms, Design and simulation of optimal controls for a MIMO Process, Adaptive/robust controller design and simulation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1506**			
Course Title	**Lab: Signal and Image Processing-II**			
Credit Distribution (L-T-P-C)	0	0	2	**1**

Course Content:

Laboratory practices and safety considerations; MATLAB experiments on DWT and multi-rate signal processing; A mini-project on DWT-based application; Experiments on histogram and histogram equalization, Edge detection algorithm, motion detection algorithm and use of circular Hough transform

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1507**			
Course Title	**Lab: Applications of Power Electronics**			
Credit Distribution (L-T-P-C)	0	0	2	**1**

Course Content:

Laboratory practices and safety considerations; Design and experiments with half-bridge and full-bridge converters; PWM generation and control of single-phase and 3-phase inverter; Experiments with DC and AC motor drives; Mini-project

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1508**			
Course Title	**MEMS and Nano-structures Technologies**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Review of Silicon crystal and unit processes; Processing steps for MEMS device fabrication; photo-lithography and backside mask alignment; Surface and bulk micro machining techniques; Deep reactive ion etching; LIGA process; Wafer-level bonding and packaging techniques; LTCC technology, materials, LTCC process steps, bonding and packaging; Testing and characterization of technology; Reliability and residual stress issues.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1509**			
Course Title	**Physics and Design of MEMS and Microsensors**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Overview of Microsensors; Mechanical properties of materials and essentials of structural mechanics; Electro-mechanical, magneto-mechanical and piezo-based sensing; Structural elements for MEMS and microsensors (Beams, plates, cantilevers, bridges and diaphragms); Electrostatic sensing and actuation (parallel plate and torsional structures, time domain analysis); Micro -fluidics; Scaling laws and miniaturization; Micro-system design principles; MEMS simulation and design Tools; RF MEMS; Reliability issues in microsensors; Examples and applications of MEMS microsensors.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1510**			
Course Title	**Nanoelectronic Devices and Technologies**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Low-dimensional structures (Quantum well, quantum wire, quantum dot, quantum confinement); Confinement energy level, band-gap enhancement, absorption-emission spectra, blue shift, luminescence; Nanoelectronic Devices (Single electron box, Coulomb blockade, single electron transistor, pump, turnstile, trap, memory); Simulation, Modeling of single electron devices and applications; Technology for fabrication of nanostructures and nanoelectronic devices; Next generation lithography techniques; Characterization of nanoscale materials and nanodevices

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1511**			
Course Title	**CMOS Analog Design**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Basic concepts of transistors and diodes, their modeling, large-signal and small signal analysis, CMOS technology, clock feed-through; Reference sources : bias circuits, band-gap reference circuit, cascode current mirror; Single-stage amplifier, common source amplifier, drain and gate amplifier, differential amplifier; Operational amplifier; Comparators; Switched-capacitor circuits; Introduction to data converters; Issues of analoglayoutanddevicenoise.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1512**			
Course Title	**Advanced VLSI System Architectures**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction and review of basic computer architectures, CISC and RISC processors; Pipelining, hazards, exception handling, optimization techniques, synchronous and asynchronous pipelining; Memory organization, caches, virtual memory, memory management; Arithmetic circuits, algorithms and architectures for high-radix adders, multipliers, sine-cosine and exponential computation; Instruction-level parallelism, super-scalar, super-pipelined and VLIW architectures, array and vector processors; Multiprocessor architectures and parallel architectures, synchronization, memory consistency; DSP architectures; Performance improvement techniques; ASIP; Lowpower architectures; Fault-tolerant architectures; Case-study on Algorithm-to-Architecture; Future trends.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1513**			
Course Title	**Optoelectronic Materials, Devices and Technologies**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Optoelectronic Materials; Growth of Epitaxial materials; Characterization of Epitaxial Materials; Optoelectronic Devices (Light Emitting Diodes, Semiconductor Lasers, UV, Visible and IR Photo-detectors and Receivers, Solar Cells); Compound semiconductors and advanced electronic devices; Compound Semiconductor Technologies; Packaging of compound semiconductor components; Applications and trends.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1514**			
Course Title	**Photonic Materials, Devices and Technologies**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to Photonics; Basic photonic components and thei r technologies; Propagation of Electromagnetic waves; Optical waveguides and optical fibers; Principle of optical fiber communications, Transmission capacity, Dispersion and losses in optical fiber; Coupled mode theory in guided wave systems; Materials and fabrication technologies; Types of waveguides; Basic photonics devices and components; Optical sensors and sensing techniques; Optical MEMS; Fiber gratings and waveguide gratings; Photonic crystal based waveguides and devices; Packaging of photonic devices; Applications of photonic devices; Recent trends.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1515**			
Course Title	**Lab: MEMS and Nano-structures Technologies**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Laboratory practices and safety considerations; Wafer cleaning; Lithography : front and backside alignment; Bulk micro-machining; DRIE process; LPCVD; Metalization; Wafer bonding; Surface planarization; Wafer dicing; LTCC process; Packaging

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1516**			
Course Title	**Lab: Design of MEMS and Microsensors**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Laboratory practices and safety considerations; MEMS design tools; Design of pressure sensors of various types; Design of gas sensors of various types; Acoustic, Ultrasonic, micro-resonator, ISFET; RF MEMS design and simulation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1517**			
Course Title	**Lab: Nanoelectronic Technologies**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Laboratory practices and safety considerations; Fabrication of metal thin films by sputtering/e-beam/resistive-heating and measurement of film thickness by making steps using wet etching; Experiments on growth of Silicon nanoparticles and their optical characterization; Experiments with nanolithography and nanopatterning; Simulation of single electron devices using SIMON; Simulation of inverter circuit using SET in SIMON; Operation of AFM/STM; Analysis of AFM/STM images; Study of annealing effect on roughness/grain size of metal films by AFM/STM imaging and analysis.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1518**			
Course Title	**Lab: CMOS Analog Design**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Laboratory practices and safety considerations; I-V characteristics of MOSFET, estimation of early voltage; Clock feed-through and its minimization; Bias generation architecture simulation; Band-gap reference circuit simulation; Design and simulation of various amplifiers; Design and simulation of 2-stage CMOS operational amplifier; Layout of analog circuits.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1519**			
Course Title	**Lab: Optoelectronic Devices and Technologies**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Laboratory practices and safety considerations; MOCVD system demonstration; PL/Prism-coupler characterization of GaN material; Metallization; Lift-off process for Ohmic contact on GaN material; Ashing; TLM measurements for specific contact resistance; Hall effect Measurement; RIE process for GaN etching; Thinning and polishing; Dicing; Wirebonding; LED characteristics

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1520**			
Course Title	**Lab: Photonic Devices and Technologies**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Laboratory practices and safety considerations; Measurement of refractive index and thickness of planar Waveguides; Propagation loss measurement of planar waveguides; Design of 1x2 and 1x4 optical power splitter; Measurement of insertion loss, uniformity and polarization- dependent loss of a packaged 1x8 optical splitter at C+L band region; Design and simulation of Bragg gratings; Waveguide patterning by photo-lithography; Testing of MUX/DEMUX by DWDM test set-up; Chip-level testing: alignment of DUT (in a diced chip) to the source and the detector with x-y-z alignment stages.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1521**			
Course Title	**Slow-wave Devices : Principles and Design**			
Credit Distribution (L-T-P-C)	4	0	0	**4**

Course Content:

Classification and high frequency limitations of conventional electron tubes. Formation and confinement of an electron beam. Slow-wave structures, couplers and RF windows. Beam-wave interaction mechanism. Spent beam collection. Efficiency enhancement by phase-velocity tapering and multi-stage depressed collection. Different types of devices, their operation, and characteristics, High power and wide bandwidth issues. Future trends

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1522**			
Course Title	**Fast-wave Devices : Principles and Design**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Merits of fast-wave devices over slow-wave devices. Operating principle of a gyrotron and design of its components: magnetron injection gun, beam tunnel, RF interaction cavity, magnetic field, non-linear taper, RF window, mode converter and collector. Beam-wave interaction and mode selection criteria. Other fast-wave devices: gyro-TWT, gyro-klystron, peniotron and FEL. Applications of gyro-devices and future trends. High Power Microwave (HPM) Devices.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1523**			
Course Title	**High Power Microwave Systems and Applications**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Special EW (Radar, ECM, ECCM) systems and their requirements in respect of microwave and millimeter wave devices; Types of jamming; Linear accelerators, Microtrons, Synchrotrons, Plasma heating systems, Proton accelerators, and Thermonuclear reactors; Other applications like imaging, spectroscopy, biomedical, industrial heating, electronic power conditioners, and modulators.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1524**			
Course Title	**Plasma-filled Microwave Sources**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Plasma and its physical parameters; Saha equation and its relevance; Motion of charged particles in static and slowly varying electric and magnetic fields; Motion of relativistic charged particles; Types of gaseous discharge; Hollow-cathode discharge and other kinds of low-pressure discharges; General features of electrons emission, control and extraction of electrons and ions from plasma in DC and pulsed mode conditions; Plasma sources for axially symmetric electron beams; Plasma cathode electron gun (PCE-gun); Advantages of plasma filling in high power microwave devices; Operating principles, characteristics, and applications of different types of plasma-filled devices including the pasotron.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1525**			
Course Title	**Vacuum Microelectronic Devices**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Basic semiconductor technologies like reactive ion etching, photo-lithography, oxidation, CVD, sputtering, LIGA; MEMS technologies; Design considerations in vacuum microelectronic devices; Photonic band-gap structures, folded wave guide and ladder structures; Tera Hertz devices including reflex klystrons; Micro -fabricated devices like TWT and klystrino; Combination of vacuum and semiconductor technologies in microwave devices, including microwave power module and their applications

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-3-1526**			
Course Title	**Lab: CAD of Microwave Tubes**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Laboratory practices and safety considerations; Components design : electron guns, slow-wave structures, fast-wave structures, RF cavities, RF windows, collectors; Electron beam and RF wave interaction simulation; Thermal and structural design and simulation; CAD of complete tube; Computer aided engineering drawing.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-4-0001**			
Course Title	**Project Proposal**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Definition of a scientific project proposal; Components of a proposal; Need and purpose of the proposal; Aims and objectives; Background and present status; Proposed methodologies and approaches; Scheduling and mile-stones; Resource allocation; Budgeting; Monitoring and evaluation mechanisms; Referencing and citing; Use of data, graphs, tables, figures; Proposal funding agencies and their formats. Every student needs to submit two proposals – one related to PhD research topic and the second in any field of electronics.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-4-0002**			
Course Title	**Review Article**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Preparation of one review article on specific research area of the student.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CEERI, PILANI**			
Course Nomenclature	**ENG-CEERI-4-0003**			
Course Title	**CSIR-800 Societal Programme Project**			
Credit Distribution (L-T-P-C)	0	0	8	**4**

Course Content:

A project needs to be undertaken in rural area for 6-8 weeks duration aligned to the CSIR-800 programme. The theme of the project may be chosen from the CSIR-800 document or from any other government department related to benefiting and empowering the economically lower 800 million Indians by way of S&T innovations. The aim is to interact with underprivileged people in the villages and propose solutions in the area of health, agriculture, energy, water, food, education, etc.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IIP, DEHRADUN**			
Course Nomenclature	**ENG-IIP-1-3101**			
Course Title	**Research Methodology**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Course Description Introduction; Research terminology and the scientific methods; Laboratory practices, discipline and safety practices; Types of Research; Research process and steps; Identifying a research problem; Literature survey and appreciation of existing literature; Conception of novel approach to solve the problem; Role of modelling and simulation; Design of experiment; Quantitative methods of data analysis; Qualitative analysis; Communicating Research results; Ethics in research. Case studies

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IIP, DEHRADUN**			
Course Nomenclature	**ENG-IIP-2-3101**			
Course Title	**Internal Combustion Engines**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Course Description Classification of Engines; Four and Two Stroke Engines, Auto and Diesel Cycles. SI Engines: Basic layout, Combustion characteristics, Ignition limits, P-ϴ diagram. CI Engines: Ignition delay, Combustion characteristics, Pre-mixed and diffusion combustion, P- ϴ diagram. Injection Systems: In-line injection system, Rotary and unit injector. Induction and Exhaust Systems: Induction and Exhaust Manifold configuration. Valves and Camshaft: Valve timing diagrams, operating conditions, valve overlap, cam design. Super charging and turbo charging: Super charging cycle, gas exhaust process. Simulation and modelling of IC engines. ·

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IIP, DEHRADUN**			
Course Nomenclature	**ENG-IIP-2-3102**			
Course Title	**Analytical Methods used in Petroleum Industry**			
Credit Distribution (L-T-P-C)	2	0	4	**4**

Course Content:

Course Description Standard procedures: Principles, procedures and significance of ASTM/IP/UOP/IS test methods for evaluation and analysis of crude oil and its products; Atmospheric distillation (ASTM D 86); Vacuum distillation; Simulated distillation; True Boiling Point (TBP) distillation; Separation Methods: Chromatography; Gas Chromatography; Liquid Chromatography and Super Fluid Critical Chromatography (SFC); Spectroscopic techniques: Applications of ultra violet spectroscopy (UV); flourier transform infrared (FTIR); Nuclear Magnetic resonance (NMR) spectroscopy and Mass spectroscopy to petroleum products analysis; Elemental analysis: C, H, O, N and S; Metal analysis: Microanalysis; Xray fluorescence; plasma spectroscopy and atomic absorption spectroscopy; All the methods will be complemented with practical work in Laboratories.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IIP, DEHRADUN**			
Course Nomenclature	**ENG-IIP-2-3103**			
Course Title	**Tribology and Tribo – Component Design**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Course Description Introduction to Tribology: Friction and Wear; Surface phenomena, nature of surface and contact, surface interaction and friction. Effect of lubricants and surface films. Theory of friction. Mechanism of wear, types of wear – adhesive, abrasive, fatigue, corrosive etc. with reference to machine elements and subcomponents like bearings, clutches, brakes etc. Minimization of wear. Wear tests and testing machines. Basic principles of lubrication, lubrication theories; Hydrostatic, boundary, hydrodynamic and elasto-hydrodynamic lubrication. Generalized Reynolds equation, flow and shear stress. Lubricants: types and properties. Effective machinery lubrication, Machine fault detection through lubricant analysis. Laboratory practical on Tribology. Tribo-component design: Tribologically relevant properties of materials, friction materials and their application in clutch and brake linings. Antifriction/plain bearing materials, wear resistant materials. Surface modification techniques. Materials for specific applications eg. Gears, Seals, hydraulic components etc. Design, application and selection of various types of bearings – sliding and rolling element bearings. Mechanism of hydrodynamic instability. Dynamic characteristics of hydrodynamic journal bearings. Concept of air and magnetic bearings. Design and performance evaluation of Engine components, clutches, brakes seals etc. Application of soft computing techniques. Mini project/seminar on design and simulation. ·

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IIP, DEHRADUN**			
Course Nomenclature	**ENG-IIP-2-3104**			
Course Title	**Chemistry of Lubricants**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Course Description Introduction to Lubrication: Fundamentals, Boundary Lubrication phenomena, Lubricants, Types of Lubricants, Base Oils from Petroleum, Bio-lubricants, Synthetic Oils, Ionic Liquids, Solid Lubricants, Lubricant Additives, Antioxidants, Dispersants, Detergents, Rust and Corrosion Inhibitors, Foam Inhibitors, Pour Point Depressants, Anti-Wear Agents and Extreme Pressure Additives, Multifunctional Additives, Formulation of Automotive Lubricants, Automotive Lubricant Specifications, Standard Tests for Lubricants, Lubricant and Environment.

Faculty	**ENGINEERING SCIENCES**
Lab Name	**CSIR-IIP, DEHRADUN**
Course Nomenclature	**ENG-IIP-2-3105**
Course Title	**Alternative Fuels**
Credit Distribution (L-T-P-C)	3 0 0 **3**

Course Content:

Course Description Overview of Energy, Global and Indian energy scene, fuel resources and environmental policies; Conventional Fuels: Introduction, liquid and gaseous fuels and desirable properties of good IC engine fuels; Alternative fuels- General aspects, type of fuels and technical and policy challenges. Alcohols: Methanol and Ethanol - Production, properties and application in engines, Ethanol and Gasoline blends and its application in vehicles, Ethanol and diesel blends and its application in C I engines; Butanol - Production, its application in SI and CI engines; Vegetable oils: Production and its application as I C engine fuel; Bio-diesel- Production and its properties; Bio-diesel- Application in engines/vehicles, F T diesel. LPG: Conventional and new techniques of Production, Domestic and automotive fuel Properties, conversion system and technological advances, engine modifications, Regulatory codes, Performance and emissions, safety issues. Natural gas: Conventional and new techniques of Production, Automotive fuel properties, gas conversion system, First generation to third generation, engine modification, Regulatory codes, Performance and emissions, safety issues. Hydrogen: Conventional and new techniques of Production, properties, Induction Techniques for Hydrogen application in SI engines and CI engines; H2+Natural gas(HCNG), HCNG Properties; HCNG- conversion system; Regulatory codes; HCNG: Performance and emissions. Bio gas: Production and Properties, Bio gasApplication in engines/vehicles, NH3- Production and properties; NH3- Application in engines/vehicles, Producer gas- potential as I C engine application. DME: Production and properties, DME application in engine and technical issues and review of the work research and development carried out in the world Alternative energy application for propulsion: Electrical vehicles, Hybrid vehicles, solar energy and solar powered vehicles, Fuel cell basics and type of fuel cells, Fuel cell vehicles. Miscellaneous: Alternative fuel powered vehicle evaluation as per Tap document, CMVR: Laboratory methods, Field Tests, Future Policy frame work for Alternative fuelled vehicles, Comparison of different alternative fuels based on vehicle usage and economics

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IIP, DEHRADUN**			
Course Nomenclature	**ENG-IIP-2-3106**			
Course Title	**Renewable Energy Conversion Technologies**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Course Description Introduction to renewable energy technologies; Energy scenarios and perspectives - past, present and future Non-renewable and renewable energy sources; description of renewable sources and their importance, current status, potential and future trends, renewable energy options for immediate and future directions. Technologies for biomass energy conversion i.e., pyrolysis, gasification, combustion, trans-esterification; fermentations, thermo-chemical conversions, value-added products from pyrolysis, thermal and catalytic methods for the upgrading of biomass; bio-refining products and applications. Solar energy sources, measurements, interconversions; Passive solar - architectural design, solar collectors; Solar energy conversion - photosynthesis and artificial photosynthesis; Photo-voltaicsemiconductor properties, performance criteria, manufacturing, economics; PV systems - installation, data collection and analysis. Historical background of wind resources - wind speeds and wind energy principles; Wind Turbines - system components, Environment Impact on applications. Ocean energy potential against wind and solar; Wave characteristics and statistics; Wave energy devices; Tide characteristics and statistics; Tide energy technologies; Ocean thermal energy; Osmotic power; Ocean bio-mass Geothermal Resources; Geothermal Technologies; Applications; Sustainable sources of hydrogen; Fuel cell technologies; Hydrogen storage and distribution; Applications and feasibility assessment; Science, technology and policy of energy conservation; Strategies for enhancing role of renewable energy.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IIP, DEHRADUN**			
Course Nomenclature	**ENG-IIP-3-3101**			
Course Title	**Advanced Thermodynamics for Mechanical Engineers**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Course Description Basic concepts P-V-T behavior of pure liquids; Application of thermodynamic Laws to real processes. Applications of equations of state; thermodynamic property calculations for fluid mixtures, Gibb's & Helmholtz functions. Available & non-available energy, Irreversability Thermodynamics of flow systems Fundamental flow equation, Flow meters, thermodynamic analysis of flows in pipes, nozzles, and compressors, fluid temperature change and its measurement at high velocities. Heat Engines & Chemical Kinetics Thermodynamic Relationships, Clausius-Clapeyron Equation; Liquefaction of Gases, The JouleThomson Effect, Inversion Point on p-v-T Surface for Water; Rankine Cycle, Efficiency of an Internally Reversible Heat Engine; Chemical Kinetics: Reaction Rates, Rate Constant for Reaction, k, Chemical Kinetics of NO, The Effect of Pollutants formed through Chemical Kinetics Thermodynamics of Combustion Combustion of Hydrocarbon Fuels, Energy Equations, Chemistry of Combustion, Bond Energies and Heats of Formation, Enthalpy of Reaction, Chemical Equilibrium and Dissociation, Gibbs Energy, Stoichiometry, Van't Hoff Relationship, Dissociation Calculations, Effect of Dissociation & Fuel on Composition of Products, Combustion and Flames: Explosion Limits, Flames, Flammability Limits, Ignition, Diffusion Flames, Engine Combustion Systems Irreversible Thermodynamics & Fuel Cells Introduction, Definition of Irreversible or Steady State Thermodynamics, Entropy Flow and Entropy Production, Thermodynamic Forces and Thermodynamic Velocities, Onsager's Reciprocal Relation, The Calculation of Entropy Production or Entropy Flow, Thermoelectricity, Electric Cells, Fuel Cells, Efficiency of a Fuel Cell, Thermodynamics of Cells Working in Steady State, Diffusion and Heat Transfer

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IIP, DEHRADUN**			
Course Nomenclature	**ENG-IIP-3-3102**			
Course Title	**Automotive Lubricants**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Course Description Introduction and Fundamentals of Automotive lubricants; Crude oil Scenario; Vacuum Distillation; Modern refining process; Base oils classifications; characterization of Base oils; Additive types and Significance; Lubricant formulations; Additives for bio-lubricants; Novel additives Introduction to fluid dynamics; Lubrication fundamentals; Characteristics of principal lubrication system; Basics of engine friction; Stribeck curve; Engine friction measurement methods; Application of Reynolds equation for Piston ring assembly friction (PRA); Significance of engine oil consumption; Mechanism of oil consumption; Influence of engine lubricant composition on Oil consumption; Influence of engines on Oil consumption; Types of engine deposits based on temperature; Significance and methodology of Deposit Rating; Rating of engine deposits as per CRC methods Tribological concepts of engine wear; Adhesive, Corrosive and Abrasive wear of Ring/cylinder/Piston; Running-in; Significance of wear metal analysis; Engine lubricant additives requirement Physico-chemical characteristics of engine lubricants; Engine lubricant qualification methodology; Engine Oil Specification (API/ ILSAC/ ACEA/ BIS) and Current performance levels; Engine lubricant's composition effect on emissions & fuel economy; Introduction to Gears lubricants and greases; Additives requirements for Gear lubricants; Gear Lubricants and Greases additive chemistry, formulations & significance; Gear lubricant specifications and Gear lubricant testing (Standard tests); Grease specifications and current trends; Wear mechanism in gear; Gear distress rating as per CRC

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IIP, DEHRADUN**			
Course Nomenclature	**ENG-IIP-3-3103**			
Course Title	**Automotive Emissions & Fuel Quality**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Course Description Automotive Emissions: Automotive engine types, combustion processes and exhaust emissions from S.I. and C.I. engines, sources of engine/vehicle emissions, emissions and pollutants, photochemical smog, emission formation in SI and CI engines, mechanisms of NOx formation, mechanisms of CO and HC formation, mechanisms of formation of soot and PM, effect of engine design and operating variables on emissions, emission control by engine design variables, crankcase emission control, evaporative emission control, exhaust gas recirculation and water injection for control of engine-out emissions, SI engine exhaust after treatment by oxidation and three-way catalytic converters, advanced catalysts for HC control, lean de-NOx catalysts, NOx storage catalyst, SCR catalysts, catalyst deactivation and poisoning, emission control in CI engines including electronic fuel injection systems, turbo charging, control of oil consumption, diesel oxidation catalysts, NSR and SCR catalyst systems, diesel particulate filters, CRT system, emission norms for various categories of vehicles, summary of trends in emission control technology, air pollution due to automotive exhaust, consequences of greenhouse effect and ozone problem, health impacts of air pollution Automotive Fuel Quality: Motor Gasoline- antiknock quality, distillation, density, RVP, oxidation and storage stability, hydrocarbon composition, sulphur content, oxygenates, reformulated gasoline, trends in gasoline specifications, emission related properties and their effect on exhaust emissions, multi-functional additives and their benefits. Diesel- ignition quality, distillation range, density, viscosity, chemical composition, sulphur content, lubricity, trends in diesel specifications, emission related properties and their effect on exhaust emissions ·

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IIP, DEHRADUN**			
Course Nomenclature	**ENG-IIP-3-3104**			
Course Title	**Automotive Test Equipments and Procedures**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Course Description Introduction: Engine testing and Vehicle Testing, Regulated, Un-regulated exhaust emissions, Emission Legislations, Indian Emission regulations, Test parameters i.e. Fuel, Emission Limits. Engine dynamometer: working principles and types, Chassis dynamometers: Control strategy, types and application, Measurement devices and conditioning systems: Fuel balancer, Fuel mass flowmeter, Oil consumption meter, Air consumption meter, Temperature control systems, Smokemeter, Opacimeter. Exhaust emission measurement systems: Raw & Diluted emissions, Classification of analysers (FID,CLD,NDIR,PMD) & their working principles, Portable emission analysers. Dilution systems: Full flow & Partial flow system, Particulate matters (PM) measurement, Engine test procedure: Test cycles, Steady State (13 mode), Transient Cycle (ETC), Load Response (ELR), Particulate Sampling, Vehicle test procedure: Test cycles, Coast down, constant speed test. Calibration of emission measurement systems: analysers, constant volume sampler (CVS), Particulate system, calibration checks for engine dynamometer load cells, chassis dynamometer load cells. Test start and operation: Test flow diagrams, Auxiliary equipments, Test conditions & preparations, Equipment operation, handling and maintenance. PRACTICAL: Engine dynamometer, Smokemeter, Fuel Balancer, Portable emission analyser, emission analysers (FID, CLD, NDIR of old AMA-2000 bench).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IIP, DEHRADUN**			
Course Nomenclature	**ENG-IIP-4-0001**			
Course Title	**Project Proposal**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Formulation of a project proposal by selecting topics of high relevance and novelty and will have state-of-the art review, methodologies, recommendations etc. in specified format in a holistic manner preferably candidate's own research work suitable for submission to appropriate funding agencies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IIP, DEHRADUN**			
Course Nomenclature	**ENG-IIP-4-0002**			
Course Title	**Review Article**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Preparation of one review article on specific research area of the student.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-IIP, DEHRADUN**			
Course Nomenclature	**ENG-IIP-4-0003**			
Course Title	**CSIR-800 Societal Programme Project**			
Credit Distribution (L-T-P-C)	0	0	8	**4**

Course Content:

The students have to undertake a project in rural area for 6-8 weeks in line with CSIR-800 programme which is primarily prepared at empowering 800 million Indians by way of S & T inventions. The theme for the project may be chosen from CSIR-800 document and as per expertise available at individual laboratory. Students will choose the topics in consultation with Doctoral Advisory Committee (DAC).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-1-1001**			
Course Title	**Materials Science and Engineering**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Periodic table and specific features/characteristics of group wise elements, electronic structure of materials (ionic, covalent, coordinate, conduction, valence, metallic and van der Waal bonds, noncrystalline and amorphous), crystalline solids (crystal system, unit cell, space lattice, Miller indices, packing factor, coordination number, slip system, planes and directions in crystals), defects/imperfections in crystalline materials like point, line, area and volume defects (dislocations, inclusions, vacancies, casting and forming), diffusion, thermal and electrical conduction, electronic & ionic conduction, electron mobility, semiconductors, p-n junction, Fermi energy, superconductivity, solid solution, intermetallic compounds, Hume-Rothery rules, dielectric behaviour (types of polarization, frequency dependence of dielectric permittivity, piezo and ferroelectricity), magnetic properties (dia-, para-, ferro-, ferri-, and antiferro-magnetism, magnetic domains, and hysteresis loops), lasers, solution and transport phenomena, solid/liquid interfaces, electrical double layer, surface tension, introduction to polymers, classification of polymers, structure and properties of polymers, polyblends, polymer composites, techniques of polymerization, molecular weight determination of polymers, Material classification (metals and alloys, foams, composites, polymers, ceramics, functional and smart materials, semiconductors, nanostructured materials, construction materials etc.), material synthesising techniques (liquid metallurgy route including pressurized solidification, rapid solidification, melt infiltration, powder metallurgy, surface engineering & treatment etc.), waste utilization and value addition (industrial wastes, natural products etc.)

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-1-1002**			
Course Title	**Scientific Ethics, Technical Communication and Safety**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Soft Skills Basic concept and approach, behavioural aspects, skill/capability development (manners, appearance, communication, transparency, compatibility with group, leadership quality, human relations, social aspects) · Scientific Ethics Basic concept, ethical behaviour, types ofproblematic behaviour (honest mistakes, unethical behaviour, noncompliance with legal or contractual requirements, deliberate deceit), self regulation and correction, the responsibilities of science funding agencies, scientific responsibility and integrity, facts and challenges, ethical issues, mistakes versus misconduct, ethical standards in science, enforcing ethical standards · Research Methodology Basic concept and approach, meaning of research problems, sources of research problems, criteria / characteristics of a good research problem, errors in selecting a research problem, meaning & types of hypothesis, format of research proposal & report, defining objective, background information, planning and execution of work (team making, task assignment, ob 2 t, flow of information, progress monitoring, assessment of work and contribution, envisaging bottlenecks/shortfalls, sharing of responsibilities), designing of experiments, data generation & filtering techniques, making and recording measurements, analysis (use of graphs, figures, bar & pie charts and tables, hints for solving numerical problems, descriptive statistics, least square method, standard deviation, choosing and using statistical tests, error, drawing chemical structures, chemometrics, computational chemistry), presentation skills (preparation and delivery of a poster display and an oral presentation), reporting and writing skill (general aspects of scientific writing (essays, literature surveys, reviews, reports, technical papers), information technology and library resources(internet and world wide web, journals, use of spreadsheets, word processors, databases and other packages, finding and citing information), error analysis · Safety Basic concept, principles and approach, health & safety and operational rules, safety and protective equipments, working withliquids and solid, basic laboratory procedures, compressed gas safety, safetypractices for disposal of broken glass wares, centrifuge safety, treated biomedical wastes and scientific ethics, chemical safety and disaster management, chemical spills, radiation spills, biohazard spills, leaking, compressed gas cylinders, fires, medical emergency, accident reporting, handling of hazardous materials, safety measures and standards, need & significance, practical implications, principles of solution chemistry, pH and buffer solution

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-2-1001**			
Course Title	**Characterization and Analytical Techniques**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Property Characterization Basic concept, approach and methodology, SI units and their uses, test types, design of experiments, factors controlling test results,sources of error in experimental results, confidence limit, standard deviation, determinate and indeterminate errors, properties (physical, mechanical, chemical, electrochemical, thermal, tribological, rheological, interfacial, magnetic, electrical), compositional, phase and microscopic analysis (surface, subsurface, removed mass) and interpretation, specimen preparation, quantitative metallography, microstructure-property correlation, failure analysis, interpretation of information, microanalysis, corrosion characterization (electrochemical/galvanic series, potential-pH diagram), chemical and thermal analysis of minerals and wastes, toxicity studies of solid wastes, evaluation of mechanical properties, characterization of radiation shielding and nano materials Analytical Tools & Techniques OM, SEM, FESEM, TEM, AFM, STM, HRTEM, AFM, fluorescence microscopy,XRD, NDT, mass spectrometry, nuclear magnetic resonance spectroscopy, classical analytical methods, ICP spectrometer, atomic absorption spectrometer, infrared spectroscopy, UVvisible spectroscopy, optical emission spectrometer, chromophores and their interaction with UV-visible radiation and utilization in structural, qualitative and quantitative analysis of different molecules, chromatography, thermal methods, DTA, TGA, DSC, rheometry, FTNMR, ATR, FT-IR, TCLP, and their salient features & limitations, CHNS, FIA, particle size analyser, surface area analyser, contact angle measurement, DSC, X-rays diffractometer, FE-SEM, viscometer, BET surface area analysis, particle size analysis Separation Techniques Introduction & classification of chromatographic methods, theory of chromatography, retention time, relationship between retention time and partition coefficient, the rate of solute migration, differential migration rates, bandbroadening & column efficiency, kinetic variables affecting band broadening

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-2-1002**			
Course Title	**Phase Transformation**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Principles and concepts, free energy - composition diagrams, diffusion in solids, high diffusivity paths, nucleation and growth, homogeneous and heterogeneous nucleation, interface and diffusion controlled growth, coherent, semicoherent and incoherent interfaces, transformations controlled by heat flow like solidification, various growth mechanisms, kinetics of eutectic and eutectoid transformations, precipitation and dispersion strengthening, recovery, static and dynamic recrystallization, grain growth, peritectic, spinodal, pearlitic, ferritic, and martensitic transformations, ordered-disordered transformation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-2-1003**			
Course Title	**Heat Treatment**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

General principles and concepts, equilibrium diagram, lever rule, TTT diagram, processes, atmospheres (salt baths, gases), furnaces, quenching media, mechanism of quenching, mechanism and kinetics of oxidation, carburization and decarburization, vacuum as controlled atmosphere, residual (thermal and transformation) stresses, shape and size distortion and control, quenching cracks, transformation induced plasticity Heat treatment of steels and cast irons: Fe-Cequilibrium diagram, carbon equivalent, effects of alloying elements on heat treatment parameters, annealing, normalizing, hardening, hardenability, tempering, austempring, martempering, ausforming, subzero treatment, patenting, themomechanical treatments, case hardening (carburinzing, nitriding, carbonitriding, aluminizing, sheradizing), microstructural changes during heat treatment, malleablizing, fluidized bed treatments, induction hardening, selection of heat treatment parameters and cycles, thermal cycling, Heat treatment of some common Non-ferrous(Al-, Zn-, Mg- and Cu-based) alloys (solutionizing, natural and artificial ageing, continuous and discontinuous precipitates, grain growth and precipitate coarsening, coherent, semicoherent and incoherent precipitates, coherency strains, ASTM temper designations)

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-2-1004**			
Course Title	**Materials Synthesis and Processing**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Concept, approach and methodology, techniques for metallic materials (liquid metallurgy, powder metallurgy, deformation processing, severe plastic deformation, thermo mechanical treatment, heat treatment, surface modification/ engineering, joining, plasma and laser processing, rapid prototyping), functionally graded materials, natural and bio fibres, natural fibre composites, biodegradable composites, hybrid composites, polymers (moulding, extrusion, heat treatment, post curing and joining)

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-2-1005**			
Course Title	**Computer Simulation & Design**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Basic concepts, approach and significance, meshing, software, hardware, algorithms, introduction to finite element analysis, steps in finite element analysis, plane stress and plane strain, axi-symmetric conditions, elements in 2d and 3d problems, development of element and global stiffness matrix, convergence criteria, linear and non-linear analysis, features of FEA software, pre-processing, post-processing and analysis in different software

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-2-1006**			
Course Title	**Lightweight Materials**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Basic concept and approach, material systems/types (metals and alloys, composites, polymers, ceramics, industrial wastes, porous materials/foams, sandwich, fibres etc.), synthesizing and processing techniques (casting, secondary deformation, powder metallurgy, foaming, process modelling, fibre extraction), characteristics, application potential and limitations

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-2-1007**			
Course Title	**Polymer Science and Engineering**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Introduction to polymers, polymer crystallinity, classification of polymers, structure & properties, techniques and aspects of structure determination, crystalline polymers, supermolecular organization of amorphous polymers, concept of physical states, the rubbery state, elasticity of an ideal rubber, kinetics theoryof rubber elasticity, elasticity of a system of isolated polymeric chains, James-Guth theory, glassy state, transition of polymer from the rubbery to the glassy state, theories of glass transition, thermal, mechanical and electrical properties of polymers, heat capacity of polymers & solids, theories of heat capacity of polymers, thermal conductivity of polymers and dielectrics, structural scattering, thermal expansion of polymers and solids, equations of state for thermal expansion of solids, mechanical behaviour of polymers, strength and durability, mechanism of polymer fracture, thermofluctuational theory, effect of relaxation processes on strength properties, DMA of polymers, physics of polymers, characterization (morphology, mechanical, chemical, thermal, degradation and rheological behaviour), processing (additives, moulding, extrusion, injection moulding, thermoforming etc.) and recycling, engineering and special polymers

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-2-1008**			
Course Title	**Tribology - Science and Practice**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Tribology (basic definition, concept and approach, Archard's laws, delamination theory), friction and wear types/modes (adhesion, abrasion, erosion, fretting, chemical etc.), wear testing (configurations, systems, methodology), high temperature tribology, simulated tests, measurement techniques, surface, subsurface and debris analysis, mechanism maps, controlling factors, interpretation of information, microstructure-property correlation, lubrication modes and types (mixed, boundary, hydrodynamic, elastohydrodynamic), Stribeck curve, P-V limit, lubricants (basic requirements, features, types, additives), tribomaterials (basic concept & approach, functions, material types and development, applications)

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-3-1001**			
Course Title	**Powder Metallurgy**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Basic principles and concept, processing steps and techniques, powder production and characterization, mechanical alloying, stages of sintering, driving forces for sintering, mechanism of sintering, solid state and liquid phase sintering, reaction sintering, sintering furnaces (conventional, microwave, SPS etc.) and atmospheres, hot pressing, cold and hot isostatic pressing, self propagating combustion sintering, specialized characterization techniques and standards, parameters controlling properties, sintered products (iron, copper titanium and aluminium base materials/products, MMCs, metal foam, functional materials), sintered product property evaluation and standardization

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-3-1002**			
Course Title	**Advanced Polymeric Materials**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Concept of nanofillers and polymer nanocomposites, polymer nanocomposites (types, synthesis, characterization, characteristics and applications), functional polymers (synthesis and characterization), introduction of inorganic nanoparticles into functional polymers, surface modification techniques, functionalization of the surface of nanoparticles, shape memory polymers, conducting polymers, magnetic polymers, role of polymers in high-tech areas such as light emitting diode, OSR insatellite communication, photovoltaic etc., polymers for insulation and electronics, laminates and sandwich panels, characterization of some important thermoplastics and thermosets, rheological behaviour, interpretation of information and application potential, liquid crystalline polymers (properties and applications), self reinforced composites. polymer blends and alloys, theories of polymer miscibility, various commercial blends and their applications, reactive blending

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-3-1003**			
Course Title	**Composites Science and Engineering**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Basic concept & approach, micromechanics of composites, rule of mixture, classification (matrix, reinforcement & processing based), reinforcements (micro and nano particles, nano tubes, fibres, whiskers, and their properties (including fillers, industrial wastes and naturally available materials), role of interfaces, synthesising techniques (in-situ, mechanical mixing, dispersion hardening, liquid and powder metallurgy routes, semisolid processing, sqeeze casting, melt infiltration, electro-deposition, selective reinforcement, spray forming, compression moulding, hand layup technique, injection moulding, etc), laminates, functionally graded materials, characterization,processing, specific features, performance evaluation, durability and life cycle assessmentstudies, limitations and application potential

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-3-1004**			
Course Title	**Functional and Smart Materials**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Basic concept and approach, stimuli, shape memory effect, response to thermal, magnetic, electrical, piezoelectric, and others effects, creation of functional and smart materials with preset properties, generation of shape memory effect, structure, phase transformation and properties, specific property characterization, interpretation of information, smart materials (shape memory alloys and polymers, piezoelectric, magnetostrictive, pH-sensitive, halochromic, chromogenic, surface active & biomimitic materials, ferrofluids, electro and magneto rheological material etc.), material development, application potential (energy sector, information technology, health, lab-on-a-chip etc.), principles of ferrofluids, synthesis, characterization, properties and applications.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-3-1005**			
Course Title	**Waste Utilization and Value Addition**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Industrial wastes (red mud, fly ash, slag, low grade minerals, stone dust etc.), different category of wastes, their source of generation and their methods of handling, environmental impact, audit, acts and regulations, global policy, regulation, waste management, municipal solid wastes, management and disposal, processes/ methods of waste utilization for different environmental applications such as decontamination of ground water, recycling, solidification/ stabilisation, immobilisation, detoxification, vitrification of toxic waste, management of hazardous and toxic waste, natural products, renewable resources, biodegradable polymers, conversion of wastes into value added materials, application potential (land use planning by reclamation of wastelands, overburden areas/mine spoil dumps, ash-back haul regions, etc for agriculture, horticulture, forestry, and other useful purposes, agriculture, construction, transportation, general engineering etc.) Introduction to industrial wastes, types, sources and characteristics, different rules and acts, classification of hazardous waste, its characteristics, waste recycle & reuse, solidification and stabilisation, waste to material approach using industrial waste, disposal of industrial wastes, chemistry of silica and silicon, ceramic, geopolymers and their applications, theory and principles of synthesis, characterization and applications of radiation shielding materials

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-3-1006**			
Course Title	**Fibre Science and Technology**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Introduction to fibres, basic concepts, fibres and their types (polymeric, inorganic, nano, natural, synthetic etc.), fibre forming materials, making and processing techniques, fibre testing methods and property characterization (mechanical, thermal, surface, electrical, moisture content etc.), application potential

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-3-1007**			
Course Title	**Cellular Materials**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Definition and classification, concepts and design, general characteristics, applicable constitutive laws and equations, foam and foaming, chemistry & physical formation, foaming ingredients, factors controlling cell fraction and morphology, types (metallic, ceramic & polymeric, open cell, closed cell, syntactic etc.), selection criteria, properties, synthesizing techniques, (liquid metallurgy, powder metallurgy and others), characterization, property controlling parameters, application potential (noise attenuation, energy absorption, damping, packaging, thermal insulation, heat exchanger, Honey comb structures, foam core sandwich panels, biomedical implants, electromagnetic shielding, hydrogen storage, fuel cells etc.)

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-3-1008**			
Course Title	**Nano Science and Engineering**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Basic concept and approach, introduction to nanomaterials (definition and classification, topdown and bottom-up approaches, synthesis methodologies, processing and characterization techniques, functionalization and applications), fundamental properties of various primary material classes (metals, ceramics and polymers), size dependent properties, challenges in processing bulk ceramic nanomaterials, processing-structure-properties of important bulk nanomaterials, mechanical, thermal, tribological and biological properties, critical issues related to understanding properties of nanomaterials, application potential of bulk nanomaterials, nano coatings, nano-composites, nano-metal powders, nano-medicines, nanotribology

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-3-1009**			
Course Title	**Analysis of Metal Forming Processes**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Stress-strain relations in elastic and plastic deformation, yield criteria for ductile metals, work hardening and anisotropy in yielding, flow curves, elements of theory of plasticity, formulation of plastic deformation problems, application of theory of plasticity for solving metal forming, problems, effect of temperature and strain rate in metal working processes, effects of friction and lubrication in cold and hot working, fundamentals, and analysis of important forming processes- forging, rolling, wire drawing, extrusion, sheet metal forming processes like deep drawing, stretch forming, bending, introduction to finite element simulation of forming processes.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-3-1010**			
Course Title	**Fatigue and Fracture Evaluation of Materials**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Fatigue, high cycle fatigue, low cycle fatigue, constant amplitude fatigue cycle, variable amplitude fatigue cycle, Overview of conventional stress, strain and energy based life approaches, cyclic stress stain curve, fatigue crack initiation and crack growth analysis, Paris equation. Introduction to fracture mechanics, different modes of fracture, Griffith criteria, linear elastic fracture mechanics, , elastic-plastic fracture mechanics, Stress concentration factor, Stress intensity factor (K), crack tip opening displacement (CTOD), j-integral, threshold stress intensity factor, fracture toughness, stretch zone width (SZW), application of finite element method in fatigue and fracture evaluation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-3-1011**			
Course Title	**Corrosion and Corrosion Protection**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Basics of corrosion including electrochemical mechanism, polarization, potential-pH diagram, electrochemical series, galvanic series, electrochemical polarization, different forms of corrosion including stress corrosion cracking,different corrosion tests like weight loss, Tafel plots, polarization resistance, testing methods and impedance measurement as per ASTM and NACE standards, electrochemical polarization (potentidynamic and potentiostatic), chronoamperometry, chronopotentiometry, electrochemical impedance spectroscopy, noise analysis, cyclic voltametry etc., electrochemical testing of corrosion (sample preparation, corrosion testing, effect of heat treatment on microstructural changes and corrosion behaviour, effects of pH, dissolved oxygen, Cl on corrosion), passivity, corrosion of metallic materials (iron, steels, Al-, Mg-, Cu-, Ni-, Pb-, Ti-, Ta- based alloys, metal matrix composites), cathodic protection (passivation, oxidation and tarnishing, coating, inhibitors), corrosion in dry condition (formation of oxides, sulphides etc.)

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-3-1012**			
Course Title	**Conducting Polymers**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Introduction to conducting polymers, synthesis ofPANI, synthesis of polypyrrole , electrical testing of conducting polymers, applications of conducting polymers, carbon filled polymers. Physical properties of PANI, Electrical properties of PANI, PANI Composites

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-3-1013**			
Course Title	**Glass Fibre Reinforced Polymer composites**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Introduction to polymeric composite materials, reinforcing materials (fibres, natural fibres whiskers and particles), glass fibres, fibre reinforced plastics, polymer based composite materials (comparison of different materials with composites, hybrid and sandwich type composites, principles of composite reinforcement, effect of fibrous reinforcement on properties, types of reinforcement such as natural, glasses, carbon/graphite, aramid fibres, high strength and high modulus fibers), surface treatment and various forms of fibres, thermosetting and thermoplastic materials for the composites and their selection for a particular application, processing and production techniques like hand-layup, bag moulding, filament winding and pultrusion prepegs, their manufacture and characterization. sheet moulding and dough moulding compounds and their processing, preform and resin transfer mouldings

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-3-1014**			
Course Title	**Tribology of Polymers and Their Composites**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Introduction to tribology of polymers (basic definition, concept and approach, Archard's laws, delamination theory), friction and wear types/modes (adhesion, abrasion, erosion, fretting, chemical etc.), wear testing (configurations, systems, methodology), measurement techniques, surface, subsurface and debris analysis, controlling factors, microstructureproperty correlation, P-V limit, lubricants (basic requirements, features, types, additives)

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-3-1015**			
Course Title	**Bio Degradable Polymers**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Introduction to biodegradable polymers, applications of biodegradable PVA, Synthesis of biodegradable PVA, Physical properties of biodegradable PVA, Electrical properties of PVA, PVA composites

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-3-1016**			
Course Title	**Natural Fibres**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Introduction to natural fibres, extraction of sisal fibres, grading of sisal fibres, physical properties of sisal fibres, types of jute fibres, jute and sisal fibre properties, jute fibre polymer composite development, sisal fibre polymer composite development

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-3-1017**			
Course Title	**Microfluidics and Microseparation**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Solvent extraction (fundamentals & principles, classification, factors favouring extraction, extraction equilibria, applications), solid phase micro extraction and single drop micro extraction (selection of solid and liquid phase for extraction, principles and applications), chemical derivatization in liquid and gas chromatography (pre, post and on column derivatization, functional groups and reaction with derivatizing agents for fluorescence, electrochemical and UV-Vis detection), electrochemical methods of analysis (potentiometry, polarography, cyclic voltametry, amperimetric determination, and coulometry, basic principles and applications), electrochemical bio sensors (principle and applications in clinical diagnostics), chromatographic techniques(principles of separation and application of column, paper, thin layer and gas chromatography, GPC, HPLC, HPTLC, size exclusion chromatography, affinity chromatography, electrophoresis. preparative and micropore columns, reverse phase columns, mobile phase selection and detectors in separation techniques), capillary electrophoresis (principle, classification, instrumentation and applications in qualitative and quantitative analysis), microfabrication techniques (principle, instrumentation and applications for fabrication of miniaturized devices), integration of microfluidic channels with pump, valve, detector etc., lab-on-a-chip

Faculty	ENGINEERING SCIENCES			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-3-1018**			
Course Title	**Unit Operations in Environmental Chemistry**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Separation techniques (crushing, grinding, size analysis, separation based on density difference, gravity separation, magnetic separation, froth flotation), chemical processes (absorption, adsorption, membranes, cryogenic distillation, order, and rate of reaction), different isotherms ((Langmuir, Freundlich etc.) and their applicability to adsorption process, removal of air pollutants, carbon dioxide capture and storage (different types of CCS, CO2 sequestration and its role in making clean environment, pre and post combustion CO2 capture, carbon capture at the source of generation, different methods of carbon capture, packed bed towers/ columns and their design), removal of water pollutants (different processes/ methods of removal of toxic/ heavy metals, impure water/ effluent treatment using different separation techniques, packed bed towers / columns and their design), adsorbents (commercial adsorbentsand their application, role of industrial wastes in synthesis and characterization of cost-effective adsorbents, their application for effluent treatment, water purification and CO2capture, zero-waste concept)

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-4-1001**			
Course Title	**Project Proposal**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Formulation of a project proposal by selecting topics of high relevance and novelty and will have state-of-the art review, methodologies, recommendations etc. in specified format in a holistic manner preferably candidate’s own research work suitable for submission to appropriate funding agencies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-4-1002**			
Course Title	**Review Article**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Preparation of one review article on specific research area of the student.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-AMPRI, BHOPAL**			
Course Nomenclature	**ENG-AMPRI-4-1003**			
Course Title	**CSIR-800 Societal Programme Project**			
Credit Distribution (L-T-P-C)	1	0	6	**4**

Course Content:

The students have to undertake a project in rural area for 6-8 weeks in line with CSIR-800 programme which is primarily prepared at empowering 800 million Indians by way of S & T inventions. The theme for the project may be chosen from CSIR-800 document and as per expertise available at individual laboratory. Students will choose the topics in consultation with Doctoral Advisory Committee (DAC).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1101**			
Course Title	**Numerical Methods**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To acquaint the students with different numerical tools that are required to solve engineering problems Interpolation, Errors in interpolation. Matrices: Numerical solution of ordinary differential equations, Numerical solution of Partial Differential Equations, Special fuctions: Introduction to Finite Element Method (FEM) and its applications Introduction to fuzzy logic, Artificial Neural Network Introduction to the softwares like MX-EXCELL, SPSS and MATLAB

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1102**			
Course Title	**Design of Building Structures**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To impart knowledge about the advanced design methodologies considering different environmental loading. Design loads with special reference to earthquake and wind loads. Wind effects on buildings Concept of earthquake resistant design of buildings Introduction to plastic analysis in steel structures Computer applications in the design.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1103**			
Course Title	**Advanced Foundation Engineering**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To impart the necessary knowledge on geotechnical engineering required for building engineering and disaster mitigation with respect to geohazard. Introduction to Geotechnical engineering Deep foundation Ground Improvement Techniques Stability of Slope Reinforced Soil Environmental Geotechnics

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1104**			
Course Title	**Disaster Resistant Building System - I**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objetive Modules To educate about the earthquake resistant foundation system and Fire safety system in buildings Earthquake Resistant System Introduction to geotechnical earthquake engineering and seismic properties of soil Seismic bearing capacity of shallow foundations Seismic analysis of pile foundation Introduction to earthquake resistant building system Fire safety system in buildings Fundamentals of fire Growth and spread of fire Reaction to fire characteristics and fire retardant materials and techniques Smoke movement and control Fire dynamics and modelling Fire detection and Fire extinguishment.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1105**			
Course Title	**Engineering Materials for Infrastructure**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To study about building materials required for construction and maintenance of building infrastructure Conventional building materials Non-conventional building materials Advanced building materials Methods of characterization of building materials Types of cements, Chemical admixtures

Faculty	ENGINEERING SCIENCES			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1106**			
Course Title	**Laboratory - II Structural Engineering & Fire Engineering**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Objective Modules To impart knowledge on the different aspects of advanced concrete structures and consequences of fire in structural systems. Structural Engineering: Experiments on concrete mix design, special concrete such as fiber concrete/geopolymer concrete; building dynamics; Non destructive tests - Schmidt hammer, UPV, corrosion analyzer, core cutting; Wind tunnel. Fire Engineering: Fire propagation index, Ignitability at various irradiances levels, Specific optical density of smoke, Toxicity index.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1107**			
Course Title	**Analysis of Building Structure**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

objective Modules To impart knowledge about advanced analysis methodologies that are required for efficient design of buildings Static analysis – stiffness and flexibility methods Application problems using finite element technique, Introduction to non-linear analysis. Dynamic analysis Single degree of freedom system Multiple degree of freedom systems, Introduction to computer programs for dynamic analysis

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1108**			
Course Title	**Seminar-II**			
Credit Distribution (L-T-P-C)	0	0	2	**1**

Course Content:

Objective: To develop scientific presentation and communication skills

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1110**			
Course Title	**Dissertation-II**			
Credit Distribution (L-T-P-C)	0	8	24	**20**

Course Content:

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1111**			
Course Title	**Laboratory - I Geotechnical Engineering, Materials and Environmental Laboratory**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Objective Modules To carry out laboratory experiments to evaluate the Geotechnical, physical and chemical properties of the material and to do the necessary characterisation Geotechnical Laboratory Work Laboratory Soil Investigation Field Soil Investigation Materials and Environmental Science and Technology Laboratory Work Physical and Chemical testing of cement and other building material Instrumental methods for analysis of building materials

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1113**			
Course Title	**Seminar-I**			
Credit Distribution (L-T-P-C)	0	0	2	**1**

Course Content:

Objective: To develop scientific presentation and communication skills

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1115**			
Course Title	**Disaster Resistant Building System II**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To impart knowledge on the techniques to designing buildings which will withstand landslide and earthquake Landslide Disaster Mitigation: Introduction - Landslide Types and processes - Landslide causes - Landslide Hazard and Risk Assessment - Landslide Investigation and failure mechanism -Landslide Instrumentation - Landslide Control Measures. Earthquake resistant building structure: Characteristics of earthquakes, analysis of structures for earthquake loading, Linear Analysis — Codal Method, Demand Capacity Ratio Method; Nonlinear Pushover Analysis, Rapid visual screening and simplified evaluation of buildings, Strengthening of existing components — RC, Steel and FRP Jacketing. Introduction to Performance based Engineering Strategies. Introduction to Tsunami Disaster.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1117**			
Course Title	**Dissertation-I**			
Credit Distribution (L-T-P-C)	0	4	16	**12**

Course Content:

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1120**			
Course Title	**Concrete Technology**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To make the students aware about the advancements that are taking place in the area of concrete technology Advances in Concrete Durability of concrete Special Concrete Concrete Technology - Sustainable & durable construction with concrete Quality Control

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1124**			
Course Title	**Industrialized Building Systems**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To apprise the students about the newer techniques that are prevalent for the different types of building systems. Introduction Standardization Building Systems Strategies for Industrialization Prefabricated Systems for Building Envelopes Case studies and design

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1126**			
Course Title	**Repair, Rehabilitation & Retrofitting of Structures**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To impart knowledge about the techniques that are adopted for repair, rehabilitation and retrofitting of building structure. Condition Assessment of different types of buildings Innovative Repair Materials suitable for buildings Repair Techniques – Existing and innovative Quality Assurance and Control of old building structures Case Studies:- Buildings & Heritage structures

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1128**			
Course Title	**Environmental Impact Assessment**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To impart knowledge on the effect of constructed projects on the environment and systematic analysis of the same. Introduction and Scope Environmental Clearance Process in India Impact assessment Environmental Quality Standards Control measures Case Studies – Green Buildings

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1130**			
Course Title	**Sustainable Design and Energy Efficient Building Systems**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To make the students aware about the sustainable design concept and to generate awareness about the energy efficient building systems Introduction Challenges driving the need for Sustainable Design Building Performance Assessment Tools Insulation and Heat Transfer Case Studies - Integrated design process, Green / Sustainable design projects.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1132**			
Course Title	**Construction, Planning & Management**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To make the students aware about the different techniques that are adopted in building construction practices and their management and usage of different construction equipments. Introduction - RCC and masonry system, pre-engineered and industrialized building system Planning Construction project management Estimation of project cost,

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1134**			
Course Title	**Fire Protection Engineering**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To impart knowledge on different aspects of fire protection in building system and schemes of disaster mitigation. Introduction to fire safety engineering Heat transfer mechanisms in fire & build up of untenability conditions Combustion flammability and retardency, Burning behaviour of materials Active and Passive fire protection

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1136**			
Course Title	**Environmental Engineering & Management**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To impart knowledge on different aspects of pollutants, thrie effect on the environment and efficient management system. Water and Wastewater Engineering. Air Quality and Modelling Solid Waste Management Emerging Technologies in Environmental Management Current trends and emerging technologies, contemporary issues.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1140**			
Course Title	**Ground Improvement Techniques**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To educate the students of geotechnical engineering on the different problematic soils and the techniques of remediation. Various problematic soils Difference between improvement and modification. Soft Soil Expansive Soil Loose Cohesionless Soil Various improvement techniques Organic Soil Contaminated Soil

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1142**			
Course Title	**Optimization Techniques**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To impart knowledge about the techniques that are adopted for optimising different design aspects related to building Introdiuction Types of optimization schemes Linear Optimization techniques Stochastic Programming etc

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1144**			
Course Title	**Deep Excavation**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To impart knowledge on the problems associated with excavation and design of large excavation. Introduction to the analysis and design of excavation Excavation methods and lateral supporting systems Lateral earth pressure Stability analysis Stress and deformation analysis of excavation Design of excavation supporting systems

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1146**			
Course Title	**Fundamentals of Structural Engineering**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction – Structural systems – Determinate & Indeterminate structural forms – different principles for analysis of structural systems – Loading on structural systems; Concept of Matrix method of structural analysis – 1D, 2D & 3D forms; Other analysis methodologies. Concept in structural designs – concrete & steel as structural material – Basics of design processes; Effects of different kinds of loads on structural systems and consequences on the design process.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-1-1148**			
Course Title	**Fundamentals of Soil Mechanics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to Soil and Soil Mechanics Formation of soil - types of soil – phase diagram - index properties & its determination - soil classification - permeability of soils & its determination -effective stress concept – compaction - one dimensional compression - magnitude of settlement - oedometer test - shear strength of soil - failure criterion - measurement of shear strength-drainage conditions and strength parameters - Boussinesq equation - New Mark's influence Chart - approximate stress computation-Westargaard's equation - different types of earth pressure – theories of earth pressure - determination of earth pressure - infinite &finite slopes - different approach of stability analysis Foundation Engineering Introduction - functions – types – capacity from various theory and load test - settlement-IS codal provision – design Stabilization Introduction-needs-principles-different stabilizer-essential properties of stabilizer-methods of applications-effect of stabilizer on engineering properties of soil-design

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-2-1104**			
Course Title	**Health Monitoring of Building Structures**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules The objective of the course is to highlight the importance of monitoring techniques for effective maintenance of buildings and analysis methodologies Introduction monitoring systems of building Numerical modelling Experimental techniques Rehabilitation processes.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-2-1106**			
Course Title	**Tall Buildings & Structures**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To make the students aware about the analysis and design methodologies of tall buildings Introduction – Tall building systems – Analysis Methodology of tall building frames – Different types of loads multibay frames; Shear walls Coupled frames – Frame with shear wall; Principles of 3-D analysis of tall buildings; Perforated cores - Pure torsion, bending and warping of cores; Floor systems – Analysis; Elastic and inelastic stability of frames and shear walls; Analysis for Thermal Stresses; Other Tall structures.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-2-1108**			
Course Title	**Behaviour of Metal Structures**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To impart knowledge on the advanced techniques of analysing metal structures and to characterise their behaviour. Introduction Stability issues Thin plates and their use in buildings Steel columns and their behaviour with residual stress Use of light gauge structure Pre-stressing in steel structure.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-3-1101**			
Course Title	**Wind Effects on Building Structures (WEBS)**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to wind engineering, wind climate and wind structure. Structure of turbulence, probabilistic distribution of wind, extreme wind events. Aerodynamics of bluff bodies, vortex shedding and associated unsteady along and across wind forces. Analytical procedures for along wind and across wind forces. Computational aspects of wind flow around buildings. Wind interference effects. Wind Tunnel Testing and its salient features. Wind effects on buildings, Performance of existing buildings and case studies. Codal provisions- Wind resistant design of buildings, glass panels of doors, windows and facades. Introduction to International Codes. Risk, hazard and vulnerability analysis of wind sensitive structures.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-3-1102**			
Course Title	**Re-engineering of Structures**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction; Structural behaviour of multi-storeyed and Industrial buildings; Various design loads-combinations and behaviour for each component; Characteristics of commonly used materials in engineered/non-engineered construction; Different types of concrete & its properties; Influence of concrete properties on serviceability and durability; Assessment of structural adequacy against different loading systems; Techniques of in-situ evaluation of material properties; Design for strengthening of existing structures; Repair Strategies, Materials for Repair; Different techniques and application of repair measures for building components, Modelling of strengthening techniques; Case studies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-3-1103**			
Course Title	**Structural Response Control for Seismic Protection**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Theory of Vibration Isolation: Theory of vibration isolation-Principle of base isolation-Components of base isolation-Advantages and limitations; Linear theory of base isolation-Applications. Isolation Devices: Different isolation devices-Modeling of isolation devices-Design of isolated devices-Stability of isolation devices-Application of devices to buildings. Energy dissipation devices: Metallic Yield dampers, Friction dampers, Viscoelastic dampers, Tuned mass dampers, Tuned liquid dampers, Shape memory alloy dampers, Application to buildings. Structural Control: Introduction to control theories; Strategies-Active Control-Passive control-Hybrid control-Semi-active control. Case Studies

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-3-1105**			
Course Title	**Computational Nonlinear Mechanics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Types of nonlinearities - Material, Geometric; Combined; general approach to solutions of nonlinear behaviour, initial stress and initial strain approaches; iterative approach using Newton Raphson and modified Newton Raphson methods, incremental and mixed incremental approaches, line search and Arc length methods, convergence criteria etc.; Non-linear constitutive laws, hypo and hyper constitutive laws for materials like concrete, soil, rocks etc. Elasto-plastic behaviour, material yield criteria - Tresca, Von-Mises, Mohr-Coulomb; Yield Criteria for concrete, rocks etc.; Isotropic and kinematic hardening of materials , stress path dependency, plastic stress-strain relations - Prandtl Rauss equations, Levi-Mises relations, stability of plastically deforming bodies, normality principle, plastic flow rule, plastic potential, hardening modulus, generalized elasto-plastic stress relations, solution algorithm using analytical and numerical schemes, application to typical problems. Concrete Plasticity, hardening and softening behaviour. Creep, visco-elasticity and visco-plasticity, Rheological aspects, basic and composite rhelogical models including- Kelvin, Maxwell, Bingham Models, compound models, governing differential equations and solutions, numerical schemes, solution algorithm, application to typical problems. Elasto-viscoplastic constitutive models for concrete, Introduction to fracture mechanics.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-3-1107**			
Course Title	**Continuum Mechanics & Finite Element Analysis**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Continuum Mechanics – Introduction - Vectors and Tensors, Analysis of Strains, large deformations and finite strains, Eulerian Langrangian and Almansi, Green's and Cauchy's strain tensors, Compatibility equations, elastic stress strain equations, generalized Hooke's Law, Material Yield Criteria-Von-mises, Tresca, Mohr-Coloumb, Drucker-Prager etc. Finite-Element Analysis - Finite element technique, discretization, energy and variational approaches, basic theory, displacement, force and hybrid models, shape function, use of isoparametric elements, convergence criteria, numerical intergration, element formulations, 2-D elements, plate bending elements, introduction to 3-D elements, shell elements , interface elements ,boundary elements, infinite elements. Application to non-linear problems; special topics. Usage of commercial packages.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-3-1109**			
Course Title	**Corrosion Control in Reinforced Concrete Structures**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Theory Deterioration of concrete structures: Constituent materials, microstructures, mix design for durability, permeability, carbonation, chloride penetration, corrosion damage, sulphate attack, alkali-silica reaction, other chemical attacks, influence of types of cement on corrosion. Basics of Corrosion: Introduction to corrosion process, forms of corrosion, steel corrosion in concrete, corrosion rate measurement instruments. Condition assessment and corrosion monitoring of reinforced concrete structures: condition survey, nondestructive testing (NDT), measurement of half cell potential, resistivity and corrosion rate, permanent corrosion monitoring systems. Repair principles, materials and corrosion control measures: Patches, overlay, repair mortars, sprayed concrete, FRP wrapping, corrosion, inhibitors, surface coatings and cathodic protection. Practical Corrosion rate measurements in laboratory – NDT and corrosion survey techniques at site – Surface coatings acceptance tests – Cathodic Protection.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**ENG-CBRI-3-1111**			
Course Title	**Applied Soil Mechanics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

This course primarily covers the problems in the field of geotechnical engineering. Syllabus will be one or more of the following problems: Design of innovative foundation in soft soil Slope stability analysis and control measures design including seismic effect Embankment design, Dam foundation design Liquefaction Potential and mitigation Study Conventional foundation design including seismic effect Design of foundations for vibration control Design of R.E. retaining wall with seismicity Solution of foundation problem by Beams on elastic medium Support system design for excavation Design of foundation in Expansive soil and control measures Design of foundation in liquefiable soil Rock anchor design Seepage problem under earth structures

Faculty	**PHYSICAL/ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**PHY/ENG-CBRI-1-0001**			
Course Title	**Research Methodology**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Objective Modules To make the student aware on the ethics necessary to be followed in research and the methodologies generally adopted for carrying out data analysis and handling of primary and secondary data Introduction to Research Methodology Designing and implementing a research project, Measurements in research, Communicating research results, Case studies Primary and secondary data, Analysis of data Quantitative analysis Professional ethics, Ethics in Research, Plagiarism, Communication Skills

Faculty	**PHYSICAL/ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**PHY/ENG-CBRI-1-1119**			
Course Title	**Fundamentals of Engineering Geology**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

ROCKS and STRUCTURES: Rocks & rock masses; Structural Geology- Joints & discontinuities, Folds & faults, Effect of discontinuities on slope stability; Structural geology in engineering construction; Earth processes - Weathering ELEMENTARY ROCK MECHANICS & SOIL MECHANICS: Rock mass classification, Engineering properties of rocks, Rocks as engineering materials, Engineering classification of soils, Index properties, Shear parameters GEOLOGICAL INVESTIGATIONS IN CIVIL ENGINEERING: Remote sensing & GIS for Civil Engineering Projects, Engineering geology in planning, design and construction of engineering structures - Dams, Tunnels, Buildings, Roads. GEOPHYSICAL METHODS: Seismic and Electrical methods for Civil Engineering investigations. LANDSLIDES: Landslide types & processes, Causes, Investigation and analysis, Remedial measures GEOHYDROLOGY: Hydrologic cycle – precipitation, runoff, infiltration, Ground water flow; Surface and subsurface exploration of groundwater- Drilling and construction of wells; Pumping tests and evaluation of aquifer parameters.

Faculty	**PHYSICAL/ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**PHY/ENG-CBRI-1-1138**			
Course Title	**Rock Mechanics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To study the behaviour of rock at site under different stress conditions and to assess its properties in field and in the laboratory as well Introduction to rock mechanics Rocks, rock structures and their importance Surface and subsurface investigations Engineering rock mass classifications & their application Physico-mechanical properties of rocks Stresses in elastic and plastic ground conditions Excavation Methods Support design and instrumentation in tunnels and slopes Problems and their remedies in rock engineering Application of rock mechanics

Faculty	**PHYSICAL/ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**PHY/ENG-CBRI-2-1102**			
Course Title	**Advanced Seismology**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules To impart concepts on the basic aspects of seismic waves, their propagation, related instrumentation and consequences on the design of buildings Science of Earthquakes Seismic Waves, Magnitude & Intensity, Earthquake Source Mechanism, Seismic Instrumentation, Seismic Zoning Map, Site Response Studies, Source and Path effect, Seismic Hazard Analysis, Risk and estimation, Seismic Micro-zonation, Earthquake Prediction Studies, Seismic Alert Systems

Faculty	**PHYSICAL/ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**PHY/ENG-CBRI-2-1110**			
Course Title	**Landslide Disaster Mitigation**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Objective Modules Study on landslide to understand its behaviour, design of slope and control measure design Introduction - Landslide Types and processes Application of Remote Sensing and GIS in Landslide studies Landslide Hazard and Risk Assessment Landslide Instrumentation SMR & Slope Stability Assessment – Landslide Control Measures Landslide case studies

Faculty	**CHEMICAL/ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**CHE/ENG-CBRI-3-1113**			
Course Title	**Advanced Instruments in Materials Research**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Mechanical properties, Thermal properties (DMA, TMA, DSC, TGA etc.), Rheology, Microscopy (SEM, TEM and ESCA), Flammability (Cone calorimetry and reaction to fire characteristics), IR Spectroscopy, Thermal conductivity etc.

Faculty	**CHEMICAL/PHYSICAL/ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**CHE/PHY/ENG-CBRI-4-0001**			
Course Title	**Project Proposal**			
Credit Distribution (L-T-P-C)	0	1	2	**2**

Course Content:

Formulation of a project proposal by selecting topics of high relevance and novelty and will have state-of-the art review, methodologies, recommendations etc. in specified format in a holistic manner preferably candidate's own research work suitable for submission to appropriate funding agencies.

Faculty	**CHEMICAL/PHYSICAL/ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**CHE/PHY/ENG-CBRI-4-0002**			
Course Title	**Review Article**			
Credit Distribution (L-T-P-C)	0	1	2	**2**

Course Content:

Preparation of one review article on specific research area of the student.

Faculty	**CHEMICAL/PHYSICAL/ENGINEERING SCIENCES**			
Lab Name	**CSIR-CBRI, ROORKEE**			
Course Nomenclature	**CHE/PHY/ENG-CBRI-4-0003**			
Course Title	**Housing related societal issues under CSIR-800 Programme**			
Credit Distribution (L-T-P-C)	0	0	8	**4**

Course Content:

The students have to undertake a project in rural areas for 6-8 weeks in the line with CSIR-800 programme which is primarily prepared at empowering 800 million Indians by way of S&T inventions. The theme for the project may be chosen from CSIR-800 documents and as per expertise available in the laboratory. Students will select the topics in consultation with Doctoral Advisory Committee (DAC).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-1-4701**			
Course Title	**Instrumentation & Sensors for Structural Response Measurement**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Introduction: Definition of Instrumentation, Why instrumentation of Structures/Structural components? concepts and Methods - Potential areas of application; measurements: Data Acquisition - Data Transmission - Data Processing - Storage of processed data - Knowledgeable information processing - Remote Structural Health Monitoring; Sensors for measurements: Electrical Resistance Strain Gages (ERSG), Vibrating Wire Strain Gages (VWSG), Fiber Optic Sensors (FOS), Temperature Sensors, Accelerometers, Displacement Transducers, Load Cells, Humidity Sensors, Crack Propagation Measuring Sensors, Corrosion Monitoring Sensors, Pressure Sensors

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-1-4702**			
Course Title	**Advanced Mechanics of Materials**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Mechanical Properties of Engineering and Engineered Materials - Stress-Strain Curve of Engineering Materials Direct stress; shear stress; Indicinal notation; compact form of representing the equations; dummy index; free index; brief introduction to vector algebra; Kroneckor delta; Properties of stress tensor; eigen vectors; normal stress; shear stress; Cauchy stress theorem; hydrostatic stress; deviatoric stress; Principal stresses in three dimensions; Stress invariants; octahedral plane, normal stress, shear stress on octahedral plane; Equilibrium equations for two dimensional and three dimensional stress; symmetrical tensor components by using moment equilibrium condition Types of strain; Deformation gradient tensor; rigid translation; rigid rotation; isochoric deformation; Strain tensor; Lagrangian and Eulerian strain tensors; Dilatation; Spherical and deviatorial strain tensor; Principal strains - Strain invariants; Octahedral strains; Equations of compatibility for strain Concept of plane stress, concept of plane strain Relation between stress and strain, Lame's constants, Generalised Hookes law; Reduction of constants in generalised Hooke's law Beams on elastic foundation – Infinite and semi-infinite beams with concentrated and distributed loads Torsion – Open and closed sections, Shear centre, warping cross-section properties, Shear flow in closed and open sections, Torsion of shafts, closed and open sections Advanced Topics - Buckling of Compressed Members and Slenderness Ratio, Elements of Structural Vibrations, Fundamentals of Fatigue Analysis

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-1-4703**			
Course Title	**Computational Methods**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Approximations: Accuracy and precision, definitions of round off and truncation errors, error propagation; Algebraic equations: Formulation and solution of linear algebraic equations, Gauss elimination, LU decomposition, iteration methods (Gauss-Seidal), convergence of iteration methods, norms and errors, condition numbers, Conjugate Gradient methods, Pre conditioning, PCG methods, eigenvalues and eigenvectors; computer implementation. Interpolation methods: Newton's divided difference, interpolation polynomials, Lagrange interpolation polynomials; Differentiation and Integration: Numerical Integration; finite differences, Newton cotes rules, trapezoidal rule, Simpson's rule, extrapolation, Gaussian quadrature; Numerical solution of ordinary differential equations; Explicit and implicit formulations, single and multi-step methods, predictor-corrector methods, accuracy, convergence, stability; Solution of nonlinear equations: Open methods, closed methods, Newton-Raphson method, convergence, Variants of Newton Raphson method, Secant method, computer implementation, Numerical solution of Partial Differential equations: solution to elliptical, parabolic and hyperbolic equations; computer implementation Regression methods: Linear and non-linear regression, multiple linear regression, general linear least squares; Introduction to optimization methods

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-1-4704**			
Course Title	**Advanced Engineering Mathematics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Ordinary Differential Equations of the First Order , Ordinary Linear Differential Equation, Laplace Transformation, Line and Surface Integrals. Integral Theorems, Matrices and Determinants (Systems of Linear Equations), Fourier Series and Integrals, Partial Differential Equations, Sequences and Series, Taylor and Laurent Series, Special Functions. Asymptotic Expansions

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-1-4705**			
Course Title	**Non-Destructive Testing & Forensic Engineering**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction – Need of non-destructive testing – Visual inspection- Crack measuring Microscope-Borescope – Image analysis; Surface Hardness Methods- Introduction- Rebound/ Schmidt Hammer test-Codal Provisions; Penetration Resistance Methods- Introduction- Probe penetration – Pin penetration-limitations; Pullout Test – Break –off test – Maturity Method – Pull – off test – In – situ strength assessment; Acoustics – Principles –Generation of ultrasonic waves – Transducers – Principles of pulse echo method – Through transmission method – Low frequency ultrasonic -Ultrasonic Pulse velocity Method for concrete- introduction- Codal provisions- Calibration – Ultrasonic testing for metals-Ultrasonic phased array - Pile integrity testing- Impact echo- ASTM Codal provisions; Electromagnetic methods- Principle- Cover meter for concrete- Radar Method- Principle- Instrumentation- A.C. Potential Drop Method for crack depth measurement-Barkhausen Noise Technique; Partially Destructive methods-Core testing- density- water absorption- Compressive strength- Codal provisions; Data processing – Analysis- Interpretation; Other methods- Radiography/ Nuclear- Infrared Thermography Acoustic Emission- Digital imaging correlation- Vibration based motion analyzer

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-1-4706**			
Course Title	**Non-Destructive Testing -Lab**			
Credit Distribution (L-T-P-C)	0	0	1	**1**

Course Content:

Introduction to Non-destructive testing (NDT) – Non-destructive versus destructive tests; Need for NDT; Methods of NDT: (brief description of equipment, test, application and limitation); Visual Inspection; Rebound Hammer Test ; Cover Meter Test; Impact-echo Test; Ground Penetrating Radar (GPR); Infrared Thermography; Core Test (partially destructive test); Techniques for corrosion monitoring/assessment of reinforcement in concrete structures: Half-cell potential measurement/survey, Resistivity measurement/survey, Corrosion rate measurement/survey

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-1-4707**			
Course Title	**Research Methodology & Professional Practice**			
Credit Distribution (L-T-P-C)	2	0	1	**2**

Course Content:

Research Methodology : Literature review ; Searching the literature; Managing references; Effective scientific writing; Effective scientific presentation; Intellectual property management; Writing and reading Patents ; Research planning; Ethics in Science Introduction to organisational structure; Communication Skills; Engineering Ethics and Social Responsibility; Introduction to Decision Making; Professionalism Using Standard; Social Intelligence; Decision Making in Company; Professional Judgment; Entrepreneurship and Risk Management; inter-relationships between professionalism and ethics; inter-relationships between Ethics and Social Intelligence; inter-relationships between Professional Judgment and Social Intelligence; mentoring; leadership exercises; group dynamics; conflict resolution

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-2-4701**			
Course Title	**Dynamics of Structures**			
Credit Distribution (L-T-P-C)	3	0	1	**3**

Course Content:

Introduction: dynamic vs. static response; types of dynamic loading: seismic, impact, wind, blast; Principles of dynamics - Formulation of equations of motion by different methods - single degree of freedom systems - free and forced response - effect of damping; Multi-degree of freedom systems - Formulation of equations of motion - Eigen values problems - Modes shapes and orthonormality of modes -Approximate methods of extraction of eigen values and natural frequency; Seismic response spectra Response spectra parameters; response spectra relationships; Dynamic response of MDOF systems - Mode superposition techniques - Numerical integration procedures; Continuous systems - Modeling - free and forced vibration of bars and beams; MDOFs : Response spectra analysis; SRSS and CQC combination methods; Introduction to frequency domain analysis; Time domain vs. frequency domain; Fourier series; the Fast Fourier transform (FFT);assessing frequency content; frequency based filtering; Application of finite element method in structural dynamics

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-2-4702**			
Course Title	**RCC & Prestressed Concrete Structures**			
Credit Distribution (L-T-P-C)	3	1	0	**3**

Course Content:

Basics of RCC: ingredients; properties; basic design concepts; working stress method; limit state method; ultimate load method; durability aspects; stress-block parameters; overview of IS:456-2000. Flat slab: advantages; disadvantages; codal provisions; design of an interior and exterior flat slab; bending moment; reinforcement; check for shear stress; reinforcement detailing. Grid or coffered floor system: importance of grid floor; advantages; methods of analysis; computation of deflection; flexural rigidities; torsional rigidities. Circular slab: comparison of physical behaviour of rectangular slab and circular slab; moment calculation of circular slab for various end conditions; reinforcement detailing. Yield line analysis of slabs: Equilibrium approach; method of virtual work; Introduction to chimney: functions of chimney; loads to be considered for the analysis and design of chimney; codes to be followed; design considerations. Introduction to prestressed concrete: materials, types of prestressing systems and devices; analysis of prestressed concrete elements for flexure: concepts of stresses at transfer and service loads, ultimate strength in flexure, losses in prestress, anchorage zone stresses; philosophy of design: limit state design for flexure and shear, tendon profiles in post-tensioned and pre-tensioned members, comparative analysis of provisions of international standards; statically indeterminate structures: continuous beams and portals, secondary moments, concordancy of tendon profiles; composite construction: longitudinal shear transfer, transverse shear, stage prestressing, creep and shrinkage effects; external prestressing; construction aspects – prestressing, precast-prestressed concrete, stressing sequence

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-2-4703**			
Course Title	**Finite Element Technology-I**			
Credit Distribution (L-T-P-C)	3	1	0	**3**

Course Content:

Review of matrix methods of structural analysis; Stationary Principles, Rayleigh-Ritz method and Interpolation: Principle of stationary potential energy- Rayleigh-Ritz method - Stationary principles and governing equations - Finite element form Rayleigh-Ritz method - FEM formulation from a functional, Interpolation, C0 and C1 elements; Displacement based Element formulations:Overview of element stiffness matrix - Load formulations - Equilibrium and compatibility - convergence requirements - patch test - stress calculations - plane stress - plane strain - axisymmetric and solid finite elements - triangular, quadrilateral, tetrahedron and hexahedron elements; Isoparametric finite elements: 1-D, 2-D and 3-D shape functions - Lagrangian and Serendipity family of elements- numerical integration- validity of isoparametric elements- element and mesh instabilities- coordinate transformations, handling of constraints; Substructuring techniques: Single and Multi level methods - Static condensation- Asynchronous block factorization technique - Various applications of static condensation technique; Plate bending elements: Plate bending theory - Mindlin and Kirchhoff element formuations - Concepts of locking, Full, reduced integration and selective reduced techniques; Finite Element Modeling techniques; Buckling & Bifurcation analysis of structures using FEM;Finite Element Methods for structural dynamics.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-2-4704**			
Course Title	**Bridge Engineering**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction - historical development, Classification and components of bridges, choice of type of the bridges, bridge aesthetics; Bridge codes – standard specifications for highway and railway bridges; Analysis and design of RC and PSC bridge decks, load distribution in slab and girder bridges, analysis and design of voided slab bridge decks, behaviour of skew bridge decks; Analysis and design of RC and PSC box-girder bridge decks; Analysis and design of steel and composite bridges; Design of bearings; Design of substructure and foundations - piers and abutments of different types, shallow and deep foundations; Modern methods of construction - Incremental launching and its impact on analysis and design, segmental construction ; Introduction to analysis and design of long span bridges: suspension and cable stayed bridges

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-2-4705**			
Course Title	**Plate and Shell Structures**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Thin plates, Kirchhoff theory - strain displacement relations, stresses and stress resultants, constitutive equations, equilibrium equations, boundary conditions, Analysis of rectangular and circular plates with different boundary conditions and loadings ; plates on elastic foundation; Buckling of plates; Membrane and bending theory for analysis of singly curved and doubly curved shells – long and short cylindrical shells, single and multi barrel shells, Beam-arch approximation for long cylindrical shells; Analysis of surfaces of revolution – domes, cylindrical, conical and hyperboloid of revolution subjected to different types of loadings; Analysis and shells of translation - elliptic paraboloids, hyperbolic paraboloids; Analysis of folded plates;

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-2-4706**			
Course Title	**Earthquake Engineering**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Elements of Engineering Seismology - Causes of earthquakes - seismic waves – magnitude and intensity - characteristics of strong earthquake ground motions - Seismic Susceptibility of Indian Subcontinent; Introduction to theory of vibrations - Flexibility of long and short period structures - concept of response spectrum; Seismic design philosophy - Concept of Earthquake Resistant Design. Building forms for earthquake resistance - Building Systems – Rigid Frames, Braced Frames, Shear Walls - Structural Configuration; Evaluation of earthquake load on structures based on IS: 1893 – response spectrum method - 3 D computer analysis of building – Importance of detailing IS 13920 Seismic design provisions for bridges, dams, tanks and Industrial structures; Performance of structures under past earthquakes - Lessons learnt - Behaviour of RC, steel, Masonry and prestressed concrete structures under cyclic loading ; Seismic design of non-engineered construction; Soil performance – Soil liquefaction – Soil structure interaction; Seismic evaluation and retrofitting of structures; Modern Concepts: Introduction to Passive and Active Control of Civil Engineering Structures, Base Isolation, energy dissipation devices, Adaptive systems – Case studies

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-2-4707**			
Course Title	**Engineering for Natural Hazards**			
Credit Distribution (L-T-P-C)	3	0	1	**3**

Course Content:

Hazard Characteristics: Seismology and ground motion characteristics; Extreme wind Characteristics; Hazard Estimation: Deterministic methods; Stochastic methods; Deterministic and probabilistic seismic hazard analysis; Risk analysis of cyclonic wind speed; Post Disaster Damage Surveys: Earthquake Disaster; Cyclone Disaster; Materials and Methodology of Constructions; Vulnerability Analysis: Damage Probability Matrix approach; Fragility Analysis approach; Risk analysis: life quality index Approach; Guidelines for Disaster Resistant Structures: Earthquake Disaster; Cyclone Disaster

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-2-4708**			
Course Title	**Fundamentals of Probability and Statistics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Theory & Application of Probability and Statistics: Nature and Purpose of Mathematical Statistics; Tabular and Graphical Representation of Samples; Sample Mean and Sample Variance; Random Experiments, Outcomes, Events; Probability; Permutations and Combinations; Random Variables. Discrete and Continuous Distributions; Mean and Variance of a Distribution; Binomial, Poisson, and Hypergeometric Distributions; Normal and other important continuous Distributions; Distributions of Several Random Variables; Random Sampling. Estimation of Parameters; Confidence Intervals; Testing of Hypotheses, Decisions; Quality Control; Acceptance Sampling; Goodness of Fit. χ2-Test; K-S test; Nonparametric Tests; Pairs of Measurements.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-2-4709**			
Course Title	**Stochastic Mechanics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction. Basic probability theory. Brownian motion and white noise. Stochastic Integrals, Ito's formula. Stochastic differential equations (SDE). Diffusion Processes. Stochastic stability. Introduction to numerical solution of SDE. Applications.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-2-4710**			
Course Title	**Wind Engineering**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Atmospheric Boundary layer and Wind Turbulence: Mean Velocity Profiles, Turbulence Intensity, Turbulence Length Scales, Turbulence Spectrum, Terrains, Full-scale Measurements; Design Wind Speeds: Mean and Gust Wind Speeds, Mean Return Period, Life of Structure, Extreme-value Analysis, Modification Factors (k1, k2, k3); Basic Bluff-body Aerodynamics: Fundamentals of Computational Fluid Dynamics, Pressure Coefficients, Force Coefficients, Vortex Shedding Phenomenon; Wind Induced Random Vibrations of Structures: Probability Theory, Random Data, Spectral Approach, Aerodynamic Admittance Function, Mechanical Admittance Function, Gust Response Factor; Aero-Elastic Phenomena: Inertial Loads, Lock-in Effect, Galloping, Flutter; Wind Tunnel Testing: Similarity Laws, Rigid Models, High Frequency Force Balance, Aero-elastic Models; Applications to Design of Buildings and Structures: Low-rise Buildings, High-rise Buildings, Chimneys, Lattice Towers, Cooling Towers, Wind Load Codes; Cyclone Wind Effects

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-2-4711**			
Course Title	**Thesis Work and Seminar**			
Credit Distribution (L-T-P-C)	0	0	0	**12**

Course Content:

N/A

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-2-4712**			
Course Title	**Dissertation Seminar**			
Credit Distribution (L-T-P-C)	0	0	0	**6**

Course Content:

N/A

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-2-4713**			
Course Title	**Dissertation Report and Viva-voce**			
Credit Distribution (L-T-P-C)	0	0	0	**14**

Course Content:

N/A

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4701**			
Course Title	**Metal Structure Behaviour and Design**			
Credit Distribution (L-T-P-C)	3	1	0	**3**

Course Content:

Philosophies of design - ASD vs LRFD and Structural Reliability; Failure Criteria; Brittle Fracture/Ductile Yielding; von Mises Yield Criteria; Lateral torsional buckling - Elastic and Inelastic Columns, plates, and compression members - Local Buckling of Plate Elements; Design Criteria; Torsional Compression Buckling, Approximate 2nd order effects; Elastic and Inelastic Behavior Frame design review -Second Order Effects and Moment Magnification; Stability and Leaning Columns; Connections: Review of Bolt and Weld Strength; Riveted and Bolted Connections Design Aids Example; Design of Aluminum Structures: Introduction, Stress-Strain Relationship, Permissible Stresses, Tension and Compression Members. Microwave and Transmission Towers – Introduction, structural configuration, function, analysis and design, codal provision for design of tower and foundation Tubular Structures - Tubular Trusses, joint details, tubular scaffoldings, codal provisions Cold Form light gauge section- Type of cross section, Stiffened, multiple stiffened and unstiffened element, flat- width ratio, effective design width, Design of light gauge compression, tension and flexural members Bending behavior - General Flexural Theory; Unsymmetrical Bending; Biaxial Bending of Tapered Members; Torsion - Pure Torsion; Shear Flow; Shear center of Open Thin-Walled Sections; Uniform Torsion; Torsion of Structural Shapes; Non-uniform Torsion; Combined Torsion and Bending Torsion of Closed Thin-Walled Sections, Single Cell and Multi-Cell; Fatigue - Stress Life, Strain Life, Fracture Mechanics; Variable Amplitude Loading and Miner’s Rule; Fatigue Design Requirements

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4702**			
Course Title	**Finite Element Technology-II**			
Credit Distribution (L-T-P-C)	3	0	1	**3**

Course Content:

Adaptive refinement techniques: Introduction, definition of errors, various basic error estimators for linear static and dynamic analysis, superconvergence and optimal sampling points, superconvergent patch recovery. Finite element procedures for fracture Mechanics problems, introduction, various implementation techniques. Nonlinear finite element analysis: Introduction, Advantages of linear analysis,necessity of nolinear analysis, Consequences of nonlinear analysis, examples of nonlinear stress analysis, components of nonlinear computational model, classification of sources of nonlinearity, geometric and material nonlinear analysis, brief introduction to different types of formulations for geometric nonlinear analysis. Geometrical nonlinear analysis: total Lagrangian and updated Lagrangian formulations for discrete elements and computer implementation, different strain measures, Brief review of continuum mechanics, geometrical nonlinear formulations and computer implementation for continuum elements. Basic plasticity: Introduction, one-dimensional elastic-Plastic analysis, Small strain plasticity relations, Elastic-Plastic analysis procedures, computer implementation

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4703**			
Course Title	**Uncertainty Handling in Engineering Decision Making**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: Basic Definitions; Examples; Different types of uncertainties; Exposure to formal frameworks for handling uncertainties; Application of Probability and Statistics in engineering decision making: Basic definitions of probability; random variables; Setting-up of framework for engineering decision making in the probabilistic/random environment; Statistical analysis of engineering data; Statistical decision making; Application of stochastic processes for engineering decision making : Basic definition of stochastic process; Some commonly used stochastic processes; Learning models for engineering decision making – learning in both stationary and non-stationary environment; Application of fuzzy sets in engineering decision making :Basic definition of fuzzy sets; Some commonly used fuzzy sets; Use of fuzzy stochastic models for engineering decision making; Handling of uncertainties using possibility and plausibility theories ; Introduction to application of game-theoretic approaches for engineering designs

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4704**			
Course Title	**Soft Computing**			
Credit Distribution (L-T-P-C)	3	1	0	**3**

Course Content:

Introduction: Introduction of Soft-computing tools, Fuzzy Logic, concepts meta-heuristics, Evolutionary algorithms, Neural Networks and Probabilistic Reasoning; Artificial Neural Networks (ANN): Different Architectures, Back-propagation Algorithm, Hybrid Learning Rule, Supervised Learning- Perceptrons, Adaline, Back-propagation Multilayer Perceptrons, Radial Basis function Networks. Unsupervised Learning – Competitive Learning Network, Kohonen Self-Organizing Networks, Hebbian Learning, The Hopfield Network; Support Vector Machines: Support vector machines and other kernel based learning algorithms, Implementation techniques for SVM, application of SVM for engineering problems; Fuzzy Set Theory: Basic Definition and terminology, Basic Concepts of Fuzzy Logic, Set Theoretic Operators, Membership functions- formulation and parameterization. Fuzzy Union, Intersection, and Complement. Fuzzy Rules and Fuzzy Reasoning. Fuzzy Inference Systems- Mamdani and Sugeno Fuzzy models. Fuzzy Associative Memories;Evolutionary Algorithms: Basics of evolutionary Algorithms, Design issues in evolutionary Algorithm, evolutionary computing; Applications with Soft Computing Tools: Case studies with ANN, fuzzy and Hybrid approaches. Multi-objective optimization and decision making

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4705**			
Course Title	**Repair & Rehabilitation of Concrete Structures**			
Credit Distribution (L-T-P-C)	3	0	1	**3**

Course Content:

General: Introduction , cause of deterioration of concrete structures, Diagnostic methods & analysis, preliminary investigations ,experimental investigations using NDT, load testing, corrosion mapping, core drilling method; Serviceability and Durability: Effects due to climate, temperature, chemicals, wear and erosion, Design and construction errors; Maintenance and Repair Strategies: Definitions: Maintenance, repair and rehabilitation, Facets of Maintenance importance of Maintenance Preventive measures on various aspects. Assessment procedure for evaluating a damaged structure; Causes of deterioration – testing techniques; Techniques for Repair: Corrosion protection, corrosion inhibitors, corrosion resistant steels, coatings, cathodic protection. Strengthening of structural elements with various methods; Case Studies: Structures affected due to corrosion related failure

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4706**			
Course Title	**New Composite Materials in Civil Engineering Applications**			
Credit Distribution (L-T-P-C)	3	0	1	**3**

Course Content:

Concrete Composite: Fresh concrete and hardened concrete – Mix Design – Use of Admixtures Mechanical and Durablity properties; Fibre Reinforced Concrete (FRC):Types of Fibres – Factors affecting strength and stiffness of fibre concrete– Production of FRC – Tests on FRC – Applications of FRC; Ferro cement-production and application; High Performance Concrete (HPC): Definition – Constituent materials – Production methods – Advantages of HPC – Applications of HPC; self compacting concrete; definition – constituent material – mix proportion – production methods – various tests on scc – applications of scc; Polymer Concrete Composite: Classification of Polymer concrete – Methods of Production – Advantages of Polymer Concrete – Applications of Polymer Concrete; FRP composites: Constituent materials – Method of Productions – Properties and Production method – Applications

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4707**			
Course Title	**Advanced techniques for characterisation of Materials**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: Introduction of different characterization techniques and its importance, structure-property correlation, characterization of materials at different levels (macro, meso, micro and nano). Structure analysis tools: X-rays, characteristic X-ray spectrum, Bragg's Law, Diffraction methods, Principle, equipment and applications, structure factor, Bravais lattice, filters and counters/detectors, applications of X-ray diffraction in materials characterization – determination of crystal structure, lattice parameter and porous structure; Optical characterization techniques: Optical microscopy - principle of working, importance and applications, sample preparation, theoretical and practical resolution, numerical aperture, principle of image formation, effective/empty magnification, Advanced Microscopic Techniques, Absorption, transmission, reflection, Different sophisticated spectroscopy methods; Thermal analysis techniques:Differential thermal analysis – principle of working, accuracy, sensitivity, calibration, importance, and applications, Differential Scanning Calorimetry; Applications: Applications of different characterization techniques for crystalline, non-crystalline materials and amorphous materials with due emphasis on cement based materials

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4708**			
Course Title	**Characterisation Techniques for Cementitious materials-Lab**			
Credit Distribution (L-T-P-C)	0	0	1	**1**

Course Content:

Spectroscopic Methods: Principle, Protocol, Analysis and Interpretation of (a)X-ray fluorescence (XRF) - Elemental and Oxide analysis,(b)X-ray diffraction (XRD) - Phase identification of crystalline materials,(c)Fourier transform infrared spectroscopy (FT-IR) - Identification of the functional groups ; Microscopic Methods: Principle, Sample preparation, Protocol, Analysis and Interpretation of (a) Scanning Electron Microscopy (SEM) - Morphological or Surface level examination of the materials Particle size analysis - Distribution of particles and their sizes:Principle, Protocol, Analysis and Interpretation. Thermal analysis - Phase changes of material with respect to temperature, Principle, Protocol, Analysis and Interpretation. Pore Size analysis: Determination of the pore size and their distributions

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4709**			
Course Title	**Molecular Dynamics**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction : Molecular Dynamics: A General Overview, General Classification of Materials - Metal, Ceramic, Polymer, Composites, Macro composites and Nano-composites, Length Scale & Time Scale (Different Experimental and modeling Techniques at different length scales), Multiscale Modeling: A brief discussion;Theoretical background: Different types of energies: Bond, Angle, Torsion/dihedral, Electrostatic, van der Waals, Hydrogen bonding , Molecular Mechanics Force fields: Definition & Types, Mathematical Formulation of Molecular Dynamics equation, Different algorithms to solve differential equations of MD, Derivation of force field parameters; Computational Modeling and Simulations: Temperature & Pressure control: different methods, Periodic Boundary Conditions (PBC), Van der Waals interaction cut-offs, Ewald summation technique (electrostatic interaction), Different Ensembles, Minimizations and simulation using different MD platforms, Introduction to Steered Molecular Dynamics (SMD);Analysis and Interpretations: Analysis and interpretation of MD output, Visualizing MD trajectories, Estimation of Radial Distribution Function, Auto correlation Function, Mechanical Properties/Load Displacement Characteristics, Potential Energy Surface (PES) ; Applications of Molecular Dynamics:SMD on nanomaterials, Mechanical characterization of hydrated, engineered cement composites, Mechanical characterization of nanomodified polymers, Surface modifications, Functionalization of polymers, Interactions of Polymer with nanocomposites

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4710**			
Course Title	**Advanced Cementious Composites & Characterisation of Materials**			
Credit Distribution (L-T-P-C)	3	0	1	**3**

Course Content:

Fiber-Reinforced Cementitious Composites, High-Strength Cementitious Composites, Polymers in Concrete, Shrinkage-Compensating Concrete, Self-Compacting Concrete, Engineered Cementitious Composite, High-Volume Fly Ash Concrete, Structural Lightweight Concrete, Heavyweight Concrete – Constituent materials– Properties and Applications, Introduction to materials and Techniques, its importance, structure sensitive/insensitive properties, structure-property correlation, levels of characterization (macro, meso and micro).Generation of X-rays, characteristic X-ray spectrum, Bragg's Law, Diffraction methods, Principle, equipment and applications, structure factor, Bravais lattice, filters and counters/detectors, applications of X-ray diffraction in materials characterization. Optical microscopy - principle of working, importance and applications, sample preparation, theoretical and practical resolution, numerical aperture, principle of image formation, microscope construction and working, effective/empty magnification, Advanced Microscopic Techniques, Absorption, transmission, reflection

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4711**			
Course Title	**Advanced Fatigue & Fracture of Engineering Structures**			
Credit Distribution (L-T-P-C)	3	0	1	**3**

Course Content:

Introduction to deformation behavior: Concept of stresses and strains, engineering stresses and strains, Different types of loading and temperature encountered in applications, Tensile Test - stress - strain response for metal, ceramic and polymer, elastic region, yield point, plastic deformation, necking and fracture, Bonding and Material Behaviour, theoretical estimates of yield strength in metals and ceramics; Yielding and Plastic Deformation: Hydrostatic and Deviatoric stress, Octahedral stress, yield criteria and yield surface, texture and distortion of yield surface, Limitation of engineering strain at large deformation, true stress and true strain, effective stress, effective strain, flow rules, strain hardening, Ramberg-Osgood equation, stress - strain relation in plasticity, plastic deformation of metals and polymers; Deformation under cyclic load – Fatigue: S-N curves, Low and high cycle fatigue, Life cycle prediction, Fatigue in metals, Notch effects, residual stress effects, fatigue under variable amplitude loading; Crack-tip Stress and Displacement Field Equations:Airy's Stress Function for Mode-I, Westergaard Solution of Stress Field for Mode-I, Displacement Field for Mode-I, Relation between KI and GI, Stress Field in Mode-II, Generalised Westergaard Approach, William's Eigen Function Approach, Multi-parameter Stress Field Equations, Validation of Multi-parameter Field Equations; Experimental Techniques: Fractrographic studies, Using special gauges, Photo Elasticity, Acoustic Emission techniques, Compliance Measurements , ACPD technique, Digital Image correlation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4712**			
Course Title	**Advanced Numericals methods for Fracture Mechanics**			
Credit Distribution (L-T-P-C)	3	1	0	**3**

Course Content:

Finite element methods: Singular finite element methods, Adaptive refinements, Error estimation techniques, NI-MVCCI technique ; Extended Finite Element Methods: Historical development of XFEM, Enrichment functions, XFEM formulation, weak discontinuities, strong discontinuities, Tracking moving boundaries; Meshless methods: Fundamental concepts, Formulation, Recent developments, Convergence analysis, Adaptivity analysis, Engineering applications; Weight Function techniques: Basic principles of greens functions, stress intensity factors as Greens functipons, Weight functions, Numerical Weight Functions, Application of BEM to weight functions, Weight functions for strip yield cracks, weight functions for residual stress fields; Engineering Application: Recent Advances in numerical fracture mechanics, Application to Multiple crack problems and non-linear applications.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4713**			
Course Title	**Mechanics of wave propagation**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Spectral Analysis and Frequency domain dynamic analysis: Introduction to frequency domain dynamic analysis, Pros and cons over time domain analysis, DFT, FFT, spectral analysis of wave motions, propagation and re-construction of waves, Group velocity, phase velocity. Uniform and Dispersive waves, Geometric damping for infinite elastic continua;Spectral finite elements: Simple axial rod, Euler Bernoulli beam, Timoshenko beam, Approximations due to various mass formulations in combination of static stiffness;Longitudinal wave propagation through rods: Rod theory, De-Alembert's solution, Dissipation in rods, throw-off elements, reflections and transmissions, Pile integrity testing;Flexural wave propagation: Euler-Bernoulli beam theory, reflections of flexural waves from discrete masses and abrupt change in impedance, Impedance matching and mis-matching, non-destructive testing and inverse problems in wave propagation;Theory of Lamb waves: Lamb wave propagation, symmetric and un-symmetric modes and lamb wave propagation through composites; Acoustics: Introduction to wave propagation through fluid medium, Doppler effect, wave propagation under sonic, ultra-sonic ranges and EM waves;Seismic wave propagation: P and S waves, Surface waves, Rayleigh and Love waves, Hydrodynamic wave propagation, Tsunamis and Sieches (In-land water waves).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4714**			
Course Title	**Advanced Structural Health Monitoring**			
Credit Distribution (L-T-P-C)	3	1	0	**3**

Course Content:

Introduction: SHM scheme, various steps in SHM, damage diagnostic methods, output only damage diagnostic methods, challenges in SHM, Experimental modal analysis, operational modal analysis and combined methods; Vibration based damage diagnostic methods: Frequencies, mode shapes, modal flexibility, modal strain energy, curvature mode shapes, mode shape relative difference, frequency response functions. Limitations of vibration based damage detection techniques; Non-model based damage detection techniques: Singular Value Decomposition, Principal Component Analysis/ Proper Orthogonal Decomposition, Demonstration of effectiveness of PCA based algorithms through numerical examples; Environment Variability in SHM: Effects of environmental variability on damage diagnostic techniques, Various Damage detection techniques to deal with environmental variability; Time-frequency analysis: Fourier transforms, short time Fourier transforms, wavelets, Hilbert Huang Transform (HHT), damage detection using HHT; Operational modal analysis: Necessity of OMA, OMA using time and frequency domain, concept NEXT, OMA using HHT, BSS algorithms; Model updating: Direct methods ,frequency response methods, iterative methods; Sensor fault detection: Types of faults, methods for sensor fault detection, sensor fault detection scheme using PCA, sensor correction, correction of faulty sensor data, multi level algorithms for sensor fault detection; Optimal sensor placement(OSP) techniques: Importance of OSP, Classification of OSP methods, Various types of OSP methods, sensor set expansion, sensor set truncation, Demonstration though numerical examples; Damage Prognosis: Damage prognosis, Damage-Prognosis Solution Process,Classification of the damage-prognosis problem,Relation between usage monitoring, structural health monitoring, and damage Prognosis, Physics-based modeling Vs Data-based modeling, Elements of Prognosis Technology, Sensing and Data Acquisition Strategies for Damage Prognosis, Data interrogation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4715**			
Course Title	**Advanced stability of Structures**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: Introduction to potential energy method; Axioms connecting potential energy to equilibrium and stability; Post-buckling responses for geometrically perfect systems; Imperfect systems and imperfection-sensitivity; Struts and Columns: Instabilities in struts and columns: Approximate methods of analysis; Rayleigh and Timoshenko methods. Design of real columns using the Perry-Robertson formulation; MDOF systems: Multiple degree-of-freedom elastic systems; General Theory approach; Diagonalised systems; Elimination of passive coordinates; Non-trivial fundamental paths; Mode interactions; Beams and frames: Instabilities in beams; Direct equilibrium and energy formulations, Lateral-torsional buckling; General loading cases and effective lengths; Instabilities in rigid framed structures; Stability function; Rings and arches: Instabilities in rings, curved bars and arches; Plates and shells: Instabilities in plates and shells: critical and post-buckling in plated structures under compression and shear; Inelastic stability: Inelastic stability studies; Reduced tangent modulus and Shanley double tangent modulus.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4716**			
Course Title	**Micromechanics of Brittle Materials**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to Micromechanics of Materials; Multiphase Materials; Unidirectional Composites, Modeling principles, stress and strain localization, Shear Modulus, Poisson Ratio, ElasticPlastic Loading, Thermo-mechanical Properties, Bonds in Solids, Ion Bond, Covalent Bond, Metallic Bond, Van der Waals Bond, Hooks Law, Thermal Stresses, Theoretical Strength; Homogenization Theory, Representative Volume Element Concept, Averaging, Basic Equations, Eigenstrains, Eigenstrains, Thermal Strains, Mechanical Loading, Dilute Approximation, Self Consistent Model, Mori-Tanaka Method; Continuum Modeling Aspects; Case study: Multiphase materials; Introduction, brittle materials, Elastic Properties - Nonlinear Properties, Failure, Energy Absorption; Introduction to Damage Mechanics, Damage as Introduction to Micromechanics of Materials; Multiphase Materials; Unidirectional Composites, Modeling principles, stress and strain localization, Shear Modulus, Poisson Ratio, Elastic-Plastic Loading, Thermo-mechanical Properties, Bonds in Solids, Ion Bond, Covalent Bond, Metallic Bond, Van der Waals Bond, Hooks Law, Thermal Stresses, Theoretical Strength; Homogenization Theory, Representative Volume Element Concept, Averaging, Basic Equations, Eigenstrains, Eigenstrains, Thermal Strains, Mechanical Loading, Dilute Approximation, Self Consistent Model, Mori-Tanaka Method; Continuum Modeling Aspects; Case study: Multiphase materials; Introduction, brittle materials, Elastic Properties - Non-linear Properties, Failure, Energy Absorption; Introduction to Damage Mechanics, Damage as Internal Variable, Micromechanics of Damage, Methods for Determination of Damage, Damage Equivalent Stress, Kinetic of Damage Evolution, Ductile Fracture Models; Emphasis on brittle materials and nano modified materials.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4717**			
Course Title	**Fatigue of Concrete Structures**			
Credit Distribution (L-T-P-C)	3	1	0	**3**

Course Content:

Historical back ground, structures subjected to fatigue, parameters of fatigue loading, fatigue limit/endurance limit, category of fatigue load spectrum, Fatigue-Life Methods, analytical approach to approximate S-N diagram, Basquin's Law, Accumulated Fatigue Damage, Palmgren-Miner Hypothesis, load sequence effects (High-low, low-high), mean stress effects on S-N behaviour, Manson-Coffin relation for fatigue life based on total strain, fatigue crack growth behaviour, Paris Law, expressions for fatigue life based on critical crack length, cycle counting methods. S-N curves for compression fatigue of concrete, effect of loading frequency, S-N-T-R diagrams/relations, Influence of range, rate and eccentricity of loading, Load history, material properties, and environmental conditions on the fatigue strength of concrete; Scatter in Fatigue, statistical considerations; Tensile Behaviour of Concrete and Fracture Mechanics, tension softening models, different types of crack closing pressure, remaining life predictions; influence of minimum stress, bar size and type, geometry of deformations on reinforcing bars, bends, welding on the fatigue performance of reinforcing bars; Influence of type of prestressing steel (wire, strand, or bar), Steel treatment, Anchorage type, and Degree of bond on fatigue strength of prestressing steel; Fatigue failure of reinforced and prestressed concrete beams, remaining life predictions

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4718**			
Course Title	**Sustainable Materials**			
Credit Distribution (L-T-P-C)	3	0	1	**3**

Course Content:

Definition of sustainable development, need for sustainable development, Global Warming, urbanization across the globe, introduction to alternate binder such as fly ash, GGBS, Silica fume, etc., introduction to alternate aggregate materials such as, recycled aggregate, copper slag, manufactured sand, etc., Mix proportioning procedure for high strength, high performance, ultrahigh performance concrete, introduction to special concretes, such as self-compacting concrete, fibre reinforced concrete, geo-polymer concrete, etc., Development of building products using sustainable materials, such as stabilized mud blocks, concrete hollow blocks, concrete solid blocks, paver blocks etc., alternative walling and roofing system, life cycle aspect of sustainable concrete, Case studies, introduction to LEED / GRIHA and other rating system, their basic understanding

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4719**			
Course Title	**Shear Thickening Fluids for Engineering Applications**			
Credit Distribution (L-T-P-C)	2	0	1	**2**

Course Content:

Overview and classification of smart materials, Introduction to fluids – Newtonian and Non-Newtonian, Shear thickening fluids – Order-disorder theory, hydrocluster theory & Scaling models, Factors affecting shearing thickening behaviour – volume fraction, particles size and its distribution, particles shape, particle interaction and viscosity of the carrier fluid, Numerical modelling of STF behaviour, Characterization of STF – Rheology, Fourier transform infrared spectroscopy, zeta potential analyser, SEM, TEM etc., Preparation of STF, Experimental investigations on STF with different compositions.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4720**			
Course Title	**Computational Fluid Dynamics**			
Credit Distribution (L-T-P-C)	3	1	0	**3**

Course Content:

Introduction: Conservation of mass, momentum and energy equations, Convective forms of the equations; Differential Equations: Parabolic, elliptic and hyperbolic equations, Boundary and initial conditions, Over view of numerical methods; Finite Difference Technique: Taylor series expansion, Integration over element, Local function method, Treatment of boundary conditions, Boundary layer treatment, Convergence criteria; Finite Volume Technique: Types of finite volume grids, Approximation of surface and volume integrals, Interpolation methods - central, upwind and hybrid formulations, Convection-diffusion problem; Methods of Solution: Iterative methods, Matrix inversion methods, ADI method; Time Integration Methods: Single and multilevel methods, Predictor corrector methods, Stability analysis, Applications to transient conduction and advection-diffusion problems; Numerical Grid Generation: Basics, Transformation and mapping; Navier-Stokes Equations: Explicit and implicit methods, SIMPLE based methods, Fractional step methods; Turbulence modeling: Direct Numerical Simulation (DNS), Large Eddy Simulation(LES) and Reynolds-Averaged Navier-Stokes equations (RANS).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4721**			
Course Title	**Advanced Modelling Techniques**			
Credit Distribution (L-T-P-C)	3	1	0	**3**

Course Content:

Mesh generation for numerical simulation: Cartesian Grids, Body-fitted grids, block-structured grids/multi-block grids, overlapping grids. Structured mesh generation methods: Algebraic grid generation, elliptic grid generation, hyperbolic grid generation. Unstructured mesh generation methods: Advancing font techniques, Delaunay triangulation techniques, Point insertion methods, Edge and face swapping techniques, quadtree/octree methods, Stretched mesh generation. Meshfree Methods: Smooth particle hydrodynamics (SPH), finite point set method (FPM), meshless local Petrov Galerkin (MLPG), radial basis function method (RBF), method of approximate particular solutions (MAPS). An introduction to hybrid methods: Cooper grids, Mixed prismatic-tetrahedral elements.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4722**			
Course Title	**Smart Materials and Structures**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: Introduction to Smart Materials, Classification of Smart Materials.Piezoelectric Smart Structural Systems: Sensing, Actuation, System Integration.Shape Memory Alloys: Constitutive Models, SMA applications.Electrorheological Fluids and Magnetorheological Fluids: Newtonian shear flow and Bingham plastic flow, ER/MR Fluid Damping, Characteristic study of MR dampers, Vibration Control using MR damper.Active control systems: Governing equations, Control algorithms, Case study

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4723**			
Course Title	**Advanced Analysis and Design of Steel Structures**			
Credit Distribution (L-T-P-C)	3	1	0	**3**

Course Content:

Introduction: Properties of Structural Steel, I. S. Rolled Sections, I. S. Specifications. Design Approach: Factor of Safety, Permissible and Working Stresses, Elastic Method, Plastic Method, Introduction to Limit States of Design; Tension and Compression Members. Connections: Type of Connections, Riveted, Bolted and Welded Connections, Strength, Efficiency and Design of Joints, Modes of Failure of a Riveted Joint, Design of fillet and butt welds, Design of Eccentric Connections. Beam Column: Eccentricity of Load, Interaction Formulae, Design Procedure, Eccentrically Loaded Baseplates. Column Base: Slab Base, Gusseted Base, Grillage Foundation. Thin walled sections: Local, distortional and overall buckling, torsional and warping behaviour. Plastic Analysis: Analysis of frames and portal frames, semi-rigid connections and second order forces. Special structures: Space frames, geodesic domes and tensegrity structures.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4724**			
Course Title	**Multiscale Modelling of structures**			
Credit Distribution (L-T-P-C)	3	0	1	**3**

Course Content:

Introduction to multiscale modelling and analysis:Computational modelling; Multiscale nature of materials; Importance of multiscale modelling; Identification of scales; Macro, meso, micro and nano scales - overview; Engineering Mechanics Principles; fundamentals of thermodynamics; Mechanics of materials; Micromechanics; Quantum mechanics; Essential continuum mechanics. Nano scale mechanics: Nanostructure; Mechanical Forces and Potential Energy, Nano computational Methods: Ab-initio simulations; Molecular Mechanics; Energy minimization methods, Molecular Forces, Interatomic force and Potential function, Pseudo-potentials, Molecular Dynamics; Monte Carlo simulations; Nano structure of cementitious composites; CSH development; Nano experimentation. Micro and meso scale modelling and analysis: Microstructure features; particle based model; particle kinetics; hydration kinetics; phase reactions; particle expansion mechanism; Microstructural analysis; Lattice model principles and mechanics; implementation of heterogeneity; generation of uniform and random lattice structures; 2D and 3D lattice structure; generation of particle structure; fracture mechanics concepts; Concrete deterioration and fracture simulation; Hydration process of cement. Macro scale response: Features of macroscale; Mechanics of structures; Material models; FEM concepts; mechanical properties; cracking mechanism; prediction of cracks; modelling of concrete. Bridging techniques: Systematic upscaling: coarsening; Homogenization methods; Representative Volume Elements; Volume Averaging; Quasi-Continuum Method, Transport of parameters; Information exchange; Concurrent and sequential multiscale models; Application to response of brittle material to performance of structure; Bottom-up and top-down approaches

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4725**			
Course Title	**Advanced Course for self-study-I**			
Credit Distribution (L-T-P-C)	3	1	0	**3**

Course Content:

Self study course or a specialized course required for the specific PhD topic

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4726**			
Course Title	**Advanced Course for self-study-II**			
Credit Distribution (L-T-P-C)	3	1	0	**3**

Course Content:

Self study course or a specialized course required for the specific PhD topic

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-3-4730**			
Course Title	**Plasticity in Metals**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction
Introduction to the concept of elastic, viscoelastic, plastic and viscoplastic plastic deformation. Stress-strain behaviour, concept of strain rate.
Tensor analysis
Euclidean space, Scalars and Vectors, Coordinate system and role of tensor calculus, Change of Coordinates, Variants and Invariants, Tensor Description of Euclidian Space, The Tensor property, Covariant Differentiation.
Continuum mechanics
Material independent universal relations – Kinematic relation, Mechanical Balance Equations and Thermodynamic Balance Equations, Constitutive relation.
Concept of stress and strain
Various strain measures – Engineering strain, Logarithmic strain, Green strain and Almansi strain, Various stress measures – Engineering stress, True stress, Second Piola-Kirchhoff Stress and Cauchy stress tensor.
Foundation of plasticity
Classical yield criteria, Hardening laws, Plasticity flow rules, Total strain theory, Uniqueness theorem, Variational principles in plasticity
Computational Methods for Plasticity
One-dimensional constitutive model, General elastoplastic constitutive model, Numerical integration algorithm for elastoplastic constitutive equations, Finite elements in small-strain plasticity problems.
Plastic Deformation of Metals
Crystalline structure in metals, Mechanism of plastic deformation, Factors affecting plastic deformation, Strain hardening, Recovery, Recrystallization and grain growth, Flow figures or Luder's cubes.
Plastic waves
Introduction to dynamic plasticity, One-dimensional waves, theory of strain localization.
Advanced Topics
Viscoplasticity, Advanced plasticity models
References:
R. Hill, Mathematical Theory of Plastisity, Oxford Classic Texts in the Physical Sciences, 1998
J. Lubliner, Plasticity Theory, Pearson Education Inc., 2006.
A. de Souza Neto, D. Peric and DRJ Owen, Computational Methods for Plasticity Theory and Applications, John Wiley & Sons Ltd., 2008.
Pavel Grinfeld, Introduction to Tensor Analysis and the Calculus of Moving Surfaces, Springer Verlag, 2010.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-4-0001**			
Course Title	**Research Proposal Writing**			
Credit Distribution (L-T-P-C)	0	1	2	**2**

Course Content:

Formulation of a project proposal by selecting topics of high relevance and novelty and will have state-of-the art review, methodologies, recommendations etc. in specified format in a holistic manner preferably candidate’s own research work suitable for submission to appropriate funding agencies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-4-0002**			
Course Title	**Review Article**			
Credit Distribution (L-T-P-C)	0	1	2	**2**

Course Content:

Preparation of one review article on specific research area of the student.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (EoS)**			
Course Nomenclature	**ENG-SERC-4-0003**			
Course Title	**CSIR-800 Societal Programme**			
Credit Distribution (L-T-P-C)	0	0	8	**4**

Course Content:

The students have to undertake a project in rural area for 6-8 weeks in line with CSIR-800 programme which is primarily prepared at empowering 800 million Indians by way of S & T inventions. The theme for the project may be chosen from CSIR-800 document and as per expertise available at individual laboratory. Students will choose the topics in consultation with Doctoral Advisory Committee (DAC).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (RE)**			
Course Nomenclature	**ENG-SERC-1-4771**			
Course Title	**Effective Presentation Skills and Dissertation Writing**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

This course teaches effective presentation skills and valuable tips on dissertation preparation and writing.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (RE)**			
Course Nomenclature	**ENG-SERC-1-4772**			
Course Title	**Mathematics for Engineers**			
Credit Distribution (L-T-P-C)	1	1	0	**2**

Course Content:

Course Content: • Linear algebra: Matrices, system of linear equations, linear transformations, vectors, vector spaces, inner product spaces, Eigen vectors and eigen values, orthogonal projection. • Transforms: Fourier series, Fourier transform (FFT, DFT, DTFT), Laplace transform, Ztransform, Wavelet transform, Karhunen–Loève theorem. • Differential equations: Introduction to differential equations, first/second order differential equations, Partial differential equations, geometrical interpretation • Integrals: Definite integrals, indefinite integrals, line and surface integrals, integrals of differential forms. • Sequences and series: convergence of series, finite and infinite series, Taylor and Laurent series expansions. • Mathematical and computational tools: Matlab, Mathematica

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (RE)**			
Course Nomenclature	**ENG-SERC-2-4771**			
Course Title	**Renewable Energy Sources for a Sustainable Future**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Course Content: • Basic thermodynamics: Laws of thermodynamics, Energy and entropy, Carnot efficiency • Non-renewable sources and climate change discussion • Introduction to various renewable technologies (solar, wind, hydro, geothermal etc.) • Decentralized hybrid power: Need and potential in Indian context • Instrumentation and sensors for power monitoring • Structural Design basics: Engineering mechanics • Energy costing and comparison with non-renewables

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (RE)**			
Course Nomenclature	**ENG-SERC-2-4772**			
Course Title	**Harnessing the power of Sun: Science and Technology of Solar Photovoltaics**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Solar photovoltaics shows the biggest promise to solve the energy crisis. This course is designed to provide a solid scientific base for understanding and designing various solar cells and hands-on experience to test and evaluate the performance of solar cells. Course Content: • Solar cell introduction: Shockley-Queisser limit, efficiency • Introduction to semiconductors: Direct/Indirect band gap semiconductors, Energy band structure of solids and band diagrams • Basic semiconductor electronics: p-n junctions, diodes, transistors, heterostructures • Quantum mechanics: Schrodinger equations, Kronig-penny model, Quantum potential wells • Detailed discussion of various solar PV technologies (Si, Thin film, GaAs etc.) • Design and simulation of solar cells Lab: • Solar cell design using TCAD/Matlab • Testing and characterization of solar cells (Si, Multijunction, Thin film) (Current-voltage characteristics, efficiency)

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (RE)**			
Course Nomenclature	**ENG-SERC-2-4773**			
Course Title	**Energy Storage and Conversion: Science & Technology**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Course Content: • Introduction to energy storage: thermal, mechanical, compressed air, pumped hydro & chemical energy. • Electrochemical energy storage: Batteries, super capacitors and fuel cells • Battery basic concepts: Cell voltage, capacity, energy/power density, primary and secondary batteries, thermodynamics, working principles, electrode process. • Battery types: Lead acid, Ni-Cd, Nickel-metal hydride, lithium ion. • Batteries for EV, solar applications and recent advances. • Dye-sensitized solar cells • Fuel cells: Types of fuel cells, materials & components, applications, thermodynamics, kinetics, system design and engineering, hydrogen storage. • Dye sensitized solar cells: • Comparison of various energy storage systems, cost economics, market trends Lab: • Fuel cell stack fabrication, assembly & testing, • General electrochemical characterization, cyclic voltametry, chronoamperometry, half-cell studies.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (RE)**			
Course Nomenclature	**ENG-SERC-2-4774**			
Course Title	**"View from the TOP" Seminar Series I**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Seminar aims at giving exposure as to how the best quality science is pursued, what drives the scientists and their experiences in overcoming various hurdles during their scientific pursuit • Talks by leading scientists in CSIR • Invited talks by various professors on specialized topics in energy

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (RE)**			
Course Nomenclature	**ENG-SERC-2-4775**			
Course Title	**Design and Engineering for Sustainability**			
Credit Distribution (L-T-P-C)	1	0	2	**2**

Course Content:

Course Content: • Design approaches • Multi-objective design • Design optimization • Metrics for design evaluation • Design for 'X' • Manufacturing and assembly • Ergonomics • Inspectability and sustainability • Practical aspects of design • CAD • Manual prototyping • Automated prototyping (3D printing/Rapid prototyping) Lab: Solve a design problem with a given constraints Ex: Solar lantern that can replace a kerosene lamp at a competitive cost ENGG-SERC- 2-935: "View from the TOP" Seminar Series II Course Coordinator: Dr. Bala Pesala (1-0-0-1)

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (RE)**			
Course Nomenclature	**ENG-SERC-2-4776**			
Course Title	**View from the TOP Seminar Series II**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Seminar to expose students to the real problems in the energy sector and the need for innovative technological solutions, unique business models to make renewable energy sustainable especially in a decentralized setting and for people at the BOP • Talks by various entrepreneurs and executives from industry working in renewable energy

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (RE)**			
Course Nomenclature	**ENG-SERC-4-4703**			
Course Title	**3-4 weeks Industrial training/CSIR 800 (Report and Presentation)**			
Credit Distribution (L-T-P-C)	0	0	2	**1**

Course Content:

CSIR800/Industrial Training

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (RE)**			
Course Nomenclature	**ENG-SERC-3-4771**			
Course Title	**Solar Photovoltaics: Power Electronics, Power Transmission and Energy Monitoring**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Course Content: • Power electronics: Power devices (BJT's, MOSFETs, IGBT's) · Microcontrollers/Embedded controllers, Charge controllers · Inverters and rectifiers · Control systems (active/passive controls), Maximum power point tracking · Single/dual axis tracking systems: Design and implementation · Sensors and instruments for monitoring: Power, Voltage, light intensity, Battery charging/discharge cycles · Remote monitoring: Wired/wireless/Power line, Wireless technologies (GSM/Wi-fi/Zig-bee) and smart power meters · Smart grid systems: Transmission (AC/DC), Grid connection topologies/super grids for renewable energy, HVAC-HVDC cost analysis and utility Lab: · Solar module performance monitoring · MPPT design and implementation · Matlab toolbox for sensor and instrument progamming and monitoring · Remote monitoring using Zig-bee communication

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (RE)**			
Course Nomenclature	**ENG-SERC-3-4772**			
Course Title	**Advanced course on Lithium-Ion Batteries**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Course Content: · Introduction to batteries: Historical perspective, Kinetics/thermodynamics/charge transfer process, Faraday's law of electrolysis, standard cells and electrode potentials · Lithium battery active materials: Anode: intercalation, conversion, alloying; Cathode: Layered, framework structures · Electrolytes: organic, polymeric, ionic liquids. Aprotic organic electrolytes, Polymer electrolytes-dry, gel and composites, polymer membranes. · Separators: materials, properties, porosity, thermal, mechanical and electrochemical stability. · Safety, assembly and recycling · Synthesis approaches for battery materials and crystallography · Instrumental methods in Li-ion battery research: XRD analysis, microscopy (SEM, TEM), thermal analysis (TGA, DTA, DSC), IR, Raman analysis, GITT, impedance analysis etc. Lab: · Li-ion battery fabrication, material preparation (cathode, anode). · Materials characterization (XRD, SEM, TEM, TGA, etc). · Electrochemical tests on Li-ion batteries (CV, charge-discharge, capacity, life cycle studies, GITT, EIS).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (RE)**			
Course Nomenclature	**ENG-SERC-3-4773**			
Course Title	**Design of Structures For Renewable Energy**			
Credit Distribution (L-T-P-C)	2	1	2	**4**

Course Content:

Course Content: · Fundamentals of Structural Mechanics: Introduction to structural mechanics, Kinetics, Kinematics and Energy theorems · FEM techniques for structural analysis: Stationary principles, Rayleigh-Ritz method and interpolation, Iso-parametric finite element, shape function, modeling, numerical integration, coordinate transformation · Design Concepts: Limit states, LRFD, fatigue for concrete/steel/composite structures · Support structures for solar photovoltaic modules: Loads and analysis, design · Support structure for wind turbines - Loads and analysis, design of superstructure and foundation · Wind turbine blades: Stress analysis and design Lab: · Structural form effect · FEM applications · Wind tunnel-scaled modelling of structures

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (RE)**			
Course Nomenclature	**ENG-SERC-3-4774**			
Course Title	**Bio Energy: The Plants Work & Let Us Reap**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Course Content: · Introduction to bio-energy · Bio-energy sustainability: Land use, bio-energy crops, feed stocks and crop harvesting, Agronomy of bio-energy crops, Environmental implications · Chemistry & biochemistry of Biomass · Biochemical processes (conversion, deconstruction, bio-processing) · Bio-fuels (ethanol, bio-butanol, biodiesel, cellulosic and other biofuels) · Physical and chemical processes (combustion, gasification, pyrolysis) · Direct biomass combustion & Co-firing technologies · Power generation from bio-mass · Economics of bio-energy (costs, prices, markets, financing and marketing · Policies & Future R&D of Biofuels & Bioenergy Lab: · Microbial conversion of plant derived biomass into bio-fuels · Pre-treatment technologies to make the lignocellulose more accessible to enzymes, hydrolysis of polysaccharides to sugars, conversion to a fuel molecule, and extraction of the fuel · Microbial fuel cell/ Microbial electrolysis cell, Microalgal biofuels · Thermo-chemical, chemical and catalyst conversion of biomass/Gasification · Bio-energy systems engineering

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (RE)**			
Course Nomenclature	**ENG-SERC-3-4775**			
Course Title	**Self-study course on Advanced topics in Renewable Energy**			
Credit Distribution (L-T-P-C)	0	2	4	**4**

Course Content:

Self-study course by the student on a new topic in consulation with guide

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (RE)**			
Course Nomenclature	**ENG-SERC-3-4776**			
Course Title	**4 week Solar Energy Workshop for High-school students (Organizing and Mentoring)**			
Credit Distribution (L-T-P-C)	0	1	0	**1**

Course Content:

Organizing of Solar energy workshop

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (RE)**			
Course Nomenclature	**ENG-SERC-3-4777**			
Course Title	**Dissertation (Seminars and report)**			
Credit Distribution (L-T-P-C)	0	4	8	**8**

Course Content:

Dissertation Seminars and report

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (RE)**			
Course Nomenclature	**ENG-SERC-3-4778**			
Course Title	**Dissertation seminars**			
Credit Distribution (L-T-P-C)	0	6	0	**6**

Course Content:

Dissertation Seminars

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-SERC, CHENNAI (RE)**			
Course Nomenclature	**ENG-SERC-3-4779**			
Course Title	**Dissertation report and Viva-Voice**			
Credit Distribution (L-T-P-C)	0	9	18	**18**

Course Content:

Dissertation report and Viva-voice

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-1-1701**			
Course Title	**Introduction to Materials Engineering**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Objective, Modules, atomic structure & bonding, structures of solids, thermodynamic principles of solid solution,phase diagrams, properties of materials, Metallic materials, Ceramic materials, Glass, Polymeric materials and Composite materials

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-1-1702**			
Course Title	**Materials Characterization-I**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Objective, Modules,Basic Crystallography, X-rays, X-ray diffraction, Small Angle X-Ray Scattering

Faculty	ENGINEERING SCIENCES			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-1-1703**			
Course Title	**Fundamentals of Glass and Ceramics**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Ojbectives, Modules, Basics of Glassand Ceramics along with Structural aspects, thermal properties, physical & optical properties, mechanical properties, electrical properties, magnetic properties, Special Glasses and their applications , advanced ceramics

Faculty	ENGINEERING SCIENCES			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-1-1704**			
Course Title	**Research Methodology and Applied Statistical Techniques for Materials Engineering**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Objectives, modules on design & implementation of a research project, planning and performing, research modeling, hypothesis, primary and secondary data, analyzing and reporting results. Professional ethics, ethics in research, IPR, copyright and plagiarism, technical writing and communicating research results. Methods of classifying data, bar charts, stem and leaf plots, mean, median, modeetc. Probability, normal and other distributions, uncertainty, accuracy, reproducibility & repeatability Statistical theories of failure, regression analysis, coefficient of determination, multiple regression, Chi-square distributions etc., statistical design of experiment, concept of standard error etc. Basics of computer programming, computer-based tools used in management, decision-making

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-1-1705**			
Course Title	**Laboratory Safety Practices**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Objective, Modules to make the students aware about general laboratory Safety Procedures ,Chemical Safety Handling of chemicals, storage, chemical hazards Electrical & Mechanical Safety , Fire Safety

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-2-1701**			
Course Title	**Processing of Glass and Ceramics**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Objective ,Modules to impart knowledge about glassy state and viscosity, commercial glasses, glass forming materials, glass melting furnaces, refining processes of glass melt,Annealing, tempering and toughening chemical strengthening defects in glass; industrial glass processes, Manufacture of glass fiber, ceramization of glass, machinable and bioactive glass-ceramics, optical and special glassesSynthesis of ceramic precursors, packing of ceramic powders, rheological properties of ceramic suspension, ceramic forming processes, forming defects. Thermal processes in ceramics, polymorphic transformation in ceramics, sintering, hot pressing, cooling of ceramic wares, microwave, laser and plasma assisted processing of ceramics, rapid prototyping, processing machines and furnaces.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-2-1702**			
Course Title	**Materials Characterization- II**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Objective,Modules to impart knowledge about Atomic absorption spectroscopy EPR and NMR spectroscopy X-ray fluorescence spectroscopy Auger electron spectroscopy EPMA, EDS, WDS Electron Energy loss spectroscopy Secondary ion mass spectrometry (SIMS), Rutherford backscattering spectrometry (RBS), X-ray photoelectron spectroscopy, UV-VIS spectrophotometry, FTIR spectroscopy, Raman spectroscopy, ellipsometry

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-2-1703**			
Course Title	**Technical Communication**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Objective Modules to impart knowledge about introduction to writing, editing, and principles of technical and professional communication.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-2-1704**			
Course Title	**Transport Phenomena in Materials Processing**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Objective Modules to impart knowledge about diffusion in solids, mass transfer in liquids, interphase mass transfer. Heat transport in solids, liquids and gases, thermal transport phenomena for glass and ceramic processing. Fluid dynamics of Newtonian and Non-Newtonian flows, rheology, concept of flow regimes, applications of momentum transport to material processing with special emphasis on glass and ceramics. Fundamental concepts of numerical simulation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-2-1705**			
Course Title	**Term Paper**			
Credit Distribution (L-T-P-C)	0	0	0	**1**

Course Content:

To take up an exercise by the student to gain thorugh knowlegde on any selected subject

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-2-1706**			
Course Title	**Seminar**			
Credit Distribution (L-T-P-C)	0	0	0	**2**

Course Content:

To develop presentation and discussion skills in selected topic by the student

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-2-1707**			
Course Title	**Comprehensive Viva**			
Credit Distribution (L-T-P-C)	0	0	0	**2**

Course Content:

Oral Examination on all the courses studied during M Tech

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-3-1701**			
Course Title	**Advanced Glass Science and Technology**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Objective, Modules to impart knowledge about Glass structures, Raman and infrared spectroscopy and transmission and scanning electron microscopy Glass preparation Fabrication and characterization of optical fibres, optical and ophthalmic glass, photonic glass, laser glass, graded Index glass, photosensitive, photochromic glass, Glasses for biomedical and nuclear applications, Specialty materials like ultra-low expansion glass-ceramics, machinable glass-ceramics, semiconductor and nanometal doped glasses Specialty materials like ultra-low expansion glass-ceramics, machinable glass-ceramics, semiconductor and nanometal doped glasses Glasses for biomedical and nuclear applications. Specialty materials like ultra-low expansion glass-ceramics, machinable glass-ceramics, semiconductor and nanometal doped glasses

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-3-1702**			
Course Title	**Fibre Optics and Devices**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Objective Modules to impart knowledge about Types of optical fibers electromagnetic theory, nonlinear optical properties of fiber, fiber design and fabrication, fiber characterization, optical fiber amplifier, fiber laser and Raman laser, photosensitive fiber and fiber Bragg grating, microstructured fiber, polymer optical fiber, nonlinear fiber optics and mathematical simulations. Modulation techniques, analogue and digital theory, multiplexing and demultiplexing of signal carrier, TDM and WDM for electronic and optical network, photonic switching, ITU-T recommendations and different telecom protocol. Optical fiber components and devices, fiber coupler, attenuator, filters, fiber Bragg grating sensor, strain-stress-temperature sensing devices.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-3-1703**			
Course Title	**Structural and Functional Coatings**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Objective Modules to impart knowledge about fabrication of coatings by physical and chemical vapour deposition, wet chemical/sol-gel techniques, thermal and plasma spraying and electroplating, surface modification by ion, electron and laser beams. Coatings to improve hydrophobic and hydrophilic characteristics, wear resistance, corrosion resistance Functional coatings and films for electrical, optical, thermal, mechanical, chemical, biochemical and energy saving applications.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-3-1704**			
Course Title	**Nanostructured Photonic and Optical Materials**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Objective, Modules to impart knowledge about electromagnetic theory of interaction of light with matter, polarization and diffraction of light, Raleigh scattering, Mie scattering, Brillouin and Raman scattering, optical absorption and emission spectroscopy, optical coherence, stimulated emission, laser, basic properties of highly transparent glasses. Nano-materials and nanostructure optics, basic concepts of plasmonics , electromagnetics of metals and metal-nano composites, surface plasmon polariton, different coupling schemes, plasmon waveguide and band gap structure. Spectroscopy and sensing, metamaterial and negative index at optical frequencies, super lensing and imaging.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-3-1705**			
Course Title	**Advanced Structural Ceramics and Refractories**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Objective ,Modules to impart knowledge Definition of refractory, classification, refractory raw materials, manufacturing process and unit operation. Importance of phase diagram in refractory Manufacturing and quality control Important properties of refractory raw materials and products Refractory Applications Monolithic refractory Primary advanced ceramics Advanced ceramics-Processing Properties and Characterization tools Properties and Characterization tools

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-3-1706**			
Course Title	**Bioceramic Prosthesis and Implants**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Objective, Modules to impart knowledge about Basics of human physiology, Preparation and processing techniques of different biomaterials, implants and devices Physical and mechanical properties of bioceramic materials. Bio-compability of biomaterials , surface modification of implants by bio-active coating, bioglass, Concept of in vitro and in vivo evaluation of bioceramics materials and implants. Applications of bioceramics as bone graft materials, hip implant, dental implant, drug delivery devices and tissue-engineered materials.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-3-1707**			
Course Title	**Ceramic Based Energy and Separation Technology**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Objective, Modules to impart knowledge about fundamentals of membrane separation process, liquid and gas separation including hot gas filtration. Membrane contractors and reactors, membrane technology in energy and environmental applications. Energy efficiency, security and credit. Design, fabrication and stack engineering of ceramic based solid oxide fuel cell, lithium-ion battery and advanced electrochemical power systems for electric and hybrid vehicles.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-3-1708**			
Course Title	**Electronic Ceramics**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Objective, Modules to impart knowledge about fundamentals of dielectrics, insulators, packaging and substrate materials. Fabrication and characterization of capacitors and ferroelectrics, pyroelectrics, piezoelectrics, and smart materials. Properties and applications of sensors, actuators, varistors, electronically conducting ceramics, ionically conducting ceramics and ceramic superconductors Basics of magnetic ceramics, storage and spintronics. Introduction to electrooptic ceramics and plasmonics and 'nano'-impact in electronic ceramics.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-3-1709**			
Course Title	**Project and Thesis- I**			
Credit Distribution (L-T-P-C)	0	0	0	**16**

Course Content:

M. Tech Project work

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-3-1710**			
Course Title	**Project and Thesis- II**			
Credit Distribution (L-T-P-C)	0	0	0	**16**

Course Content:

M. Tech Project work

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-4-0001**			
Course Title	**Project Proposal**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

To develop practice of writing up project proposals

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-4-0002**			
Course Title	**Review Article**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

To survey the literature in the area of interst and find gaps to coin objectives for the Ph D project

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CGCRI, KOLKATA**			
Course Nomenclature	**ENG-CGCRI-4-0003**			
Course Title	**Project with societal/rural issues under CSIR-800**			
Credit Distribution (L-T-P-C)	0	0	8	**4**

Course Content:

Student has to carryout a project in rural area for 6 - 8 weeks on the topics in line with CSIR- 800 programme

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-1-2301**			
Course Title	**Statistical Methods in engineering**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Representation and Summarisation of data: Introduction to statistical methods - attribute, types sources and collection of data; Frequency distribution; Measures of central tendency; Dispersion; Skewness and kurtosis. Probability and distribution: Concepts of probability; Conditional probability, Independence of events; Baye's theorem, Random variable, Probability distributions; Binomial poisson, uniform, exponential, normal and lognormal distributions and applications to Infrastructure Engineering Problems. Sampling technique, Distributions and Test of Significance: Sampling techniques; Sampling distribution; Statistical decisions; Tests of significance. Chi-square tests of goodness of fit and for independence of attributes in contingency tables. Bi-Variate and Multivariate Analysis: Bivariate Models- Related variables, Scatter diagram. Least square curve fitting, Fitting of linear correlation and regression, product moment correlation coefficient. Multivariate Analysis, Principle Component Analysis, Factor Analysis, MANOVA Calculations. Time series modelling: Components of Time Series; Stationery and Non-Stationery Processes; Smoothing and Decomposition Methods; Correlation and Line Spectral Diagrams; Auto Correlations and Moving Averages; ARIMA. Advanced Statistical Methods: Operation Research - Network models, Assignment problems, Shortest path methods, Queuing theory, Simulation techniques; Artificial Neural Networks; Genetic Algorithms and Neuro-Genetic models. Use of computer software's in statistical analysis: Descriptive statistics, correlation, regression, analysis of variance, decision making using statistical software like MS-EXCEL, SPSS and MATLAB.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-1-2302**			
Course Title	**Design and Construction of Pavements**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: Types, components and comparison of pavements, Factors affecting design/performance of pavements, Road and airport pavements; Stresses and deflections in flexible pavements: Stresses and deflections in homogenous masses; layer theories; wheel load stresses, ESWL computation, Repeated loads and EWL factors; sustained loads. Transient traffic loads. Flexible pavement design methods; Stresses in rigid pavements: Types of stresses and causes, general considerations in rigid pavement analysis, EWL; Rigid pavement design: Design of CC pavements, Types of joints in cement concrete pavements and their functions, joint spacing ; design of joint details; Equipment/Machinery in highway construction: Equipments for excavation, grading and compaction. Equipments for bituminous, cement concrete, stabilised and composite pavements. Earthwork construction, problems, quality control aspects. Design factors; Flexible pavements: Specifications of materials, choice, construction method and field control checks for various specifications of sub-base, base, binder and surface course layers and mix design methods; Cement concrete pavement layers: Specifications and method of cement concrete pavement construction, quality control aspects; Drainage: Design and construction of drainage systems for road pavements, drainage materials, procedures and guidelines. Maintenance of pavements, shoulders and drainage; Hill Roads: Special problems in construction and maintenance of hill roads; landslides, causes, investigations and remedial measures.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-1-2303**			
Course Title	**Traffic Engineering & Road Safety**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Traffic Engineering - Definition, concepts, scope and utility; Traffic Flow Theory – Fundamentals, Scope, relationship between the variables of traffic flow, relationship between speed and traffic elements; Design of Streets and Highways Infrastructure - Design Control Criteria for highway alignment, geometry of highway elements; Highway Capacity - Review, definition, factors affecting capacity and level of service, capacity of basic freeway segment and two lane bi directional rural carriageways, capacity of signalized intersection, design and operation, evaluation of weaving section; Design of Intersection and Inter Changes - Intersection conflict, type of intersections, design of inter-section design elements, ramp gradient, acceleration and deceleration lanes; Traffic Signal Control and Regulation - Introduction, warrant for signal phasing, signal aspect and inter green period. Vehicle actuated signal facilities, effect of traffic and environmental factors, optimization of signal approach, Coordination of traffic signals, Area Traffic Control (ATC) system. Regulation of speed, Parking regulation and enforcement; Street Infrastructure - Street lighting, vehicle lighting, Lighting of carriageways, Guard rails, traffic signs, highway landscapes and drainage; Traffic Management - Traffic management measures, Transport System Management (TSM) techniques and its application, Impact of TSM techniques; Road Safety - Characteristics of Road accidents. Planning & Road Design for Safety. Safety Audits (RSA) including RSA Principles and Issues, RSA Procedures and RSA Checklists.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-1-2304**			
Course Title	**Transportation Planning**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to Transportation Planning: Introduction to transport planning practices, transportation problem and problem domain in Indian context, objectives and constrains, flow chart for transportation planning process. Transportation Planning Process: Zoning & travel demand surveys, transportation planning process-inventory, model building, forecasting and evaluation stages. Trip Generation Models: Regression models, Category analysis, House hold models, Trip attractions, Quick Response Techniques. Trip Distribution Models: Trip distributions Models-Growth factor models, Gravity models, Opportunity models. Mode Choice Models: Utility maximisation theory, functional form, elasticity of demand, modelling mode choice - probabilistic models such as probit, logit model etc. Network Assignment Models: Elements of transport networks, shortest paths, All-or-Nothing (AON) Assignment, equilibrium, user equilibrium (UE), stochastic user equilibrium (SUE), and Frank Wolfe (FW) Algorithm and MSA algorithm. Land Use Transportation Models: Location Models-Opportunity models, accessibility models, lower based land use transportation models in practice, Lowry models. Urban and Regional Mass Transport Planning: Introduction to Urban and Regional mass transportation planning, planning for intermediate public transport (IPT) Planning for non motorised transport: Issues of non motorised transport, planning for bicycles, pedestrians and other slow moving vehicles.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-1-2305**			
Course Title	**Advanced Highway Engineering Materials**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Soils and Aggregates : New Materials for Soil Stabilization, Geosynthetics (Applications and Economics) , Production of Quality Aggregates, Requirements of Aggregates for High Speed Road Corridors and Airfield Pavements, Factors affecting Adhesion of Bitumen with different Aggregate, Durability, Transportation and Economics. Beneficiation of Marginal Materials, New Materials for Sub base and Base Courses. Characterization of Fly Ash, Properties and Applications of Metallurgical Slag as Soil & Aggregate, Beneficiation and Use of Industrial and Mining Waste, Characterization and Use of Demolition Waste. Paving Bitumen: Composition, Structure and Rheology, Durability, Physical Constants, Performance Based (SHRP) Specifications, Additives viz. Warm Mix Additives and Anti-stripping Agent. Value Added Bitumen Products: Specification of Multigrade Bitumen, Rubber and Polymer Modified Bitumen, Bitumen Emulsion, Modified Bitumen Emulsions, Foam Bitumen, Rejuvenating Agents, Pigmentable Bitumen, Fuels Resistant Bitumen, Cut-back Bitumen, Hard Bitumen, Oxidized Bitumen, Sulphur Extended Bitumen.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-1-2306**			
Course Title	**Advanced Geotechnical Engineering**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to basic Geotechnical engineering: Sub soil investigation using SPT, SCPT, DCPT and Plate load tests, analysis of data, shear strength, consolidation characteristics, and settlement analysis. Ground improvement Techniques: Soil improvement, dynamic compaction, Lime stabilization, Cement stabilization, organic and inorganic stabilizers, , Blasting, drains, Lime columns, Soil grouting, soft soils, embankments on soft soils, stage construction Vertical sand drains, Prefabricated vertical drains (PVD), Fiber drains, Instrumentation techniques, peizo-meters, settlement gauges, inclinometers, Field tests on soft soils, Stone columns, wet and dry methods, soil nailing, pull out tests, construction process, design methods, case studies. Stability of slopes and earth retaining structures: Earthen embankments, specifications, case histories, Finite and infinite slopes, Method of slices, Bishop's method, Factor of safety, submerged case, sudden draw-down case, steady seepage case, long term and short term stability, gravity walls, cantilever walls. Geosynthetic materials for highway applications: Geotextiles, woven, non-woven, Geo ties, Geogrids, Properties, applications, Reinforced earth walls, Mechanism, Reinforcement-soil interaction, Analysis and design checks, Internal and external stability, Tests for soil reinforcement, Field applications, software applications. Environmental Geo-techniques: Utilization of Waste materials, Reduction of carbon footprint, Hazardous waste containment, slurry wastes, Liners, Stability of landfills, landfill construction, Design aspects, Barriers.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-1-2307**			
Course Title	**Research Methodology**			
Credit Distribution (L-T-P-C)	1	1	0	**2**

Course Content:

Introduction to Research Methodology - Research terminology and the Scientific methods; Designing and Implementing a research project - Types of Research; Measurements in Research - Primary and Secondary data; Analysis of primary and secondary data (quantitative analysis); Communicating Research results; Case studies. Professional Ethics - Ethics in Research – Plagiarism – Nuremberg code etc. Communication skills – presentation – inter personal communication.

Faculty	ENGINEERING SCIENCES			
Lab Name	CSIR-CRRI, NEW DELHI			
Course Nomenclature	ENG-CRRI-1-2308			
Course Title	Transport and Environment			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Sources of air pollution; road transport related air pollution; air pollution meteorology; control of vehicular emissions in urban areas; role of public transportation & non-motorized transport in improving urban air quality; traffic noise and vibration and its mitigating measures; introduction to vehicular air & noise pollution modelling; vehicular emissions loads estimation; measurement & analysis of vehicular emissions; vehicular emission standards and norms; alternate fuels; road transport and GHG emissions, environmental clearance for road & highway projects in India; EIA requirements for highway projects.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-1-2309**			
Course Title	**Geospatial Techniques for Infrastructure**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Definition and scope of geospatial technology, Techniques in geospatial technology, Historical development of geospatial technologies. Introduction of geographic information system (GIS) and Remote sensing techniques. Essential components of GIS data acquition, Geo-referencing and Geo-reference systems. GIS data: spatial and non-spatial, raster, metadata, Topology and topological models; Spatial data acquisition; Data storage, RDBMS, database operations; Spatial and non-spatial data editing functions; Data acquisition and conversion techniques, data interpretation, query development, spatial querying, spatial analysis, advanced analysis tools, model design & development, customization issues, case studies in GIS applications in infrastructure projects. Implementing GIS based Management Information; GPS surveys applications to various projects. Digital Elevation Model (DEM). Introduction to various GIS software.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-1-2310**			
Course Title	**Economic Evaluation of Highway Projects**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to Highway Projects: National planning and project choice; Project definition and formulation; Project appraisal and evaluation; Economic analysis. Concepts of Economic Analysis: Cost-benefit, Cost-effectiveness analysis; Financial and economic analysis; Salvage value; Environmental economics. Project Evaluation: Stages involved in economic evaluation; Feasibility studies, Techniques of economic evaluation; Project evaluation practices. Determination of Costs: Total transportation costs – Construction cost; Road user costs; Road maintenance cost; Evaluation of environment and congestion costs. Valuation of benefits: Direct benefits - Savings in user cost, etc.; Indirect benefits -socio-economic benefits, distributional benefits, etc.; Estimation of benefits from construction of turnkey projects, rail/road over bridges, low volume rural roads and urban transportation projects; Economic function of transportation projects; Economic evaluation using the various benefits incidence Tables. Comparing Costs and Benefits: Method of comparison – NPV, IRR, B/C ratio and other methods; comparison of project alternatives; Risk and uncertainties; Application of HDM and RED software. Financial Analysis: Estimation of financial costs and returns; Financial aspects of BOT, SPV projects; Determination of toll rates, annuity, etc. Case Studies - Expressways, two/four lane highways, rural roads, urban roads, bridge projects, bye-pass roads, urban transport projects.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-1-2311**			
Course Title	**Advanced Concrete Technology**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Concrete - Characterisation of ingredients. Concrete mix design. Concrete science (mixing, Transportation, placing and curing of concrete). Properties of fresh and hardened concrete. New materials for concrete, Quality control - Quality assurance of concrete. Durability of concrete. Concrete technology- Sustainable construction.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-1-2312**			
Course Title	**Soft Computing Techniques in Transportation Engineering**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction to Neural Networks: Artificial Neuron and its models, activation functions, Neural Network architecture, single layer and multilayer feed forward networks, various learning techniques, convergence rules. Neural Network Models: Architecture, perception models, Single ANN model, Multi layer ANN model, back propagation learning models, effect of learning rules, back-propagation algorithm, factors effecting back-propagation algorithm, Radial basis function. Bayesian networks, Application of ANN models to traffic engineering and transportation planning. Introduction to Fuzzy Logic: Basic concepts of fuzzy logic, fuzzy sets, fuzzy set theory and operations, Properties of fuzzy sets, Fuzzy and crisp relations. Fuzzy logic Models: Membership functions, interference in fuzzy logic, fuzzy if then rules, fuzzy implications and fuzzy algorithm, fuzzyfications and de- fuzzyfications, fuzzy controllers. Applications of fuzzy logic in Traffic and Transportation Planning. Genetic Algorithm: Basic concepts, Procedure of GA, Genetic representations, Initialization, genetic operators, mutation, generation, cycle. Applications related to transportation engineering. Hybrid Modeling Techniques: Integration of Neural Networks, Fuzzy Logic and Genetic Algorithms, Genetic Algorithm Based Back propagation Networks, Fuzzy Back Propagation Networks.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2301**			
Course Title	**Pavement Evaluation Techniques and Management System**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Pavement Evaluation   Evaluation of functional performance and serviceability of pavements, evaluation of pavement structural capacity, distress types and causes, safety- skid resistance etc., combined measures of pavement quality, data management.   Introduction to PMS - Prediction models for pavement deterioration, rehabilitation and maintenance strategies, Framework for pavement design, characterization of physical design inputs, basic structural response models, Intervention criteria for maintenance planning, economic evaluation of alternate pavement design strategies – selection of optimal design strategy, HDM – 4 & other tools, Pavement life cycle assessment. Implementation of PMS, Asset Management.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2302**			
Course Title	**Bridge and Tunnel Engineering**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Bridge engineering - Classification and components, Site investigation and planning of bridge and tunnel. Design considerations- geometric, hydrological, scour, soil, loading. Introduction to bridge codes. Analysis of bridges. Design of RC superstructure: Slab, T-girder, box girders. Considerations for Integral bridges. Pre-stress concrete bridges-design considerations, I-girder, box-girder bridges. Design of steel superstructure: truss, plate girder, composite bridge decks. Introduction to long span bridges - Cantilever, arch, cable stayed, suspension bridges. Design of substructure and foundation: pier and abutments, wing walls and approaches. Design of open, pile, well foundations. Design of appurtenances: bearing, expansion joints, parapet/ crash barrier etc. Construction methods and quality control. Tunnel engineering - Introduction to rock mechanics: engineering classification and strength criteria, rock slope stability. Tunneling - Feasibility, environmental impact, construction method, problems associated with tunneling, construction subsidence. Design parameters, loading, ground condition in tunneling, application stereographic projection, rock mass support interaction analysis, stress distribution around opening, design of support system.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2303**			
Course Title	**Public Transportation System**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Development of Public Transit System: Historical Growth, Modes of public transport and comparison, public transport travel characteristics, technology of bus, rail, rapid transit systems, basic operating elements. Transit Network Planning: Objectives, principles, Intercity and Regional transit system, considerations, transit lines – types, geometry and characteristics, transit routes and their characteristics, timed transfer networks, prediction of transit usage, network evaluation, and accessibility considerations. Transit Scheduling: Components, determination of service requirements, scheduling procedure, marginal ridership, crew scheduling. Transit Infrastructure Facilities: Design of bus stops, design of terminals – principles of good layout, types of layout, depot location, twin depot concept, crew facilities and amenities. Transit Agency and Economics: Organisational structure of transit agency, management and personnel, transit system statistics, performance and economic measures, operations, fare structure.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2304**			
Course Title	**Health Monitoring of Road Infrastructure**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction : Measurement & Instrumentation Principles & Technologies, Data Acquisition systems, Signal processing, Intelligent & Virtual Instrumentation Health Monitoring of Bridges:- Measurement of Parameters, Sensors/Transducers technologies, Measurement & Health monitoring Techniques: Vibration signal analysis, Strain gage based Instrumentation, Destructive & Non destructive testing, Load Test, etc Health Monitoring of Pavements: Structural and Functional Evaluation of Pavement: Pavement Surface Defects, Skid Resistance, Pavement Deflection using FWD, Benkelman Beam and condition survey using Modern Instrumental Methods.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2305**			
Course Title	**Transport Logistics and Operations**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Logistic, movement of goods and people, inventory , procurement, ware housing, transportation planning including freight, integrated transport managements , operation, network, Management, Transport Models, Transport Control and Telemetric, Public Transport, Project and ITP, Transport Appraisal.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2306**			
Course Title	**Environmental Impact Assessment of Infrastructure Projects**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction and Scope- EIA, EIA and Sustainable Development, Environmental Impacts of Infrastructure Projects. Introduction of applicability of Various Environmental laws to EIA of Infrastructure Projects. Salient Features of EIA Notification (Sep. 14th , 2006); Impact assessment - Assessment of Impact on Air, Water, Soil and Ground Water, Noise, Biological Environment and Socio-economic Environmental including Resettlement and Rehabilitation (R&R) issues. Environmental Assessment Methods and Techniques, Matrices, Network and Checklist Methods. Prediction Technique for Quality of Environment Attributes. Noise & Vehicular Pollution Modelling: Evaluation Methods. Environmental Quality Standards - Regulations and Legislations; Control measures - Management, Air & Noise Pollution Control & Preparation of Environmental Management Plan (EMP) including Resettlement & Rehabilitation (R&R) Aspects. Case Studies- EIA of Road, Buildings, Metro Rail & other infrastructure Projects Laboratory Experiments/ Field Studies Related to EIA Studies viz. Air Quality and Noise Pollution Measurements, Water Quality Analysis& Traffic.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-3-2301**			
Course Title	**Advanced Self Study**			
Credit Distribution (L-T-P-C)	0	2	4	**4**

Course Content:

Specialised advanced courses would be offered in consultation with the thesis supervisors and Doctoral Advisory Committee (DAC).

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-4-0001**			
Course Title	**Project Proposal**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Formulation of a project proposal in specified format in a holistic manner preferably candidate's own research work suitable for submission to appropriate funding agencies

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-4-0002**			
Course Title	**Review Article**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

One review article is to be prepared before submission of Synopsis by selecting topic in the area of research.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-4-0003**			
Course Title	**CSIR-800 Societal Program**			
Credit Distribution (L-T-P-C)	0	0	8	**4**

Course Content:

The students have to undertake a project in rural area for 6-8 weeks in line with CSIR-800 programme, which is primarily prepared at empowering 800 million Indians by way of S & T inventions.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-1-2313**			
Course Title	**Basic Pavement Engineering**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Introduction, Types and Components of different pavements, Soil characteristics, Factors effecting design and performance of pavements, Layered system approach, Stresses in flexible and rigid pavement, Design factors of stabilized pavement layers. Mix design aspects for stabilized materials. Drainage and its importance, Design of hill roads pavements for special conditions.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-1-2314**			
Course Title	**Super Pave Asphalt Binders and Mixtures**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Introduction to asphalt binder and its chemical composition, Asphalt binder manufacturing process, Durability of asphalt binders, Rheology of asphalt binders, Performance based asphalt binders, properties of performance based asphalt binder for roads, properties of mineral aggregate, asphalt-aggregate interactions and adhesion, introduction to asphalt mix design procedures including super pave asphalt, performance of Super Pave asphalt, significant of Super Pave Asphalt, Merits and demerits of Super Pave Asphalt, Test Procedures.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-1-2315**			
Course Title	**Introduction to Optimization Techniques**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Different types of optimization problems, One dimensional optimization technique such as Golden Section method, Bisection Method and Newton Method. Introduction to Linear Programming problems, Application and Model formulation.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-1-2316**			
Course Title	**BASICS OF PAVEMENT EVALUATION**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Introduction: Structural and functional evaluation of pavements. Pavement distress : Definition and different types of pavement distress, causes of distress Evaluation of Pavement functional Condition: Factors effecting functional condition of pavements. Different types of equipment used to measure roughness and skid resistance. Evaluation of Pavement Structural Condition: Factors effecting structural condition of pavements. Evaluation of structural condition of pavements by conventional method (destructive methods such as test pits) and different types of equipment. Overlay Design: Design of flexible pavement overlay using Benkelman beam deflection (IRC method),

Faculty	ENGINEERING SCIENCES			
Lab Name	CSIR-CRRI, NEW DELHI			
Course Nomenclature	ENG-CRRI-1-2317			
Course Title	INTRODUCTION TO PAVEMENT MANAGEMENT SYSTEM			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Introduction: Definition and different Components of pavement management systems, different pavement maintenance techniques, Application of system concepts to pavement management, pavement management levels-Network & Project level, Concept of Pavement life cycle Establishing criteria – Prediction models for pavement deterioration – determining the future needs Intervention criteria for maintenance planning, Introduction to economic evaluation of alternate pavement design strategies. Introduction to HDM – 4 other tools.

Faculty	ENGINEERING SCIENCES			
Lab Name	CSIR-CRRI, NEW DELHI			
Course Nomenclature	ENG-CRRI-2-2307			
Course Title	Introduction to Engineering Mechanics (Solid Mechanics)			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Concept of stress / strain, modulus of elasticity, Characterization of engineering materials e.g. steel, concrete, asphalt, soil, bricks. Bending, shear, torsion of simple bodies. Concept of stiffness and response to external loading. Different structural forms – axial, beam, plate, shell. Failure of material including non-linearity, buckling. Experimental mechanics:Introduction to measurement, electrical strain gauges Measurement of structural response (strain & deflection),Correlating experimental and theoretical responses. Sensors and NDT:Introduction to transducers, sensors, interpretation of data ,NDT – tools in engineering Concepts of signal processing (acoustic, spectroscopy),Time-domain, frequency domain & FFT analysis. application to NDT Numerical modeling of structure's response: Numerical modeling of basic shapes and study of response Application to pavement, bridge and building Vibration analysis: Introduction to vibration – source, characteristics Mathematical treatment, measurement of acceleration, application to typical structures

Faculty	ENGINEERING SCIENCES			
Lab Name	CSIR-CRRI, NEW DELHI			
Course Nomenclature	ENG-CRRI-2-2308			
Course Title	Introduction to Big Data Analytics			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

INTRODUCTION TO BIG DATA: Big data sources, Features of Big Data, Evolution of Big data, Best Practices for Big data Analytics, Big data characteristics and Data Appliance and Integration tools DATA ANALYSIS: Evolution of analytic scalability, Convergence, parallel processing systems, Cloud computing Analytic methods, analytic tools, Statistical significance techniques STREAM COMPUTING: Introduction to Streams Concepts – Stream data model and architecture - Stream Computing, Sampling data in a stream – Filtering streams Data stage – Statistical analysis PREDICTIVE ANALYTICS: Predictive Analytics, Supervised and Unsupervised learning Neural networks, Kohonen models, Clustering Techniques, Hierarchical, K- Means Clustering high dimensional Applications to Transportation Engineering

Faculty	ENGINEERING SCIENCES			
Lab Name	CSIR-CRRI, NEW DELHI			
Course Nomenclature	ENG-CRRI-2-2309			
Course Title	PRINCIPLES OF PAVEMENT EVALUATION			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Introduction: Structural and functional evaluation of pavements. Pavement distress : Definition and different types of pavement distress, causes of distress Evaluation of Pavement functional Condition: Factors effecting functional condition of pavements. Different types of equipment used to measure roughness and skid resistance. Evaluation of Pavement Structural Condition: Factors effecting structural condition of pavements. Evaluation of structural condition of pavements by conventional method (destructive methods such as test pits) and different types of equipment. Overlay Design: Design of flexible pavement overlay using Benkelman beam deflection (IRC method),

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2310**			
Course Title	**PRINCIPLES PAVEMENT MANAGEMENT SYSTEM**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Introduction: Definition and different Components of pavement management systems, different pavement maintenance techniques, planning on investment, Application of system concepts to pavement management, pavement management levels-Network & Project level, functions - Data needs, Pavement life cycle Establishing criteria – Prediction models for pavement deterioration – determining the future needs – rehabilitation and maintenance strategies Framework for pavement design, Intervention criteria for maintenance planning, variability, reliability and risk, economic evaluation of alternate pavement design strategies – selection of optimal design strategy. Introduction to HDM – 4 & other tools. Asset Management

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2311**			
Course Title	**ADVANCED PAVEMENT EVALUATION**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: Structural and functional evaluation of pavements. Pavement distress : Definition and different types of pavement distress, causes of distress, methods for measuring different distresses with its severity level,and their rectification measures Evaluation of Pavement functional Condition: Factors effecting functional condition of pavements. Different types of equipment used to measure roughness and skid resistance. Evaluation of Pavement Structural Condition: Factors effecting structural condition of pavements. Evaluation of structural condition of pavements by conventional method (destructive methods such as test pits) and different types of equipment. Overlay Design: Design of flexible pavement overlay using Benkelman beam deflection (IRC method), flexible overlays and rigid overlays over rigid pavements. Failure Investigations: causes of premature failures, investigation and case studies

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2312**			
Course Title	**ADVANCED PAVEMENT MANAGEMENT SYSTEM**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: Definition and different Components of pavement management systems, different pavement maintenance techniques, planning on investment, Application of system concepts to pavement management, pavement management levels-Network & Project level, functions - Data needs, Pavement life cycle and its analysis Determining Present and Future Needs: Establishing criteria – Prediction models for pavement deterioration – determining the future needs – rehabilitation and maintenance strategies – developing combined programmes for maintenance & rehabilitation Project Level Design: Framework for pavement design, characterization of physical design inputs, basic structural response models – Organiosational requirements, Intervention criteria for maintenance planning, variability, reliability and risk – generating alternate design strategies, rehabilitation design procedures, economic evaluation of alternate pavement design strategies – selection of optimal design strategy. Tools : HDM – 4 & other tools. Implementation of PMS: Major steps in implementing PMS Applications of Expert System Technology Asset Management

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2313**			
Course Title	**Basics of Soil Mechanics**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Origin & formation of soils, Soil water statics (phase systems), Grain size analysis, Plasticity characteristics, Classification of soil, Surface tension, Capillary attraction, Permeability, Seepage, Flow through soil, Flow nets, Effective stress. Stress due to load, Contact pressure, Consolidation, Settlement of compressible layers. Shear Strength- stress-strain characteristics of granular and cohesive soils. Earth pressure theories, Slope stability analysis. Subsoil investigations, Soil stabilization. Fundamental of retaining wall and bearing capacity. Laboratory and field tests. Grain size analysis, LL/PL, Specific gravity, Proctor compaction test, CBR, Consolidation, Relative density, Direct shear test, Unconfined compressive strength test, Tri-axial test, SCPT, Plate load test, DCPT, Core cutter, Sand replacement test etc.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2314**			
Course Title	**Basics of Engineering Geology**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Scope of Engineering Geology; Rocks: Classification, Engineering Properties, Problematic rocks; Intact Rock & rock mass; Rock Structures: Discontinuities & Folds and their relevant properties; Discontinuities analysis using stereographic projections; Rock mass characterization techniques; Role of Engineering geologists in civil engineering projects related to highways; Significance of Engineering geological mapping; Surface processes: Weathering; Landslides: Overview of Landslides: Classification, Causes, Investigation, Hazard mapping & stability analysis and Remedial measures; Scope of hydrogeology in Engineering Geology.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2315**			
Course Title	**Atmospheric Chemistry**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Characterization and Sampling of Atmospheric Pollutants – Types of Pollutant Sampling and Measurement, Ambient Air Sampling, Collection of Gaseous Air Pollutants, Collection of Particulate Pollutants, Analysis of Air Pollutants – Sulphur Dioxide, Nitrogen Oxides, Carbon Monoxide, Ozone, Hydrocarbons, Particulate Matter, Formation of Oxidants in Photochemical Smog in the Atmosphere; Effects of Air Pollutants on Materials and Human Health and Injury to Vegetation; Air Pollution Control Methods and Equipment – Control Methods, Source Correction Methods, Particulate Emission Control – Gravitational Settling Chambers, Cyclone Separators, Fabric Filters, Electrostatic Precipitators, Wet Scrubbers, Selection of a Particulate Collector; National Ambient Air Quality Standards; Control of Specific Gaseous Pollutants, Absorption by Liquids, Adsorption by Solids, Combustion, Control of Sulphur Dioxide, Control of Nitrogen Oxides, Carbon Monoxide, Hydrocarbons, Mobile Sources, Catalytic Convertor; Stratospheric Chemistry (Ozone), Tropospheric Chemistry, Atmospheric Aerosols, Chemistry of Global Climate (Greenhouse Gases), Ozone Layer Depletion; Chemical Toxicity–Identification through Chromatography; Spectro-Analytical Methods–IR, UV and Visible–Atomic Absorption, Atomic Emission and Mass Spectroscopy (Instrumentation Details and Analysis)

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2316**			
Course Title	**Optimization Techniques**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Optimisation Problems: Different types of optimization problems, One dimensional optimization techniques such as golden section method, Bisection method, Fibonacci method and Newton method. Linear Programming Problem (LPP): Applications and Model formulations, Simplex method, Integer LPP, Cutting plane method, branch and bound method, sensitivity Analysis in Linear Programming. Queuing Theory: Pseudo random numbers, random variables, Queuing models, Stochastic simulation techniques: Stochastic Simulation techniques such as Monte Carlo Simulation, Stochastic Response methods, Markov Chains and Bayesian Methods

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2317**			
Course Title	**Planning for Sustainable Transport System**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Introduction: Evolution of urban transportation, Scope of transportation and impact on society; transportation problems. Urban Mass Transit systems, types, System planning process and problem solving process; characteristics, suitability and adaptability of these systems. Transit System Planning: Planning needs; Short-range and long-range planning; Planning procedures and methodology, Data collection; Medium performance transit systems and high-performance transit systems; trends in transit planning. Transit Demand Estimation and Evaluation: Transit demand forecasting; transit mode evaluation; comparison and selection of most suitable transit mode. Transit System Operations: Basic operational elements; transit travel characteristics; transit scheduling; transit line analysis – planning objectives, geometry, types and their characteristics, capacity of transit lines, system procedures for improving transit line capacity. Transit Networks and System Analysis: Transit networks – types and their characteristics; transfers in transit networks; system analysis in transit – conceptual models, modeling procedures; terminal or station location planning – issues, objectives, station spacing decisions. Economics and Financing of Transit Systems: Transit system performance and economic measures; transit fares – structure, collection and levels; financing of transit services; public and private integration of transit services. Sustainable Transportation Planning: Sustainable transportation – issues and principles; non-motorized transportation planning; Impact evaluation and impact models, Policy framework for non Motorized transport

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2318**			
Course Title	**Life Cycle Assessment Applications in Transport Sector**			
Credit Distribution (L-T-P-C)	2	1	0	**3**

Course Content:

Introduction to Life Cycle Assessment (LCA) – Definition, Benefits and Limitations of conducting LCA, ISO standards for LCA Life cycle impact assessment (LCIA) methodologies – Overview of different methodologies adopted for conducting LCA Life cycle Greenhouse gas emissions – Publicly available specifications (PAS2050) (Specifications for the assessment of life cycle greenhouse gas emissions of goods and services) Industrial ecology – Key concepts of industrial ecology, Sustainability – concepts and metrics, LCA as a tool to support industrial ecology, material flow analysis Fuels and Transportation systems – Conventional fuels in transport sector, Role of alternative fuels Life cycle costs analysis – Definition, Terminology of LCCA, comparing alternatives, incorporating life cycle costs in life cycle analysis Tutorial and model development - Developing LCA with SimaPro.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2319**			
Course Title	**Durability of Concrete Structures**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Concrete and the environment – Concrete micro-structure, voids, types of exposure Overview of concrete deterioration- Non-structural cracks, corrosion, carbonation, alkali-aggregate reaction, Sulphate attack Permeability of concrete and its measurement - Penetration of carbon dioxide and chlorides into concrete Corrosion of steel in concrete - Electrochemistry of corrosion, micro and macro cell corrosion, corrosion cells and currents, role of concrete, prevention of corrosion, corrosion induced longitudinal cracks: nature and properties of corrosion products Alkali aggregate reaction - Reactive minerals, mechanism of deterioration, identification and tests; Deterioration models – Corrosion models – Carbonation model, chloride attack model, alkali-silica reaction model. Codal provisions for durability – Provisions in different codes for minimizing the concrete deterioration due to environmental exposure Non-destructive testing – Tests for corrosion, carbonation, alkali-silica reaction, chloride content, Sulphate attack

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2320**			
Course Title	**Dynamics of Structures**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Introduction (need of dynamics, role of dynamics in mechanics-safety-forensic eng., source & nature of dynamic loading). Single degree freedom system (SDOF). Multi-degree of freedom system. Continuous system. Random Vibration. Frequency domain and time domain analysis, spectral methods. Modeling of dynamic forces- Wind forces on structures. Earthquake loading on structures. Blast-Resistant design. Modeling sea wave forces. Soil structure interaction, nonlinearity in structures, Pushover analysis. Control of vibration. Experimental study of vibration from structures with a case study.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2321**			
Course Title	**Transport Network Analysis**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Introduction to transportation System: Analysis of Network flows, Transportation Networks, Network theory, shortest path methods, Wardrops principles of traffic assignment, Network analysis. Overview on Optimization techniques: Constrained and unconstrained optimization problems, Single variable and multivariable problems, Non-negativity and linear equality constraints, Line search algorithms, Newton's method, Method of steepest descent, Convex combination method. Traffic assignment: User equilibrium, System optimum formulation, Frank-Wolf algorithm User Equilibrium with variable demand, Stochastic User Equilibrium (SUE), Method of successive averages. Dynamic Traffic Assignment (DTA): Introduction and Analytical models, Mathematical formulations of DTA, First-in-first-out (FIFO) condition, Optimal control formulations, Variational inequality formulations. Macro and microscopic simulation based DTA models: Overview of simulation tools, Simulation based DTA algorithms, Calibration of simulation models, application of DTA software tools in network analysis (DRACULA Software)

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2322**			
Course Title	**Microstructure and Mechanics of Cement Concrete**			
Credit Distribution (L-T-P-C)	3	1	0	**4**

Course Content:

Microstructure of concrete- Aggregate particle packing studies without and with reference to Recycled Concrete Aggregate .Porosity, pore structure, permeability of concrete and their relation to durability .Advances in Study of concrete Workability- Rheology of concrete-Representation of rheological behavior, Measurement, Factors affecting rheological properties Advances in concrete mechanics- fracture mechanics, Linear Elastic fracture mechanics, Fracture process in concrete ,Non linear fracture mechanics, Micro cracking and stress strain relations, Stress strain relationships and Constitutive equations, Fatigue strength and Impact strength. Dimensional stability of concrete- Elastic behavior, Models for drying shrinkage and creep, Fire resistance, Thermal properties, Extensibility and Cracking. Practice on software for concrete proportioning on the basis of particle packing

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**ENG-CRRI-2-2323**			
Course Title	**Air Quality & Dispersion Modeling**			
Credit Distribution (L-T-P-C)	3	0	2	**4**

Course Content:

Road Transport Related Air Pollution, Sources of Air Pollution; Mechanisms of Formation of Exhaust Pollutants: CO, HC, NOX, SO2, Particulate Matters, Important Factors Affecting Exhaust Composition, Air Fuel Ratio, Catalytic Converters; Air Pollution Meteorology- Composition and Structure of Atmosphere, Meteorological Parameters-Wind Circulation, Solar Radiation, Adiabatic Lapse Rate, Environmental Lapse Rate, Atmospheric Stability Conditions and Classification, Wind Velocity Profile, Mixing Height, Temperature Inversions, Dispersion Parameters. Wind Rose Diagram, Heat Island Effect; Downwind Pollutant Concentrations; Types of Air Quality Model-Deterministic, Numerical and Statistical Modeling Approach, Box Model Theory of Gaussian Plume Model Assumptions, Limitation and its Application, Gaussian Dispersion Model-Point, Area and Line Sources; Introduction to Vehicular Pollution Modeling, CALINE 4 Highway Dispersion Model; Methodology for Vehicular Emissions Loads Estimation, Factors Affecting Vehicular Exhaust Emissions; Vehicular Emission Parameters, Vehicular Emission Standards and Norms, Road Transport and GHG Emissions, Role of Public Transportation in Improving Urban Air Quality Laboratory: Air Pollution Measurements (Including Meteorological Parameters) Using Air Pollution Mobile Van Fitted With Pollutant Specific Air Quality Analyzer(s): Principle of Measurement of Different Air Pollutants, Sampling Site Selection Criteria, Field Measurements, Data Collection and Analysis.

Faculty	CHEMICAL/ENGINEERING SCIENCES			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**CHE/ENG-CRRI-1-2318**			
Course Title	**Chemistry of Portland Cement and Pozzolanic Admixtures**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Pre-historic binders: Non-hydraulic and hydraulic binders - Development of cement Manufacture of cement Chemical analysis of cement Hydration of cement Types of cement and non-Portland cement Testing and properties of cement Specifications of cement Cementitious admixtures to concrete – Pozzolanic materials and other admixtures, their characterization, specifications, and properties

Faculty	**CHEMICAL/ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**CHE/ENG-CRRI-1-2319**			
Course Title	**Polymers for Construction and Maintenance of Bridges**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Introduction to Polymers, Rubbers, Fibers, and FRP's Use of Polymers as / for Chemical admixtures Polymer Concrete Polymer Modified Concrete Polymer Impregnated Concrete Coatings on Reinforcement Coatings on Concrete Repair of Concrete Use of Rubbers as / for Bridge Bearings Expansion Joints Water Proofing Membranes Use of Fiber Reinforced Plastics for Rehabilitation

Faculty	**CHEMICAL/ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**CHE/ENG-CRRI-1-2320**			
Course Title	**Polymers in Road Construction Applications**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Introduction to polymers, Types of polymers, Synthesis of polymers, Characterization of polymers, Polymers for bitumen modification, Polymers in concrete construction, Polymers for soil stabilization, Polymers for road marking paints, Polymer in repairs of structure, Geotextiles, polymer modified emulsions, Polymer in road safety applications, Characterization of polymer modified asphalts, Performance characteristics of polymer modified asphalt mixes

Faculty	**CHEMICAL/ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**CHE/ENG-CRRI-1-2321**			
Course Title	**Asphalt Emulsions, Foamed Asphalt and Cold Mixes**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Introduction to colloidal chemistry, composition of bitumen, classification of emulsions including asphalt emulsions, surface characteristics of mineral aggregates, classification and properties of emulsifiers characterization of foam and emulsions, manufacturing processes for bitumen emulsions, applications of bitumen emulsions in road construction, water proofing and stabilization, foamed asphalts, applications of foamed asphalt in road construction, physical properties of foamed asphalt, preparation of foamed asphalt, modified foams, modified asphalt emulsions, cold mixes, micro surfacing, slurry sealing, emulsion based patching mixes, use of foamed asphalt and emulsions in recycling process, preparation, laying and compacting of cold asphalt mixes.

Faculty	**CHEMICAL/ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**CHE/ENG-CRRI-1-2322**			
Course Title	**Metallurgical Slag for Construction Procedures**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Introduction to Slag, Type of slag and Manufacturing process, Cooper Slag, Zinc slag Basic Oxygen Furnace Steel Slag, Electric Arc Furnace Slag, Iron Blast Furnace Slag and Air cooled blast Furnace slag. Characterization of slag material. Uses. Slag as alternative to aggregate in road construction. Replacement of aggregate in asphalt Pavement, Replacement of aggregate in Concrete Pavement

Faculty	**CHEMICAL/ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**CHE/ENG-CRRI-1-2323**			
Course Title	**Polymer Materials**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Important polymer materials, their raw materials. Production technologies and applications in different polymer based industries: Polyolefins (LDPE, HDPE, LLDPE, and PP), Polystyrene, and Polyvinylchloride. PTEE, Polyisoprene, Polybutadiene, olefin copolymers, acrylics, PMMA, Polyvinylacetate. Acrylic plastics. Polybutadiene. SBR polyester, polyurethanes. Epoxies, Silicones. Phenolics and amino resins. Cellulosics, Polyamides.

Faculty	**CHEMICAL/ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**CHE/ENG-CRRI-2-2324**			
Course Title	**Polymer Chemistry and Characterization**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Chemical structure of monomers and polymers: Basic concepts and polymer nomenclature, Classification of polymers, Special features of polymer structure, Molecular weight and its distribution. Preparation of polymeric materials and their characterization. Fundamentals of chain and step growth polymerization. Principle and instrumental details of techniques for polymer characterization and testing for molecular weight and its distribution, Mechanical strength , Tensile, Compression, Flexural, Impact, Torsion, Electrical properties, Optical properties, Thermal properties, Structure determination-NMR and Scanning election microscopy, etc. Rheology: Types of flow, viscosity measurement, flow curve, zero-shear viscosity, activation energy of flow, effect of different parameters on viscosity; Boltzmann principle, Linear Viscoelastic models. Time-temperature superposition principle, WLF equation and its applications, Master curve and its use.

Faculty	**CHEMICAL/ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**CHE/ENG-CRRI-2-2325**			
Course Title	**Instrumental methods for Characterization of Environmental Pollutants**			
Credit Distribution (L-T-P-C)	2	0	2	**2**

Course Content:

Introduction to environmental pollution (Air pollution and water pollution) and broad introduction to methodology and instrumental techniques used Instruments used for the collection of samples like tedlar bags, canister sampler, high volume sampler, impactors, grab sampling etc. and its pretreatments or proper maintenance in the laboratory till analysis Extraction of organic pollutants, traces, sample cleanup Characterization of pollutants by Chromatographic techniques like GC, GC – MS, Titrimetric analysis and colorimetric analysis Application of HPLC in environmental analysis Characterization of pollutants by Atomic absorption spectroscopy, ICP MS, Water analysis Parameters required for air quality and water quality monitoring Experiments for the water analysis pH, Turbidity, conductivity etc. Experiments for the collection of ambient air and characterization by GC Collection of particulate matter and sample preparation for AAS

Faculty	**CHEMICAL/ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**CHE/ENG-CRRI-2-2326**			
Course Title	**Instrumental methods for Characterization of Engineering Materials (Bituminous Materials)**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Introduction to engineering materials and their characterization : Binders: Paving Bitumen, Industrial Bitumen, Bitumen Emulsion Modifiers: Polymers, Rubbers, Antioxidants, Antistripping Agents ,Waste Plastic, Other Additives Characterization of Binders : Bitumen: (viscosity, Complex modulus using DSR ,Aging of Binder using Thin Film Oven Test, Rolling Thin Film Oven Test and Pressure Aging Vessel(PAV) Bitumen Emulsion and Modified emulsion: Particle Charge, Residue and its characterization Characterization of Modifiers: Modifiers: Thermal and FTIR, and particle Size Modified Binders: Characterization as per IRC SP-53 and SHRP specifications Characterization of different types of Bituminous and modified bituminous mixes: Indirect Tensile Strength Resilient Modulus ,Creep, Tensile Strength Ratio, Rutting and Fatigue Characterization of special types of Bituminous Mixes including Mastic asphalt, Microsurfacing , Porous, Warm, Cold and SMA mixes

Faculty	**PHYSICAL/ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**PHY/ENG-CRRI-1-2324**			
Course Title	**Nanotechnology for Infrastructure**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Physics and Chemistry of Nano-materials Materials Characterization Techniques Nanotechnology for Construction Materials Applications of Nanotechnology in Road Pavement Smart Materials for Construction Environmental Nanotechnology

Faculty	**PHYSICAL/ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**PHY/ENG-CRRI-1-2325**			
Course Title	**Material Characterization Instrumentation**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Introduction to following instruments, (Working principles, procedures and applications) Atomic absorption spectroscopy (AAS), Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES), Inductively Coupled Plasma Mass Spectrometry (ICP-MS), X-Ray Diffraction (XRD), Field Emission Scanning Electron Microscopy(FESEM), Transmission electron microscopy (TEM), Field Emission Scanning Microscopy/Energy Dispersive X-ray Analysis (FESEM/EDX), Fourier transform infrared spectroscopy (FTIR), Atomic force microscopy (AFM), Particle Size Analyzer, Differential Scanning Calorimeter (DSC), Thermo gravimetric Analysis (TGA), RAMAN Spectrometer

Faculty	**MATHEMATICAL & INFORMATION /ENGINEERING SCIENCES**			
Lab Name	**CSIR-CRRI, NEW DELHI**			
Course Nomenclature	**MIS/ENG-CRRI-1-2326**			
Course Title	**Human Value & Professional Ethics**			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Introduction to Value Education: Understanding the need, basic guidelines, content and process for value education Basics of Professional Ethics :Ethical Human Conduct, To identify the Scope and Characteristics of People Professional Ethics in Practice: Professional Accountability, Role of a Professional Engineering Profession and Ethics: Technology & Society, Ethical Obligation of Engineers in Industries, Society, Nation & World

Faculty	MATHEMATICAL & INFORMATION /ENGINEERING SCIENCES			
Lab Name	CSIR-CRRI, NEW DELHI			
Course Nomenclature	MIS/ENG-CRRI-1-2327			
Course Title	Introduction to Finite Element Analysis			
Credit Distribution (L-T-P-C)	1	0	0	**1**

Course Content:

Introduction to Finite Element: Mathematical aspects of analysis, Matrix operations, Elastic modeling of an object. Basic Concepts: Concepts of Finite Element Analysis, Virtual Work and Variational Principle. Finite Element Method: Displacement Approach, Stiffness Matrix and Boundary Conditions. Element Properties: Natural Coordinates, Triangular Elements, Rectangular Elements, Lagrange and Serendipity Elements, Solid Elements, Isoparametric Formulation. Stiffness Matrix of Isoparametric Elements, Beam elements. Solution of equations, Numerical Integration. Interpretation of results. Exposure to general FEM software- NISA, SAP, STAAD etc Case studies: One Dimensional heat problem, truss, beam and shells.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NIIST, THIRUVANANTHAPURAM**			
Course Nomenclature	**ENG-NIIST-1-4101**			
Course Title	**Research Methology**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Good laboratory practices, Safety in the laboratory, First Aid in the laboratory, Maintenance of laboratory records, Scientific literature management, Intellectual property management & planning, Ethics in Science, Computer applications and tools, Measurements in research - primary and secondary data Statistical methods & Data analysis Role and importance of communication, Effective oral and written communication. Technical report writing, Technical/R&D proposals, Research paper writing, Dissertation/Thesis writing, Letter writing and official correspondence. Oral communication in meetings, seminars, group discussions; Use of modern aids; Making technical presentations.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NIIST, THIRUVANANTHAPURAM**			
Course Nomenclature	**ENG-NIIST-1-4102**			
Course Title	**Mathematics for Engineers and Scientists**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Linear Algebra: Linear independence, Orthogonality, Vector Spaces and their bases and dimensions, Gram-Schmidt method for orthogonal basis set, Orthogonal projections. Matrices and Linear Mappings, Solution methods for Linear Simultaneous Equations, Eigenvalue problems. Vector Analysis: Vector differentiation and its applications, Vector operators: Grad, Div and Curl. Vector integration & related Integral Theorems (Gauss' Divergence and Stoke's Theorems) and applications.Cylindrical and Spherical Co-ordinate Systems. Differential Equations: Linear ODEs of first and second orders, Systems of first order ODEs, Applications of homogeneous and non-homogeneous linear second order equations. Partial Differential Equations, Solving various ODEs, PDEs, Fourier Series and Applications, The Laplace Transform.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NIIST, THIRUVANANTHAPURAM**			
Course Nomenclature	**ENG-NIIST-2-4101**			
Course Title	**Advanced Materials Science and Engineering**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Atomic Structure and Bonding: Atomic structure and bonding in materials. Crystal structure of materials, crystal systems, unit cells and space lattices, determination of structures of simple crystals by x-ray diffraction, miller indices of planes and directions, packing geometry in metallic, ionic and covalent solids. Concept of amorphous, single and polycrystalline structures and their effect on properties of materials. Imperfections in crystalline solids and their role in influencing various properties. Dislocation and strengthening mechanisms: Dislocation and Plastic deformation, strengthening mechanism, recovery, recrystallisation and grain growth, strengthening by second phase particles. Phase Diagrams: Equilibrium phase diagrams, Solid solutions, solubility limit, phase rule, binary phase diagrams, eutectic, peritectic, eutectoid and peritectoid reactions, iron-carbon phase diagram.Materialprocessing: Advanced polymer processing techniques - melting and processing of metallic materials - basics of powder metallurgy - ceramic processing - powder pressing techniques - slurry processing methods - processing of ceramic films and fibers. Mechanical Properties: Stress-strain diagram, modulus of elasticity, yield strength, tensile strength, toughness, elongation, ductility, viscoelasticity, hardness, impact strength, creep, fatigue and fracture toughness. Thermal, Electrical and Magnetic Properties: Thermal -Heat capacity, thermal conductivity and thermal expansion of materials; Electrical- Conductors, superconductors, semiconductors and insulators; Magnetic - magnetism in metallic and ceramic materials, paramagnetism, diamagnetism, ferromagnetism and magnetic hysteresis

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NIIST, THIRUVANANTHAPURAM**			
Course Nomenclature	**ENG-NIIST-2-4102**			
Course Title	**Advanced Materials Characterization**			
Credit Distribution (L-T-P-C)	2	0	2	**3**

Course Content:

Microscopy: Optical microscopy (Bright field, Dark field, Phase contrast, differential interference contrast, polarized light, fluorescence and confocal imaging), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning Tunneling Microscopy (STM), Atomic Force microscope (AFM), Energy Dispersive Spectrometry (EDS), Auger Electron Spectroscopy X-Ray Techniques: X-Ray Powder Diffraction (XRD), Single-Crystal X-Ray Structure Determination, X-Ray Fluorescence(XRF), and X-Ray Photoelectron Spectroscopy (XPS) Thermal Analysis: Introduction, Thermogravimetric Analysis (TG), Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC); Spectroscopy: Basic principles, Instrumentation and Applications of Ultraviolet and Visible Absorption Spectroscopy (UV-Vis), Fourier Transform Infrared Spectroscopy (FT-IR), NMR and Raman Spectroscopy Physical and Mechanical Testing: Particle size analysis, BET analysis, porosimetry, pyconometry, density measurements; Tension, Compression, Hardness, Impact toughness, fracture toughness, ,fatigue, creep, wear.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NIIST, THIRUVANANTHAPURAM**			
Course Nomenclature	**ENG-NIIST-2-4103**			
Course Title	**Physical Metallurgy**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Crystallography and Crystal Defects: Crystal systems-Detailed discussion of common crystal structures in metals and alloys. Crystal defects: Classification - Point, line, area and volume defects - Voids - types and location in BCC, FCC and .HCP structures- influence of defects on properties. Alloying Theory: Types of solid solutions and compounds - Hume-Rothery rules for formation of substitutional solid solutions- properties of solid solutions. Essential principles of solidification. Phase Diagrams: Determination and uses of phase diagrams. Types of phase reactions with examples. Phase rule and its application to phase diagrams- Lever rule. Concept of ternary phase diagrams - Exercise problems. Diffusion In Solids: Diffusion - Concept of activation energy- Mechanisms of diffusion - Fick's I Law of diffusion -Diffusion coefficient- factors affecting diffusion coefficient - Fick's II Law of diffusions - inter diffusion - Kirkendall effect - Modes of diffusion (surface, volume and grain boundary) - Industrial applications - Numerical problems. Theory of Phase Transformations: Nucleation and growth - homogeneous and heterogeneous nucleation. Martensitic transformation in ferrous and non-ferrous metals - Shape Memory Effect and its applications, Diffusion controlled transformations and diffusion less transformations. Cold Working and Hotworking: Structure and properties of cold worked metals - Annealing- Recovery, recrystallisation and grain growth, comparison of cold working and hot working. Strengthening Mechanisms: Cold working, Grain size control, precipitation hardening, martensitic strengthening, dispersion hardening.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NIIST, THIRUVANANTHAPURAM**			
Course Nomenclature	**ENG-NIIST-2-4104**			
Course Title	**Thin film technology (new-approval requested)**			
Credit Distribution (L-T-P-C)	2	0	0	**2**

Course Content:

Thin Films-Introduction Thin films and their importance, Essential fundamental aspects, as well as the technology, of thin-film nucleation and growth from the Sputter coating, DC and RF sputtering, Magnetron Sputtering, Physical and Chemical Vapour deposition, Electro vapour deposition, Ion Beam Sputtering, Pulsed laser ablation, and Chemical vapour deposition (CVD); Relationships between deposition parameters and film properties, Applications of thin films Physics of Thin Films Steps in thin film growth process- sticking coefficients, surface bombardment rate; Thin film growth models- adsorption, thermal accommodation, Van der Waals forces, lifetime of adsorbed species, surface diffusion, chemisorption; Film growth modes- capillary theory of nucleation and growth, coalescence processes; Epitaxy and Defects in Thin Films Epitaxy-Introduction, Environment for Film Growth- Real surfaces, Surface passivation, Vacuum requirements for film growth, Techniques to grow thin films at atomic scale and to fabricate multilayers/superlattices at nanoscale. Evaporating alloys and compounds, Molecular beam epitaxy (MBE), RHEED, Atomic Layer Deposition. Different types of crystal growth in epitaxial films, Defects formation in thin films, Effect of Stress, Applications and emerging technologies

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NIIST, THIRUVANANTHAPURAM**			
Course Nomenclature	**ENG-NIIST-3-4101**			
Course Title	**Nanomaterials Science and Technology**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Introduction: Introduction and importance of materials at Nano Size, Properties at Nano Scales, Advantages & Disadvantages, Application in comparison with bulk materials (Nano structure, nano wires, tubes, nano composites), Low-dimensional structures: Quantum wells, Quantum wires, and Quantum dots, Nano clusters & Nano crystals, Processing of Nanomaterials: Introduction- Basic fabrication techniques, Top down vs. bottom up techniques, nucleation theory, surface energy, and stabilization; Chemical Processing Methods, Physical processing methods (lithography, thin film deposition and doping) MEMS fabrication techniques-Nano fabrication techniques (E-Beam nano-imprint fabrication, Epitaxy and strain engineering. Scanned probe techniques), Mechanical Processing techniques - Mechanical alloying/milling, mechanochemical synthesis Properties of Nanomaterials: Size and Properties relationship, Physical, Chemical, Magnetic, mechanical and tribological properties of nanomaterials, Properties of nano particles and Bulk nanomaterials, Nano Particles: Synthetic Methods- wet chemical approach & physical vapour synthesis approach etc size effect & shape change and their properties - examples of systems involved - characterization techniques - properties & their applications Nano tubes: Different systems involved in nano tubes -single walled, multi-walled, Carbon based, metal incorporated tubes. Synthesis procedures (Solid & gaseous carbon source based production techniques etc.) Growth mechanism of carbon nano tubes - properties of carbon nano tubes - characterization applications. Nano Composites: Introduction-Synthesis procedures-various systems (metal-polymer, metalceramics and polymer-Ceramics). Characterization - procedures - Applications. Applications of Nanomaterials: Catalysis, Electronic, Aerospace, Automotive, Surface coatings, Magnetic, Optical, Medicine etc.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NIIST, THIRUVANANTHAPURAM**			
Course Nomenclature	**ENG-NIIST-3-4102**			
Course Title	**Advanced Composite Materials**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Concept and Classification: Concept and Historical development of Composite materials, Material properties that can be improved by forming a composite material and its engineering potential, Types of composites, Classification based on Matrix Material: Organic Matrix composites Polymer matrix composites (PMC), Carbon matrix Composites or Carbon-Carbon Composites, Metal matrix composites (MMC), Ceramic matrix composites (CMC); Classification based on reinforcements: Fiber Reinforced Composites, Fiber Reinforced Polymer (FRP) Composites, Laminar Composites, Particulate Composites.Constituent materials in Composites: Types of Reinforcements/FibersRole and Selection or reinforcement materials, Types of fibres, Glass fibers, Carbon fibers, Aramid fibers , Metal fibers, Alumina fibers, Boron Fibers, Silicon carbide fibers, Quartz and Silica fibers, Multiphase fibers, Whiskers, Flakes etc., Mechanical properties of fibres. Matrix Materials -Functions of a Matrix, Desired Properties of a Matrix, Polymer Matrix (Thermosets and Thermoplastics), Metal matrix, Ceramic matrix, Carbon Matrix, Glass Matrix etc. Processing of Advanced composites: Metal Matrix Composites- Casting - Solid State diffusion technique, Cladding - Hot isostatic pressing; Ceramic Matrix Composites: Liquid Metal Infiltration Liquid phase sintering; Carbon - Carbon composites: Knitting, Braiding, Weaving Polymer matrix composites: Preparation of Moulding compounds and prepregs - hand lay up method Autoclave method - Filament winding method - Compression moulding - Reaction injection moulding. Special systems: Introduction to Processing and characteristics of nanocomposites, hybrid composites, functionally graded composites, smart and functional composites

Faculty	ENGINEERING SCIENCES			
Lab Name	CSIR-NIIST, THIRUVANANTHAPURAM			
Course Nomenclature	ENG-NIIST-3-4103			
Course Title	Advanced Ceramics Processing			
Credit Distribution (L-T-P-C)	3	0	0	3

Course Content:

Ceramic Processes before firing: Prologue to ceramic processing,Comminution process, mechanical effects in comminution, dry milling, wet milling, tumbling milling, planetary ball milling, vibratory ball milling, particle size characterization, BET analysis, pyconometry, Agglomeration offine particles, sintering-aids and dopants, surfactants, wetting agents ,dispersants, binders and plasticizers, viscosity, green body forming Fundamentals of Ceramic Forming: Consolidation of ceramic powders, mechanical compaction, powder packing, uniaxial pressing, isostatic pressing, hot pressing, hot isostatic pressing, slip casting, tape casting, plastic forming, extrusion, injection moulding, rapid prototyping, green ceramic, drying, green machining Sintering of Ceramics: Dilatometry, sintering curve, kinetics of sintering, solid state sintering, liquid phase sintering, reaction sintering, microwave sintering, spark plasma sintering, laser sintering, rate controlled sintering, density analysis, grain size and microstructure analysis techniques Advanced Functional Ceramic Coatings and Thin Films: Co-precipitation, Solgel processing, coating techniques, rheology of coating precursors, functional coatings, wetting and non wetting surfaces, coating characterizations, multilayered coatings, nanocomposites, porous ceramics ceramic membranes, organic-inorganic nano hybrids Advanced Electronic Ceramics and Applied Superconductors Dielectric ceramics, microwave ceramics, low k materials, SOFC materials, solid-ionic conductors, phosphor materials, Impedance analysis, varistors, sensors, superconductivity and high temperature ceramic super conductors. Advanced High Temperature Ceramics: Engineering Ceramics - Properties and applications of AI2O3, SiC, Si3N4, zirconia, mullite, AbTiOs, rare earth phosphates, B4C, Cubic Born nitride, thermal shock resistance and super plastic ceramics

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NIIST, THIRUVANANTHAPURAM**			
Course Nomenclature	**ENG-NIIST-3-4104**			
Course Title	**Materials Chemistry**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Atomic Structure and Bonding: Atomic structure and bonding in materials. Crystal structure of materials, crystal systems, unit cells and space lattices, determination of structures of simple crystals by x-ray diffraction, miller indices of planes and directions, packing geometry in metallic, ionic and covalent solids. Concept of amorphous, single and polycrystalline structures and their effect on properties of materials. Imperfections in crystalline solids and their role in influencing various properties. Materialsystems: Introduction to Ceramics, Polymers, Metals and Alloys and Composites Ceramic processing Consolidation of ceramic powders, mechanical compaction, powder packing, uniaxial pressing, isostatic pressing, hot pressing, hot isostatic pressing, slip casting, tape casting, plastic forming, extrusion, injection moulding, Polymer processing: Condensation polymerization, Addition polymerisation (Radical polymerisation, Ionic and coordination polymerisation), copolymerization, Polymerisation conditions and polymer reactions Composites: Introduction Definition and classification, Matrix (polymer, metal and ceramics), Thermoset and thermoplastic polymer matrix composites, Reinforcement (glass, aramid and carbon fibres), functionally graded and nanocomposites Processing of Polymer composites Processing of thermoset matrix composite- Hand lay-Up and Spray techniques, Filament winding, Pultrusion, Resin transfer molding, Thermoplastic matrix composite- Film stacking, diaphragm forming, Thermoplastic tape laying, Injection Molding, Sheet molding compounds. Advanced materials Introduction to Functional and Smart materials, nanomaterials - synthesis, properties and applications

Faculty	ENGINEERING SCIENCES			
Lab Name	**CSIR-NIIST, THIRUVANANTHAPURAM**			
Course Nomenclature	**ENG-NIIST-3-4105**			
Course Title	**Light and Rare Earth Metals, Alloys and Composites**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Aluminium and its Alloys: General characteristics, Minerals and Process Metallurgy of Al, Alloy specification, Effect of alloying elements, Cast and wrought alloys, applications. Magnesium and its alloys: General characteristics, Minerals and Process Metallurgy of Mg, Alloy specification, Effect of alloying elements, Cast and wrought alloys, applications.Titanium and its Alloys: General characteristics, Minerals and Process Metallurgy of Ti, Alloy specification, Effect of alloying elements, Major Ti alloys, applications. Light Alloy Composites: Metal Matrix Composites (MMC), classification, Light Alloy matrices, Reinforcements, Processing Methods, Liquid metal stir casting, infiltration, Powder and casting processes, Mechanical and Tribological behaviour of MMC. Rare Earth (RE) Metals, Alloys and Composites: Characteristics of RE Metals, Source of RE metals, RE Metal processing, Major RE Alloys and Composites, Applications.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NIIST, THIRUVANANTHAPURAM**			
Course Nomenclature	**ENG-NIIST-3-4106**			
Course Title	**Polymers and Composites**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Concepts of polymer science: Molecular forces - Degree of polymerization, Molecular weight determination (number average and weight average, viscosity average molecular weight and their statistical equations) and molecular weight distribution. Polymerisation: Condensation polymerization, Addition polymerisation (Radical polymerisation, Ionic and coordination polymerisation), copolymerization, Polymerisation conditions and polymer reactions Structure and properties: Configuration of polymer chains,crystal structure of polymer, crystallisation and melting, Viscous flow, Viscoelasticity, The glassy state and the glass transition. Composites: Definition and classification, Matrix (polymer, metal and ceramics), Thermoset and thermoplastic polymer matrix composites, Reinforcement (glass, aramid and carbon fibres, nanodispersoids), functionally graded, hybrid and nanocomposites, Processing of Polymer composites Processing of thermoset matrix composite- Hand lay-Up and Spray techniques, Filament winding, Pultrusion, Thermoplastic matrix composite- Film stacking, diaphragm forming, Thermoplastic tape laying, Injection Molding, Sheet molding compounds.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NIIST, THIRUVANANTHAPURAM**			
Course Nomenclature	**ENG-NIIST-3-4107**			
Course Title	**Advanced Materials Processing**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Ceramic processing -Consolidation of ceramic powders, mechanical compaction, powder packing, uniaxial pressing, isostatic pressing, hot pressing, hot isostatic pressing, Slurry processing, slip casting, tape casting, pressure casting, gel casting, plastic forming, extrusion, injection moulding. Rapid prototyping, electrophoretic casting, electro-spinning. Green strength, drying, binder burnout, green machining, sintering. Sol-gel processing, Thermal and plasma spraying, Thick and thin film coatings PVD and CVD techniques. Vapor infiltration techniques. Metals processing: Metal Casting - sand, permanent, pressure, centrifugal and investment processes. Deformation processing - stress during various metal working operations, friction and its role in bulk metal forming operations, microstructural evolution during deformation processing, superplastic forming; Sheet metal forming, ehancement of sheet metal formability; Fundamentals of powder processing of metals, solid and liquid state sintering, driving force and mechanism of sintering Polymer Processing: Compounding of plastics and rubbers, fabricating processes like compression, transfer, injection and blow moulding, extrusion, calendaring, thermoforming, roto molding, casting, sintering and compaction, dip coating, RTM, RIM, RRIM, post forming and finishing operations. Composite Processing - Hand lay-up, Filament Winding, Pultrusion, Resin Transfer Molding, Processing Science of Reactive Polymer composites - Process steps for production, Selection of processing conditions Toolings, and equipments, Carbon- Carbon Composites - Processing, thermal and mechanical properties, Quality control

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NIIST, THIRUVANANTHAPURAM**			
Course Nomenclature	**ENG-NIIST-3-4108**			
Course Title	**Advanced Functional Materials**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Advanced Functional Ceramic Coatings and Thin Films-Co-precipitation, Solgel processing, coating techniques, rheology of coating precursors, functional coatings, wetting and non wetting surfaces, coating characterizations, multilayered coatings, nanocomposites, porous ceramics ceramic membranes, organic-inorganic nano hybrids Advanced Electronic Ceramics and Applied Superconductors-Dielectric ceramics, microwave ceramics, low k materials, SOFC materials, solid-ionic conductors, phosphor materials, Impedance analysis, varistors, sensors, superconductivity and high temperature ceramic super conductors. Advanced High Temperature Ceramics-Engineering Ceramics - Properties and applications of Al203, SiC, Si3N4, zirconia, mullite, AbTiOs, rare earth phosphates, B4C, Cubic Born nitride, thermal shock resistance and super plastic ceramics. Functionally Graded Materials, Shape Memory Alloys, Piezoelectric materials, bomimetic functional materials, organic-inorganic hybrid materials.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NIIST, THIRUVANANTHAPURAM**			
Course Nomenclature	**ENG-NIIST-3-4109**			
Course Title	**Surface Science and Technology**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Surface Science - Prologue, Atomic and electronic structure of surfaces - surface degradation of metals, ceramics and polymers and their control measures. Surface and Coating Technologies-Selection of Coating and Surface Technologies, Surface Coating processes: Electroless deposition- Electro deposition - Chemical vapour deposition - Physical vapour deposition - Thermal spraying - Flame Spraying -Plasma spraying - surface heat treatments and hardening - Carburising - Nitriding -Anodising - Laser surfacing - Sputtering - Ion Plating -Sol-gel Coating - Hot-dip Coating - surface alloying - self-cleaning surfaces - surface functionalization - self assembly Brazed and welded coating methods - Thin film technologies - Other advanced surface techniques Testing methods and assessment of coatings - Coatings for Aerospace structures and components. Surface Coating Materials: Metallic, ceramic, polymer and composite coatings, nanomaterial coatings, superhard and functional and functionally graded coatings. Corrosion and its control - Basic principles of corrosion processes, Corrosion problems in the aerospace industry, General corrosion, pitting corrosion, crevice corrosion, stress corrosion cracking, influence of deposits and anaerobic conditions, Exfoliation, corrosion. Corrosion control. High temperature oxidation and hot corrosion, Corrosion / mechanical property interactions. Paint and paint systems. Tribology-Friction, Lubrication and wear of surfaces, coefficient of friction, Types of wear- Abrasive, erosive and sliding wear, interactions between machine parts and environments, failure mechanisms of wear, Interaction between wear and corrosion, Testing methods and control measures of wear

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NIIST, THIRUVANANTHAPURAM**			
Course Nomenclature	**ENG-NIIST-3-4110**			
Course Title	**Advanced Foundry Technology**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Sand casting process- pattern, mould, core, gating, riser, casting yield, Classification of casting processes, Types of Foundries, General layout and sections in foundries, Patterns and Cores - Selection of parting line, allowances on pattern, pattern materials, color coding, core plates, core-boxes - metallostatic pressure, design of core print, chaplets) Mold making - Green sand moulding, dry sand moulding, molding sands, Properties of foundry sands and their testing, additives, Sand Control, core sands, mould compaction machines, Jolt, jolt-squeeze, high pressure molding, sand slinger, refractory coatings, Venting, molding boxes, chills ,roll of additives & technical terms in sand like Total clay, active clay, latent clay, dead clay etc Special molding and casting processes - C02-Silicate process, Coremaking-Introduction to modern core sand binders like ,hot box, cold box, ester & Shell moulding, Evaporative Pattern (EPC) and Vacuum-sealed (V-) processes, Plaster mould, Ceramic mould, Investment casting, Die casting process - gravity die, pressure die, low pressure die and squeeze casting; centrifugal casting, Introduction to Mold & Core coatings, their significance in getting satisfactory casting quality. Melting furnaces- Cupola and its types, Cupola charge calculations, chill testing of C.I., rotary furnace, induction furnaces, Arc furnace, holding furnaces, inoculation, fluxes, degassing, use of vacuum, de-oxidation practices in steel and cast iron foundry, converters for SG iron making, effects of melt Fluidity and its testing. Foundry refractory. . Aluminium alloy, Magnesium alloy, copper alloy and special alloy foundry practice. Solidification of metals and alloys, long freezing range and short freezing range alloys, Directional Solidification, Constitutional super-cooling, Segregation, Modes of solidification planner, cellular, dendritic modes, Casting feeding - shrinkage, riser and chills, Cain's formula, NRL method, Inscribed circle method, modulus method, padding, Gating systems- fluid flow, Pressurized and non-pressurized gating systems, metal filtration, Software for casting process

Faculty	ENGINEERING SCIENCES			
Lab Name	CSIR-NIIST, THIRUVANANTHAPURAM			
Course Nomenclature	ENG-NIIST-3-4111			
Course Title	Modeling for Casting and solidification processing			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Mechanisms of transport phenomena: Ø Heat transfer, Mass transfer and Momentum transfer; Governing equations for transport phenomena; Introduction to diffusive transport phenomena: Flux laws, Macroscopic heat transport, Macro mass transport; Fluid dynamics during mold filling : Ø Fluidity of molten metals, capillary flow, gating systems for castings; Fluid dynamics during solidification: Ø Basics of Casting and solidification, Shrinkage flow, Natural convection, Surface tension driven flow, Flow through mushy zone, Metal shrinkage & feeding, Shrinkage effects Fundamentals of casting process modeling; Ø Macro energy transport,Governing equations, Boundary conditions, Analytical solutions for steady & non steady state solidification of castings Numerical macro modeling of solidification Ø Basics of finite difference methods; Steady state heat conduction, transient heat conduction, phase change problems, Numerical micro modeling of solidification Ø Deterministic models, Stochastic models & Phase filed models Hands on training in FLOW3D

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NIIST, THIRUVANANTHAPURAM**			
Course Nomenclature	**ENG-NIIST-3-4112**			
Course Title	**Magnetic materials and their technological application**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Magnetism Magnetostatics,Magnetism of electrons,Magnetism of Localized electrons, types of magnetism and exchange interactions, magnetic domains, magnetic anisotropy and magnetostriction Magnetic Materials Magnetism in metals, alloys and oxides. Rare-earth magnetism, organic and molecular magnets, Spintronics, magneto resistive materials, Gaint magneto resistance, magneto-optical materials, Biomagnetism and spin glasses. Experimental techniques in magnetic characterization, magnetic measurements for material property evaluation. Technological application Soft magnetic materials for electromagnets, hard magnets, Permanent magnets, Magnetic refrigeration, magnetic recording technology, Magneto-optical devices, magnetic levitation and biomedical applications.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NIIST, THIRUVANANTHAPURAM**			
Course Nomenclature	**ENG-NIIST-3-4113**			
Course Title	**Cryogenics, Vacuum technology and its process applications**			
Credit Distribution (L-T-P-C)	3	0	0	**3**

Course Content:

Cryogenics: Production and measurement of low temperature, Properties of liquid oxygen, liquid nitrogen and liquid helium, Construction of Thermostat and Cryostat. Measurements of low temperature physical properties (includes electrical transport, thermal transport and magnetic) of solids and their experimental concepts Vacuum Techniques Concepts of Vacuum and its applications in different processes (Metallurgical, electronic, Chemical, electrical, space, nuclear, pharmaceutical, food and cryogenics). Production of medium, high vacuum and ultra-high vacuum. Different pumps to produce vacuum of required order (Rotary pump, Diffusion pump,Sorption pump Turbomolecular, ion and Cryopumps), Different Guages to measure the Vaccum. Pressure measurement in vacuum systems using different primary and secondary gauges. Calibration/ maintenance of vacuum gauges.Residual gas analysis in vacuum systems. Design and Fabrication of vacuum chambers, flanges, couplings, and components for different applications. Leak detection/trouble shooting/maintenance of vacuum systems, handling of mass spectrometric leak detectors, degassing procedures. Handling of vacuum based furnaces/coating units/ driers and other process-systems.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NIIST, THIRUVANANTHAPURAM**			
Course Nomenclature	**ENG-NIIST-4-0001**			
Course Title	**Project Proposal Writing**			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

Formulation of a project proposal in specified format in a holistic manner preferably candidate's own research work suitable for submission to appropriate funding agencies

Faculty	ENGINEERING SCIENCES			
Lab Name	CSIR-NIIST, THIRUVANANTHAPURAM			
Course Nomenclature	ENG-NIIST-4-0002			
Course Title	Review Article Writing			
Credit Distribution (L-T-P-C)	0	0	4	**2**

Course Content:

One review article is to be prepared before submission of Synopsis by selecting topic in the area of research.

Faculty	**ENGINEERING SCIENCES**			
Lab Name	**CSIR-NIIST, THIRUVANANTHAPURAM**			
Course Nomenclature	**ENG-NIIST-4-0003**			
Course Title	**CSIR-800 Societal Programme Project**			
Credit Distribution (L-T-P-C)	0	0	8	**4**

Course Content:

The students have to undertake a project in rural area for 6-8 weeks in line with CSIR-800 programme, which is primarily prepared at empowering 800 million Indians by way of S & T inventions.