Department of Mechanical Engineering

1.	MAN-001	Mathematics-1	BSC	4
2.	PHN-001	Mechanics	BSC	4
3.	CEN-105	Introduction to Environmental Studies	GSC	3
4.	HS-001A	Communication Skills (Basic)	HSSC	2
5.	HS-001B	Communication Skills (Advance)	HSSC	2
6.	HSN-002	Ethics and General Awareness	HSSC	2
7.	MIN-101A	Introduction to Mechanical Engineering	DCC	2
8.	MIN-103	Programming and Data Structure	ESC	4
9.	MAN-004	Numerical Methods	BSC	4
10.	PHN-008	Electromagnetic Theory	BSC	4
11.	MIN-104	Manufacturing Technology-I	DCC	4
12.	MIN-106	Engineering Thermodynamics	DCC	4
13.	MIN-108	Mechanical Engineering Drawing	DCC	4
14.	MTN-106	Material Science	ESC	4
15.	CEN-102	Solid Mechanics	ESC	4
16.	MIN-201	Kinematics of Machines	DCC	4
17.	MIN-203	Manufacturing Technology-II	DCC	4
18.	MIN-205	Fluid Mechanics	DCC	4
19.	MIN-291	Engineering Analysis and Design	DCC	4
20.	EEN-112	Electrical Science	ESC	4
21.	MIN-204	Machine Drawing	DEC	4
22.	MIN-206	Mechanics of Materials	DEC	4
23.	MIN-208	Theory of Production Processes	DCC	4
24.	MIN-210	Energy Conversion	DCC	4

25.	MIN-301	Dynamics of Machines	DCC	4
26.	MIN-303	Principles of Industrial Engineering	DCC	4
27.	MIN-305	Heat and Mass Transfer	DCC	4
28.	MIN-302	Machine Design	DEC	4
29.	MIN-304	Fluid Machinery	DCC	4
30.	MIN-305	Heat and Mass Transfer	DCC	4
31.	MIN-209	Thermal Engineering	DCC	4
32.	MIN-211	Theory of Machines	DCC	4
33.	MIN-212	Machine Design	DCC	4
34.	MIN-214	Engineering Economy	DCC	4
35.	MIN-216	Theory of Production Processes - I	DCC	4
36.				
37.	MIN-309	Theory of Production Processes - II	DCC	4
38.	MIN-310	Quality Management	DCC	4
39.	MIN-311	Operations Research	DCC	4
40.	MIN-312	Operations Management	DCC	4
41.	MIN-313	Work System Design	DCC	4
42.	MIN-320	Automobile Engineering	DEC	4
43.	MIN-321	Vibrations and Noise	DEC	4
44.	MIN-322	Principles of Lubrication Technology	DEC	4
45.	MIN-323	Design of Pressure Vessels and Piping	DEC	4
46.	MIN-324	FEM Applications in Mechanical Engineering	DEC	4
47.	MIN-325	Numerical Methods in Manufacturing	DEC	4
48.	MIN-327	Reverse Engineering	DEC	4

49.	MIN-328	Manufacturing System Analysis	DEC	4
50.	MIN-329	Computer Integrated Manufacturing	DEC	4
51.	MIN-330	Ergonomics	DEC	4
52.	MIN-331	Total Quality Management	DEC	4
53.	MIN-332	Industrial Hazards and Safety	DEC	4
54.	MIN-333	Industrial Management	DEC	4
55.	MIN-334	Facilities Design	DEC	4
56.	MIN-335	Concurrent Engineering	DEC	4
57.	MIN-336	Financial Management	DEC	4
58.	MIN-337	Processing of Non-Metals	DEC	4
59.	MIN-338	Measurement & Instrumentation	DEC/DHC	4
60.	MIN-339	Heat Exchangers	DEC/DHC	4
61.	MIN-340	Refrigeration &Air-conditioning	DEC/DHC	4
62.	MIN-341	Thermal System Design	DEC/DHC	4
63.	MIN-342	Environnemental Pollution & Control	DEC	4
64.	MIN-343	Power Plants	DEC	4
65.	MIN-344	Industrial Combustion	DEC/DHC	4
66.	MIN-345	Compressible Flow	DEC/DHC	4
67.	MIN-346	Waste Heat Recovery Systems	DEC/DHC	4
68.	MIN-349	Fire Dynamics	DEC/DHC	4
69.	MIN-352	Experimental Methods in Thermal Engineering	DEC/DHC	4
70.	MIN-354	Surface Engineering	DEC	4
71.	MIN-355	Building Ventilation&Air-conditioning	GSEC	4
72.	MIN-357	Combustion Science & Technology	GSEC	3

73.	MIN-359	Fundamentals of Sound and Vibration	DEC	4
74.	MIN-410	Product and Process Optimization	DEC	4
75.	MIN-411	Maintenance Techniques for Rotating Components	DEC	4
76.	MIN-412	Vehicle Dynamics	DEC	4
77.	MIN-413	MEMS	DEC	4
78.	MIN-415	Piping Technology	DEC	4
79.	MIN-416	Nonlinear Dynamics	DEC	4
80.	MIN-417	Energy and Variational Principles in Engineering Mechanics	DEC	4
81.	MIN-445	Value Engineering	DEC	4
82.	MIN-500	Instrumentation and Measuring Systems	DEC/DHC	4
83.	MIN-502	Robotics and Control	DEC	4
84.	MIN-508	Advanced Automatic Controls	DEC	4
85.	MIN-509	Extended Finite Element Methods	DEC	4
86.	MIN-516	Artificial Intelligence	DEC	4
87.	MIN-523	Renewable Energy Systems	DEC/DHC	4
88.	MIN-524	Two Phase Flow and Heat Transfer	DEC/DHC	4
89.	MIN-525	Solar Energy	DEC/DHC	4
90.	MIN-526	Advanced Gas Dynamics	DEC/DHC	4
91.	MIN-527	Computational Fluid Dynamics and Heat Transfer	DEC/DHC	4
92.	MIN-528	Boundary Layer Theory	DEC/DHC	4
93.	MIN-529	Turbulent Flows	PEC	4
94.	MIN-530	Cold Preservation of Food	DEC/DHC	4

95.	MIN-531	Hydrodynamic Machines	PEC	4
96.	MIN-532	Renewable Energy Systems	RASE	4
97.	MIN-533	Refrigeration & Air-conditioning System Design	DEC/DHC	4
98.	MIN-534	Air-conditioning and Ventilation	DEC/DHC	4
99.	MIN-535	Cryogenic Systems	DEC/DHC	4
100.	MIN-536	Convective Heat & Mass Transfer	RASE	4
101.	MIN-537	I.C. Engines	DEC/ DHC	4
102.	MIN-539	Micro & Nano Scale Thermal Engineering	PEC	4
103.	MIN-540	Combustion	DEC/DHC	4
104.	MIN-541	Bio – fluid Mechanics	PEC	4
105.	MIN-542	Energy Management	DEC/DHC	4
106.	MIN-543	Fluid Power Engineering	DEC	4
107.	MIN-544	Design of Heat Exchangers	DEC/DHC	4
108.	MIN-545	Fuel Cells	DCC/DHC	4
109.	MIN-550	Advanced Machine Design	DEC	4
110.	MIN-551	Dynamics of Mechanical Systems	DEC	4
111.	MIN-553	Industrial Tribology	DEC	4
112.	MIN-554	Computer Aided Mechanism Design	DEC	4
113.	MIN-555	Experimental Stress Analysis	DEC	4
114.	MIN-556	Dynamics of Road Vehicles	DEC	4
115.	MIN-558	Fracture Mechanics	DEC	4
116.	MIN-559	Computer Aided Design	DEC	4
117.	MIN-560	Mechanics of Composite Materials	DEC	4
118.	MIN-561	Advanced Mechanical Vibrations	DEC	4

119.	MIN-562	Noise Control in Mechanical Systems	DEC	4
120.	MIN-563	Mechatronics	DEC	4
121.	MIN-565	Smart Materials, Structures and Devices	DEC	4
122.	MIN-566	Computer Aided Analysis of Mechanical Systems	DEC	4
123.	MIN-567	Computer Graphics	DEC	4
124.	MIN-568	Advanced Robotics	DEC	4
125.	MIN-573	Design for Manufacturability	DEC	4
126.	MIN-574	Maintenance Management	DEC	4
127.	MIN-575	Product Design and Development	DEC	4
128.	MIN-576	Machine Tool Design and Numerical Control	DEC	4
129.	MIN-577	Industrial Automation	DEC	4
130.	MIN-578	Computer Aided Process Planning	DEC	4
131.	MIN-579	Information Systems & Data Management	DEC	4
132.	MIN-580	Welding Science	DEC	4
133.	MIN-581	Manufacturing Resources Management	DEC	4
134.	MIN-582	Flexible Manufacturing Systems	DEC	4
135.	MIN-583	Materials Management	DEC	4
136.	MIN-584	Operations Research	DEC	4
137.	MIN-585	Supply Chain Management	DEC	4
138.	MIN-586	Metal Forming	DEC	4
139.	MIN-587	Metal Casting	DEC	4
140.	MIN-588	Non-Traditional Machining Processes	DEC	4
141.	MIN-593	Non Conventional Welding Processes	DEC	4
142.	MIN-594	Safety Aspect of Welded Structures	DEC	4

143.	MIN-595	Failure Analysis of Welding Joints	DEC	4
144.	MIN-596	Automation and Application of Robotics in Welding	DEC	4
145.	MIN-597	Welding Procedure for Specific Applications	DEC	4
146.	MIN-598	Weldability of Metals	DEC	4
147.	MIN-599	Surface Engineering	DEC	4
148.	MIN-205	Fluid Mechanics	DCC	4

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **Department of Civil Engineering**

1. Subject code: **CEN-102** Course Title: **Solid Mechanics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs): **Theory: 3** **Practical: 0**

4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **ESC**

8. Pre-requisite: **Nil**

9. Objective : To introduce the concepts of equilibrium and deformation in components, and structures for engineering design.

10. Details of Course :

S. No.	Contents	Contact Hours
1.	**Analysis of Stresses and Strains :** Concept of stress, normal stress and shear stress, nine Cartesian components of stress at a point, sign convention and notation, equality of shear stresses on mutually perpendicular planes and their planes of action, stress circle; Concept of strain, normal and shear strain, two dimensional state of strain, Poisson's ratio, volumetric strain, strain circle, Concept of strain energy	**08**
2.	**Stress-Strain Relationships :** Hooke's law and its application to isotropic materials, elastic constants and their relationships, plane stress and plain strain conditions.	**02**
3.	**Mechanical Properties :** Uniaxial tension test to determine yield and ultimate strength of materials, stress-strain diagram, proof stress, ductile and brittle materials, hardness and impact strength; Conditions affecting mechanical behaviour of engineering materials	**02**
4.	**Members in Uniaxial State of Stress :** Uniform cross-section and tapered bars subjected to uniaxial tension and compression, composite bars and statically indeterminate bars, thermal stresses; Introduction to plasticity; S.E. under axial loading.	**04**
5.	**Members Subjected to Axi-Symmetric Loads :** Stresses and strains in thin cylindrical shells and spheres under internal pressure, stresses in thin rotating rings.	**02**
6.	**Members Subjected to Torsional Loads :** Torsion of solid and hollow circular shafts, stepped and composting shafts, close-coiled helical springs subjected to axial loads, S.E. in	**02**

	torsion.	
7.	**Members Subjected to Flexural Loads :** Statically determinate beams, support reactions, relationship between load, shear force and bending moment, shear force and bending moment diagrams; Theory of flexure for initially straight beams, distribution of bending stresses across the beam cross-section, principal stresses in beams; Equation of elastic curve for the loaded beam, relationship between bending moment, slope and deflection; Calculation of deflection by integration, moment area and unit-load methods, S.E. in flexure.	**15**
8.	**Members Subjected to Combined Loads :** Short struts subjected to eccentric loads, shafts subjected to combined bending, torsion and axial thrust, concept of theory of failure.	**02**
9.	**Elastic Stability of Columns :** Euler's theory of initially straight columns, critical loads for different end condition of columns, eccentric loading, columns with small initial curvature, empirical formulae.	**02**
10.	**Stresses in Beams (Advance Topics) :** Composite beams, Transformed section method, Bending of unsymmetric beams, The shear-center concept.	**03**
	TOTAL	**42**

11. Suggested Books :

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Gere, J.M. and Goodno, B.J., "Strength of Materials", Indian Edition (4th reprint), Cengage Learning India Private Ltd.	2009
2.	Beer, F.P., Johuston, Jr., E.R., Dewolf, J.T. and Mazureu, D.E., "Mechanics of Materials", Fifth Edition, McGraw Hill.	2009
3.	Hibbeler, R.C., "Mechanics of Materials", Sixth Edition, Pearson.	2005
4.	Crandall, S.H., Dahl, N.C. and Lardner, T.J., "An Introduction to the Mechanics of Solids", 2nd Edition, McGraw Hill.	1999
5.	Timoshenko, S.P. and Young, D.H., "Elements of Strength of Materials", Fifth Edition, (In MKS Units), East-West Press Pvt. Ltd.	2009 (reprint)

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Electrical Engineering**

1. Subject Code: **EEN-112** Course Title: **Electrical Science**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 15** **PRS: 15** **MTE: 30** **ETE: 40** **PRE: 0**

5. Credits**: 4** 6. Semester**: Both** 7. Subject Area**: ESC**

8. Pre-requisite**: NIL**

9. Objective: To introduce the students to the fundamentals of Electrical Engineering concepts of network analysis, principles of electrical machines, basics of electrical measurement and measuring instruments.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Energy Resources and Utilization:** Conventional and non-conventional energy resources; Introduction to electrical energy generation from different resources, transmission, distribution and utilization.	5
2.	**Network Fundamentals**: Types of Sources and elements, Kirchoff's Laws, Mesh and Node Analysis of D.C. Networks, Network Theorems: Thevenin's Theorem, Norton's Theorem, Superposition Theorem, Maximum Power Theorem, Star-Delta Transformation.	5
3.	**A.C. Fundamentals**: Concept of phasor, impedance and admittance; Mesh and Node analysis of AC networks; Network theorems in AC networks; Active and reactive power in AC circuits; Resonance in series AC circuits; Power factor correction.	4
4.	**Three-phase A.C. Circuits**: Analysis of 3-phase balanced start-delta circuits, Power in 3-phase Circuits.	2
5.	**Measurement of Electrical Quantities**: Measurement of Voltage, Current, and Power; Measurement of 3 phase power; Energy meters.	5
6.	**Single Phase Transformer**: Introduction to magnetic circuit concepts, Basic constructional features, operating principle, phasor diagram, equivalent circuit, voltage regulation; Eddy current and Hysteresis losses, efficiency; Open circuit and Short Circuit tests.	5

7.	**D.C. Machines**: Principle of operation, constructional features; Emf and torque equations; Types of excitation; Generator characteristics; Starting and speed control of D.C. motors.	**5**
8.	**AC Machines**: Three-phase Induction Motor - Operating principle, constructional features, torque-speed characteristics, starting and speed control; Single-phase Induction Motor - Operating principle, constructional features, torque-speed characteristics, starting methods.	**5**
9.	**Industrial Applications and Control:** Various industrial loads, traction, heating, lighting; Concept of power electronic control of AC and DC motors.	**6**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Mukhopadhyaya P., Pant A.K., Kumar V. and Chittore D.S., “Elements of Electrical Science”, M/s Nem Chand & Brothers.	1997
2.	Vincent Del Toro, “Electrical Engineering Fundamentals”, Prentice Hall of India.	2002
3.	Dubey G. K., “Fundamentals of Electric Drives”, 2^{nd} Ed., Narosa Publishing House.	2007
4.	Alexander C.K., Sadiku M.N.O., “Fundamentals of Electric Circuits”, McGraw Hill, 5^{th} Edition.	2012
5.	Chapman, Stephen, J., “Electric Machinery Fundamentals”, McGraw Hill Book Company.	1985
6.	Hughes Edward, “Electrical & Electronic Technology”, Pearson Publishing, 8^{th} edition.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mathematics**

1. Subject Code: **MAN-004** Course Title: **Numerical Methods**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weightage**:** **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: BSC**
8. Pre-requisite**: Nil**
9. Objective: To introduce various numerical methods to get approximation solutions.
10. Details of Course:

S.No.	**Contents**	**Contact Hours**
1	**Error Analysis**: Exact and approximate numbers, Rounding of numbers, Significant digits, Correct digits, various types of errors encountered in computations, Propagation of errors.	**3**
2	**Solution of system of linear equations**: (i) Direct methods: Gauss elimination method without pivoting and with pivoting, LU-decomposition method. (ii) Iterative methods: Jacobi and Gauss-Seidel methods.	**8**
3	**Roots of non-linear equations**: Bisection method, Regula-Falsi method, Newton-Raphson method, direct iterative method with convergence criteria, Newton-Raphson method for solution of a pair of non-linear equations.	**6**
4	**Eigen values and Eigen vectors**: Dominant and smallest Eigen values/Eigen vectors by power method.	**3**
5	**Interpolation**: Finite difference operator and their relationships, difference tables, Newton, Bessel and Stirling's interpolation formulae, Divided differences, Lagrange interpolation and Newton's divided difference interpolation.	**6**
6	**Numerical differentiation**: First and second order derivatives by various interpolation formulae.	**4**
7.	**Numerical integration:** Trapezoidal, Simpsons 1/3rd and 3/8th rules with errors and their combinations, Gauss Legendre 2-points and 3-points formulae	**6**
8.	**Solution of first and second order ordinary differential equations:** Picard's method, Taylor's series method, Euler, Modified Euler, Runge-Kutta methods and Milne's method.	**4**
9.	Case studies	**2**
	Total	**42**

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1	Gerald, C. F. and Wheatly, P. O.," Applied Numerical Analysis", 6th Edition, Wesley.	2002
2	Jain, M. K., Iyengar, S. R. K. and Jain, R. K., "Numerical Methods for Scientific and Engineering Computation", New Age Pvt. Pub, New Delhi.	2000
3	Conte, S. D. and DeBoor, C., "Elementary Numerical Analysis", McGraw-Hill Publisher	1982
4	Krishnamurthy, E. V. & Sen, S. K., "Applied Numerical Analysis", East West Publication.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical & Industrial Engineering**

1. Subject Code: **MI-101A** Course Title: **Introduction to Mechanical Engineering**

2. Contact Hours: **L: 2** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** **2** **Practical** **0**

4. Relative Weightage**: CWS** **15** **PRS** **00** **MTE** **35** **ETE** **50** **PRE** **0**

5. Credits**:** **2** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce the field of mechanical engineering and its applications in analysis, design, and manufacture of mechanical products and systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Overview of Mechanical Engineering:** Role of mechanical engineers, tools in ME, skills and abilities, ethics in engineering, intellectual property.	2
2.	History of machines and mechanisms.	2
3.	**Design as a creative problem-solving process:** phases of design, design philosophy, design for success, materials in design.	4
4.	**Electromechanical systems:** Fundamentals of electromechanical systems, the need for control systems.	2
5.	**Energy Conversion:** History of energy conversion, overview of thermodynamics, mechanical energy, work and power, energy conservation and conversion, heat engines and efficiency, sustainable energy; Case Study 1: Internal-Combustion Engines; Case Study 2: Electrical Power Generation; Automobile Engineering.	5
6.	**Overview of Fluid Mechanics:** Properties of fluids, pressure and buoyancy, laminar and turbulent flows, fluid flow in pipes, drag and lift.	3
7.	**Introduction to Manufacturing Processes:** Casting, machining, welding.	8
8.	Recent trends in mechanical engineering.	2
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication/ Reprint
1.	Wickert, J. and Lewis, K., "An Introduction to Mechanical Engineering", 3rd Edition, Cengage Learning	**2012**
2.	Kalpakjian, S., Schmid, S. R., "Manufacturing Engineering and Technology", 7th Edition, Pearson Education	**2013**
3.	Groover, M. P., "Automation, Production Systems, and Computer Integrated Manufacturing", 3rd Edition, Pearson Education	**2008**
4.	Bolton, W., "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering", 5th Edition, Pearson Education	**2010**
5.	Bautista Paz, E., Ceccarelli, M., Echávarri Otero, J., Muñoz Sanz, J.L., "A Brief Illustrated History of Machines and Mechanisms", Springer	**2010**
6.	Shigley, J., Mischke, C., Budynas, R. and Nisbett, K., "Shigley's Mechanical Engineering Design", 8th Edition, Tata McGraw Hill.	**2008**
7.	Cengel, Y., "Introduction to Thermodynamics and Heat Transfer", 2nd Edition, McGraw Hill	**2007**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-103** Course Title: **Programming and Data Structures**
2. Contact Hours: **L: 3** **T: 0** **P: 2**
3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0
4. Relative Weightage: **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0
5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **ESC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the concepts of procedural and object oriented programming in C++ and its application to problem solving.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Programming:** Introduction to computer systems; Data representation; Basic idea of program execution at micro level; Concept of flow chart and algorithms, algorithms to programs.	4
2.	**Basic Programming in C++:** Constants, variables, expressions and operations; Naming conventions and styles; Conditions and selection statements; Looping and control structures; File I/O; Header files, string processing; Pre-processor directives such as #include, #define, #ifdef, #ifndef; Compiling and linking.	8
3.	**Programming Through Functional Decomposition:** Functions (void and value returning); Parameters passing by value, passing by reference, passing by constant reference; Design of functions and their interfaces (concept of functional decomposition), recursive functions, function overloading and default arguments; Library functions; Scope and lifetime of variables.	10
4.	**Data Structures:** Fixed size data structures --- arrays and structures; Pointers and dynamic data, relationship between pointers and arrays, function pointers, dynamic arrays; Introduction to dynamic data structures --- linked lists, stacks, queues and binary trees.	8
5.	**Object Oriented Programming:** Data hiding, abstract data types, classes, access control; Class implementation – default constructor, constructors, copy constructor, destructor, operator overloading, friend function; Object oriented design, inheritance and composition; Dynamic binding and virtual functions; Polymorphism.	12
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	Dietel, H.M. and Dietel, P.J., "C++ How to Program", 8th Edition, Prentice Hall	**2012**
2.	Spephan Prata, "C++ Primer Plus", 6th Edition, Pearson Education	**2012**
3.	Venugopal, K. R., Rajkumar, B. and Ravishankar, T., "Mastering C++", Tata-McGraw Hill	**1997**
4.	Prinz, U.K. and Printz, P., "A Complete Guide to Programming in C++", Jones and Bartlett Learning	**2002**

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPARTMENT: **Department of Mechanical & Industrial Engineering**

1. Subject Code: **MIN-104** Course Title: **Manufacturing Technology – I**
2. Contact Hours : **L: 2** **T: 0** **P: 4**
3. Examination Duration (Hrs.) : **Theory: 3** **Practical: 0**
4. Relative Weightage : **CWS: 0** **PRS: 25** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits: **4** 6. Semester : **Both** 7. Subject Area: **Department Core (DCC)**
8. Pre – requisite: **Nil**
9. Objectives of Course: To familiarize students with the principles of sheet metal forming, material removal and finishing operations.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Introduction :** Classification of different manufacturing processes, application areas and limitations, selection of a manufacturing process	**2**
2	**Sheet Metal Forming:** Introduction to sheet metal forming operations, Types of presses, drives, Operations: shearing bending, spinning, embossing, blanking, coining and deep drawing. Die materials, compound and progressive dies and punches. Construction details of die set. Auxiliary equipments, safety devices.	**10**
3	**Material Removal Processes:** Classification of machining processes and machine tools. Tool's materials, different types of cutting tools, Nomenclature of single point and multi point cutting tool. Concept of cutting speed, feed and depth of cut. Coolants. Drilling, Boring and broaching machines. Indexing head, milling operations using simple, differential and compound indexing. Introduction to CNC Machines.	**10**
4	**Abrasive Finishing:** Operations and applications of surface, cylindrical and centreless grinding processes; dressing, truing and balancing of grinding wheels; grading and selection of grinding wheels.	**6**
	Total	**28**

List of Experiments:

S. No.	Name of Experiment/Study
1.	Study of turret lathe
2.	Study of grinding machines, attachments and accessories
3.	External threading on a given job on lathe machine
4.	Internal threading on a given job on lathe machine
5.	Taper turning on a given job on lathe machine
6.	V-groove cutting on a gven job on lathe machine
7.	Profile turning on a given job on lathe machine
8.	Cutting teeth on a spur gear on milling machine
9.	Helical milling on a given circular job
10.	Slot cutting on a given job on milling machine
11.	Shaping operation on cast iron job
12.	Keyway cutting on a given job on slotting machine

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	DeGarmo, E. P, Black, J. T., Kohser, R. A. " Materials and Processes in Manufacturing", Prentice Hall of India Pvt. Limited	1997
2.	Kalpakjian, S. and Schmid, S. R, "Manufacturing Engineering and Technology", Pearson Education	2000
3.	Groover, M. P., "Fundamentals of Modern Manufacturing", John Wiley and Sons Inc.	2002
4.	Lindberg, R. A., "Processes and Materials of Manufacture", Prentice Hall India Limited	1990
5.	Rao, P. N., "Manufacturing Technology (Vol. 1&2)", Tata McGraw Hill	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical & Industrial Engineering**

1. Subject Code: **MIN-106** Course Title: **Engineering Thermodynamics**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20** **PRS: 20** **MTE: 20** **ETE: 40** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **DCC/ESC**

8. Pre-requisite: **Nil**

9. Objective: To familiarize the students with basic concepts of macroscopic thermodynamics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Introduction to thermodynamic system, surrounding, state, process, properties, equilibrium, heat and work, Zeroth Law of Thermodynamics	**3**
2.	**Properties of Pure Simple Compressible Substance:** PvT surface, Pv, T v, T P diagrams. Equation of state for ideal and real gases. Virial equation of state, van der Waal equation, use of steam tables and Mollier diagram	**6**
3.	**First Law of Thermodynamics:** First law application to non-flow processes such as isochoric, isobaric, isothermal, adiabatic and polytropic processes. Steady flow energy equation, flow work. Application to various practical systems viz. nozzles, diffuser, turbines, heat exchangers etc. Application of energy equation to transient flow problems.	**7**
4.	**Second Law of Thermodynamics:** Second law, reversible and irreversible processes, Clausius and Kelvin Planck statements, Carnot cycle, corollaries of second law: thermodynamic temperature scale, Clausius inequality, entropy as a property, principle of	**6**

	increase of entropy. Calculation of entropy change.	
5.	**Entropy and Exergy:** Entropy and its generation, entropy balance for closed system and for control volume, basic concepts of exergy and irreversibility, exergy for closed system and control volume, exegetic efficiency.	**5**
6.	**Gas-Vapour Mixtures and Air-conditioning:** Properties of gas-vapour mixtures, adiabatic-saturation and wet-bulb temperatures, psychrometric chart, human comfort and air conditioning, various air conditioning processes.	**4**
7.	**Gas and Vapour Power Cycles:** Otto, Diesel, Dual, Stirling, Joule-Brayton cycle. Thermal efficiency and mean effective pressure, Rankine cycle.	**5**
8.	**Refrigeration Cycles:** reverse Carnot cycle, vapour compression refrigeration cycle.	**4**
	TOTAL	**42**

List of Experiments:

1. Study of P-V-T surface of H_2O and CO_2.
2. Determine P-T relationship for steam and verify Clausius Clapeyron equation.
3. Determine the calorific value of coal using Bomb calorimeter.
4. Analysing exhaust gases using Orsat apparatus.
5. Determine Relative Humidity and Specific Humidity of air using Sling Psychrometer and Psychrometric Chart.
6. Determine COP of a vapour compression refrigeration unit.
7. Analysing different processes on an air conditioning unit.

11. Suggested Books:

S. No.	**Name of Books / Authors**	**Year of Publication**
1.	Borgnakke, C. and Sonntag, R.E., "Fundamentals of Thermodynamics," Wiley India	2011
2.	Cengel, Y.A. and Boles, M.A., "Thermodynamics an Engineering Approach", Tata McGraw-Hill	2008
3.	Moran, M.J. and Shapiro, H.M., "Fundamentals of Engineering Thermodynamics", 4^{th} Ed., John Wiley	2010
4.	Russel, L.D., Adebiyi, G. A.,"Engineering Thermodynamics", Oxford University Press	2007
5.	Arora, C.P., "Thermodynamics", Tata-McGraw Hill	2001
6.	Nag, P.K., "Engineering Thermodynamics", Tata-McGraw Hill	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-108** Course Title: **Mechanical Engineering Drawing**

2. Contact Hours: L**: 2** T: **0** P**: 4**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage: **CWS: 0** **PRS: 25** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits: **4** 6. Semester: **Both** 7. Subject Area: **DCC/ESC**

8. Pre-requisite: **Nil**

9. Objective: The course objective is to teach the basic concepts of Mechanical Engineering Drawing to the students. The emphasis is on to improve their power of imagination.

10. Details of Course:

S. No.	Contents	Contact Hours
1	General Instructions : Sheet Layout, Line Symbols and Groups, Preferred Scales, Technical Sketching	**1**
2	Types of projections: Reference Planes and Quadrants, Orthographic Projection	**2**
3	Projection of point and lines	**3**
4	Projection of plane figures	**2**
5	Projection of solids	**2**
6	Section of solid and development	**2**
7	Shape Description(External): Multiplanar Representation, Systems of Projection, Sketching of Orthographic Views from Pictorial Views, Conventional Practices, Precedence of Views , Precedence of Lines	**2**
8	Uniplaner Representation: Sketching of Pictorial Views (Isometric and Oblique) from Multiplaner Orthographic Views	**2**
9	Shape Description (Internal): Sectioning as an Aid to Understanding internal features, Principles of Sectioning, Types of Sections, Section Lines, Cutting Plane Lines and Conventional Practices	**3**
10	Size Description: Dimensioning, Tools of Dimensioning, Size and Position Dimensions, Unidirectional and Aligned Systems, Principle and Practices of Dimensioning,	**4**
11	Conventional Representation: Representation and	**1**

	Identification of Common Machine Elements and Features	
12	Introduction to Solid Modeling	**4**
	Total	**28**

Practical Exercises:

Topics	**Practice Classes of Two Hour Duration**
Projection of points and lines	04
Projection of plane figures	02
Projection of solids	03
Section and development	02
Sketching of Orthographic Views from Pictorial Views	04
Sketching of Pictorial Views (Isometric and Oblique) from Multiplanar Orthographic Views, Missing Lines Exercise, Missing Views Exercise	04
Sectioning Exercise	02
Dimensioning exercise	02
Identification Exercise	01
Solid Modeling, orthographic views from solid models	04

11. Suggested Books:

S.No.	**Name of Authors / Books / Publishers**	**Year of Publication/ Reprint**
1.	Technical Drawing, Giesecke, Mitchell, Spencer, Hill, Dygdon and Novak, Macmillan Publishing Company	2003
2.	Engineering Graphics, A. M. Chandra and Satish Chandra, Narosa Publishing House, New Delhi	2003
3.	Engineering Drawing and Graphics Technology, T.E. French, C.J. Vierck and R.J. Foster, McGraw-Hill Inc	1993
4.	Fundamentals of Engineering Drawing, W.J. Luzadder, J. Warren and J.M. Duff, Prentice Hall International Editions	1989
5.	SP 46: 1988 Engineering Drawing Practice for Schools and Colleges, Bureau of Indian standards	-------

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPARTMENT: **Mechanical & Industrial Engineering**

1. **Subject Code: MIN-203 Course Title: MANUFACTURING TECHNOLOGY – II**
2. **Contact Hours : L: 2 T: 0 P: 4**
3. **Examination Duration (Hrs.) : Theory: 3 Practical: 0**
4. **Relative Weight :CWS: 0 PRS: 25 MTE: 25 ETE: 50 PRE: 0**
5. **Credits: 4** **6. Semester : Autumn**
7. **Pre – requisite: Nil**
8. **Subject Area: Departmental Core (DCC)**
9. **Objectives o f C ourse:** Aim of thi s s ubject is de velop in-depth unde rstanding on manufacturing processes n amely casting, w elding a nd f orming and i ntroduce none-destructive examination methods.

10. **Details of Course:**

S. No.	Particulars	Contact Hours
1	**Foundry :** Sand ca sting proc ess- Steps; Core; S and Testing; Molding Processes, Gating system, Solidification Phenomena, Melting Furnaces, Special casting m ethods - Centrifugal cast ing; P ermanent m old casting; H ot cha mber and cold chamber d ie casting; Investment c asting; Shell m old casting; Plaster mold casting; CO_2 mold casting.Casting design considerations, Casting defects and remedies.	**10**
2	**Welding:** Classification of welding processes, electric arc, ISI classification of coated electrodes, spe cial w elding methods: M MAW, G TAW, G MAW, GMAW-CO_2 welding, submerged arc w elding, electro-slag w elding, electron beam w elding, l aser b eam w elding, ul trasonic w elding, r esistance w elding, welding defects, and arc blow.	**12**
3	None-destructive examination: Principle and application of common Non-Destructive Examination Methods DPT,MPT and UT of Castings and Weldments	**2**
4.	**Forming** : Forging, Rolling, Extrusion, Wire Drawing and Tube drawing, Forging Defects and Remedies.	**4**
	Total	**28**

11. **Suggested Books:**

S.No	Name of Book / Authors / Publisher	Year of Publicati on

1	DeGarmoE.Paul, Black J.T., Ronald A. Kohser,Materials and Processes in Manufacturing;; Prentice Hall of India Pvt. Limited-Delhi	1997
2	Kalpakjian S., Schmid S.R. Manufacturing Engineering and Technology;; Pearson Education, Delhi	2000
3	GrooverMikell P.,Fundamentals of Modern Manufacturing;; John Wiley and Sons Inc.	2002
4	Lindberg R.A. Processes and Materials of Manufacture; Prentice Hall India Limited;	1990
5	Rao P.N. Manufacturing Technology; Tata McGraw Hill	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-205** Course Title: **Fluid Mechanics**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 20** **PRS: 20** **MTE: 20** **ETE: 40** **PRE: 0**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: To provide the basic knowledge of fluid statics and dynamics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Continuum concept, properties of fluids, Newtonian and Non-Newtonian fluids.	3
2.	**Fluid Statics:** Pascal's law, hydrostatic pressure, pressure measurement, manometer and micro-manometer, pressure gauge; Forces on plane and curved surfaces, centre of pressure, equilibrium of submerged and floating bodies, buoyancy, metacentric height; Fluids subjected to constant linear acceleration and to constant rotation.	5
3.	**Kinematics of Fluid:** Types of flow, Lagrangian and Eulerian approach, path line, streak line and stream line, stream tube, stream function and potential function, flownet; Deformation of fluid elements, vorticity and circulation.	4
4.	**Fluid Dynamics:** Reynolds transport theorem; Conservation equations of mass, momentum and energy, Navier-Stokes, Euler and Bernoulli equations; Forces due to fluid flow over flat plates, curved vanes and in the bends, applications of Bernoulli equation.	8
5.	**Ideal Fluid Flow:** Ideal flow identities, flow over half body, Rankine oval, stationary and rotating cylinders, Magnus effect, d'Alembert's paradox.	5
6.	**Viscous Flow:** Reynolds experiment, laminar and turbulent flow, plane Poiseuille flow, Couette flow, Hagen-Poiseuille flow; Friction factor and Moody's diagram, losses in pipes and pipe fittings; Flow over aerofoil, lift and drag, flow separation.	6
7.	**Dimensional Analysis:** Basic and derived quantities, similitude and dimensional analysis, Buckingham π – theorem, non-dimensional parameters, model testing.	4

8.	**Flow Measurement:** Flow measuring devices, Pitot tube, obstruction flow meters, principles of hot anemometry and particle image velocimetry.	**3**
9.	**Compressible Flow:** Propagation of sound waves, Mach number, isentropic flow and stagnation properties, one dimensional convergent-divergent nozzle flow, normal shock.	**4**
	Total	**42**

LIST OF EXPERIMENTS

S. No.	Name of Experiment
1.	Experimental verification of Bernoulli's theorem
2.	Impact of jet of a fluid on vanes
3.	Calibration and determination of coefficient of discharge for (1)Venturimter and (2) Orificemeter
4.	Calibrate V and rectangular notch (or weir) and compare their performances
5.	Flow visualization/patterns
6.	Flow field investigation by using educational PIV setup

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Munson, B.R., Young, D.F., Okiishi, T.H., and Rothmayer, A.P., "Fundamentals of Fluid Mechanics", 7th Ed., John Wiley & Sons	**2012**
2.	Som, S.K., Biswas, G. and Chakraborty, S., "Introduction to Fluid Mechanics and Fluid Machines", 3rd Ed., Tata McGraw Hill	**2012**
3.	Massey, B.S. and Ward-Smith, J., "Fluid Mechanics", 9th Ed., CRC Press	**2011**
4.	White, F.M., "Fluid Mechanics", 7th Ed., McGraw-Hill	**2010**
5.	Yuan, S.W., "Foundation of Fluid Mechanics", 2nd Ed., Prentice-Hall	**1988**
6.	Streeter, V.L., Wylie, E.B., and Bedford, K.W., "Fluid Mechanics", 9th Ed., McGraw-Hill	**1998**

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPARTMENT: **Department of Mechanical & Industrial Engineering**

1. Subject Code: **MIN-208** Course Title: **Theory of Production Processes**

2. Contact Hours : L: **3** T: **1** P: **2/2**

3. Examination Duration (Hrs.) : Theory: **3** Practical: **0**

4. Relative Weight :CWS: 20 PRS: **20** MTE: **20** ETE: **40** PRE: **0**

5. Credits: **4** 6. Semester : Spring **7.**Pre –requisite: NIL

8.Subject Area: **DCC**

9.Objectives of Course: This course is intended to impart fundamentals of the theory of various manufacturing processes used in industry and fundamentals of tooling design and metrology.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Theory of Metal Cutting:** Tool geometry, chip formation, chip control, mechanics of single point orthogonal machining, tool life, economics of metal cutting.	**08**
2	**Non-Conventional Machining Methods:** Comparison with conventional methods, principles and applications of ECM, EDM, ultrasonic, electron beam and laser machining.	**05**
3	**Jigs and Fixtures:** Usefulness of Jigs and Fixtures**,** Design principles of jigs and fixtures, Principles of location and clamping,Types locating and clamping devices, Few simple design of Jigs and Fixtures : lathe, milling, boring, shaping, broaching, grinding, assembly and welding fixtures, Economics of Jigs and Fixtures.	**06**
4	**Metrology:** Introduction, inspection types and principles, radius and taper measurement, measurement of screw threads and gears. Limits, fits, and dimensional and geometrical or form tolerances, computer vision system based measurement, coordinate measuring machines, measurement of form tolerances, measurement of surface roughness: surface roughness terminology, different methods of surface roughness measurement.	**06**
5	**Foundry:** Gating system design, Risering design, production of gray, malleable and spheroidal graphite iron castings.	**06**
6	**Welding:** Weldability, structure in weld and heat affected zones, distortion and residual stresses, welding of cast iron, stainless steel and aluminum, hard facing.	**05**

7	**Forming**: Introduction of forming process analysis methods (slab method, uniform deformation energy method, limit analysis), Analysis of extrusion, rolling and forging processes, forming defects, formability & workability, temperature & lubrication aspects in forming.	**06**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication
1	Ghosh, A., and Mallik, A.K., "Manufacturing Science" Affiliated East-West press Pvt. Ltd.	1985
2	Lal, G.K., "Introduction to Machining Science" New Age International Publishers	1996
3	Gupta, I.C., "Text Book of Engineering Metrology" DhanpatRai Publishing Co.	2003
4	Heine, R.W., Loper, C.R., and Rosenthal, P.C., "Principles of Metal Casting", 21st reprint, Tata McGraw-Hill	1997
5	Kuo, S., "Welding Metallurgy", John-Wiley & Sons Inc.	2003
6	Dieter, G.E., "Mechanical Metallurgy", McGraw Hill Book Company	1988

Laboratory Work Outline:

Experimental studies on the cutting tool angle measurement, cutting tool grinding, use of dynamometers, mechanical measurements etc.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical and Industrial Engineering Department**

1. Subject Code: **MIN-209** Course Title: **Thermal Engineering**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 20** **PRS: 20** **MTE: 20** **ETE: 40** **PRE: 0**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: The course is designed to familiarize the students with fundamentals of thermodynamics and heat transfer.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Introduction to Thermodynamics, examples of thermal power plants, refrigeration systems; Definitions: system, boundary, surroundings, closed and open systems, properties, processes, work and heat interactions.	**2**
2.	**Laws of thermodynamics:** Zeroth law, concept of temperature, temperature scales, methods of temperature measurement; First law for cyclic process in closed system, internal energy; First law for open system, steady flow energy equation (SFEE), application of SFEE for simple devices.	**8**
3.	**Properties of pure substance:** Properties of pure substance, *T-v, p-v* diagrams, properties of steam, use of steam tables, example problems for use of steam tables.	**6**
4.	**Second law of thermodynamics:** Kelvin-Planck and Clausius statements of second law of thermodynamics, Carnot theorem, corollaries of Carnot theorem for absolute temperature scale, entropy.	**6**
5.	**Power Cycles:** Rankine vapor power cycles on T-s diagrams, gas power cycles, Otto, Diesel and Joule cycles, simple problems.	**6**
6.	**Refrigeration & Air-conditioning:** Working of simple vapor compression cycle, representation of various processes on p-h diagram, air-conditioning principles, definitions of humidity, relative humidity, wet-bulb and dry-bulb temperatures. Psychrometric chart, representation of various air-conditioning processes on	**6**

	psychrometric chart.	
7.	**Heat Transfer:** Introduction to different modes of heat transfer, conduction, convection and radiation. **Conduction:** Fourier's law of heat conduction, 1D heat conduction equation, different types of boundary conductions, thermal resistance, composite wall for plane wall and cylindrical geometries. **Convection:** Free and forced convection principles, important non-dimensional numbers, correlations for Nusselt number. **Radiation:** Basic laws of radiation, black body concept, emissivity, absorptivity, reflectivity, transmissivity.	**8**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	Cengel, Y. A. and Boles, M. A., "Thermodynamics: An Engineering Approach", 7th Ed., Tata McGraw-Hill	2011
2.	Van Wylen G.J. and Sonntag, R.E., "Fundamentals of Classical Thermodynamics", 4th Edn., John Wiley & Sons	2002
3.	Rogers, G. and Mayhew, Y., "Engineering Thermodynamics and Heat Transfer", 4th Ed., Addison-Wesley	2002
4.	Cengel, Y. A. and Ghajar, A. J., "Heat and Mass Transfer", 4th Edn., Tata McGraw Hill Education Pvt. Ltd., New Dehi	2011
5.	Incropera, F .P., Dewitt, D .P., Bergman, T . L. and A . S . Lavine, "Principles of Heat and Mass Transfer", 7th Ed. (International Student Version), John Wiley & Sons	2012

12. List of experiments:

I – Applied Thermodynamics
- (i) Flash point and fire point of and lubricants and diesel
- (ii) Calorific value of coal using Bomb Calorimeter
- (iii) Performance test on single cylinder diesel engine

II – Heat Transfer
- (i) Thermal conductivity of metal rod
- (ii) Natural convection over a heated vertical wall
- (iii) Forced convection over a heated cylinder
- (iv) COP of vapor compression refrigeration system

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical & Industrial Engineering**

1. Subject Code: **MIN-210** Course Title: **Energy Conversion**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **20** **PRS** **20** **MTE** **20** **ETE** **40** **PRE** **0**

5. Credits**:** **4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**:** **Nil**

9. Objective: The objective of the course is to make the students aware of various energy conversion systems, and the underlying principles on which they operate.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Vapor Power Systems:** Brief description of vapor power system, Rankine cycle, deviation of actual cycle from ideal cycle, principal irreversibilities and losses, superheat and reheat, the regenerative vapor power cycle, binary vapor cycles and cogeneration.	07
2	**Boilers:** Classification, fire tube boilers: Lankashire, Cornish, Cochran, Locomotive; water tube boilers: Stirling, Babcox & Wilcox, package type; boiler mountings and accessories, equivalent evaporation, boiler efficiency, high pressure boilers: La Mont, Benson, Loeffler and Velox; draught and chimney, performance of boiler, combustion of fuel, boiler trial.	05
3	**Nozzles and Diffusers**: Type of nozzles and diffusers, equation of continuity, sonic velocity and Mach number, momentum equation entropy change, nozzle and diffuser efficiency, mass of discharge, choked flow and shape of nozzle, critical pressure ratio, effect of friction, supersaturated flow.	05
4	**Steam Turbines:** Types and application, impulse turbines compounding, velocity diagrams, work output, losses and efficiency. Reaction Turbine, velocity diagrams, degree of reaction, work output asses and efficiency, constructional features and losses in steam turbine.	07

5	**Condensers:** Elements of a condenser unit, type of condensers, Vacuum and condenser efficiencies, cooling towers.	**03**
6.	**Gas Turbines:** Gas turbine cycles, intercooling, reheat and regeneration, deviation of actual cycles from ideal cycles, combined cycle power plants, velocity diagram, jet propulsion.	**06**
7.	**Internal Combustion Engines:**	
a.	Classifications, working of two stroke & four stroke engines, thermodynamics of fuel-air cycles, real cycles, various losses in actual engines.	**03**
b.	Combustion processes in SI engine and its various stages, spark ignition, normal and abnormal combustion, knock preignition, combustion stages in CI engines, ignition delay, types of combustion systems. Fuels for SI and CI engines, their characteristics.	**03**
c.	Emissions from SI and CI engines, supercharging and turbocharging, cooling and lubrication, testing and performance of engines, modern developments in IC engines.	**03**
	Total	**42**

11. Suggested Books:

S. No.	Author(s) / Title / Publisher	Year of Publication/ Reprint
1	Moran MJ & Shapiro HM. Fundamentals of Engineering Thermodynamics, John Wiley, (4^{th} Edn.)	**2000**
2	Wark K.Jr. & Donald E.R, Thermodynamics,.McGraw Hill, (6^{th} Edn.)	**1999**
3	El-Wakil M.M., Power Plant Technology, McGraw Hill	**1988**
4	Roger Gordon & Yon Mayhew, Engineering Thermodynamics work and heat Transfer, Addison-Wesley, (4^{th} Edn.)	**2001**
5	Cengel Y.A. & Boles M.A, Thermodynamics an Engineering Approach, Tata McGraw-Hill, (3^{rd} Edn.)	**2002**

12. List of Experiments

1. Two stroke variable engine study and trial
2. Determination of the constant speed characteristics of the Indec Diesel Engine
3. To draw the valve timing diagram of the Black Stone Diesel engine and study.
4. Determination of the heating value of fuels using bomb calorimeter.
5. Flash point and fire point of and lubricants and diesel
6. Calorific value of coal using Bomb Calorimeter

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-214** Course Title: **Engineering Economy**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: To expose the students to in various methods of computation, cost analysis and replacement studies, which are the essential tools for an Industrial engineer.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Nature and purpose of engineering economy studies, functions of engineering economy, physical and economic laws, consumer and producer goods.	**3**
2.	**Interest and Depreciation:** Productivity of capital, nominal and effective interest, interest factors, CAF, PWF, SPWF, SCAF, SFF, and CRF, deferred annuities, perpetuities and capitalized cost, equivalence, gradient factors GPWF and GUSF, Classification of depreciation, methods of computing depreciation, economic life and mortality data, capital recovery and return.	**11**
3.	**Industrial Costing and Cost analysis:** Classification of costs: direct material, direct labour and overheads, fixed and variable cost, semi-fixed cost, increment, differential and marginal cost, sunk cost and its reasons, direct and indirect cost, prime cost, factory cost, production cost and total cost. Break-even analysis, two and three alternatives, graphical solution, break-even charts, effects of changes in fixed and variable cost, minimum cost analysis, economic order quantity, effect of risk and uncertainty on lot size.	**7**
4.	**Replacement Studies:** Reason of replacement, evaluation of proposals, replacement because of inadequacy, excessive maintenance, declining efficiency, obsolescence; MAPI formula.	**7**
5.	**Cost Estimation and Risk analysis:** Difference between cost estimation and cost accounting, qualifications of an estimator, estimating procedure, estimate of material cost and labour cost,	**10**

	Estimation of cost in machining, forging, welding and foundry operations. Introduction to risk analysis, measures of risk, techniques of risk analysis; RAD and CE approach.	
6.	**Economy Study Patterns:** Basic economy study patterns and their comparison, effect of taxation on economic studies.	**4**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Ardalan, A., "Economic and Financial Analysis for Engineering and Project Management", CRC Press	1999
2.	Grant, E.L., Grant, W., and Leavenworth, R.S., "Principles of Engineering Economy", 8^{th} Ed., John Wiley & Sons Inc	2001
3.	Eschenbach, T.G., "Engineering Economy by Applying Theory to Practice (Engineering Technology)", 2^{nd} Ed., Oxford University Press, USA	2003
4.	Blank, L.T., and Tarquin, A.J., "Engineering Economy", McGraw-Hill Inc.	2005
5.	Hartman, J.C., "Engineering Economy and the Decision-Making Process", Prentice Hall Inc.	2006
6	Theusen Gerald J., Fabrycky W.J., Engineering Economy, PHI	2008

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPARTMENT: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-216** Course Title**: Theory of Production Processes – I**

2. Contact Hours : **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.) :**Theory: 3** **Practical: 0**

4. Relative Weight :**CWS: 20** **PRS: 20** **MTE: 20** **ETE: 40** **PRE: 0**

5. Credits: **4** 6. Semester : **Spring**

7. Pre –requisite: **NIL** 8. Subject Area: **DCC**

9. **Objectives of Course:** This course is intended to impart fundamentals of the theory of machining, advanced machining, finishing processes besides tooling design and metrology.

10. **Details of Course:**

S. No.	Contents	Contact Hours
1.	**Theory of Machining: S**ingle point and multi-point machining, chip formation: mechanism, chip types, chip control, tool geometry: single point, specifications in different systems, selection of tool angles, orthogonal and oblique machining, cutting tool geometry, mechanics of single point orthogonal machining: Merchant's circle, force, velocity, shear angle, and power consumption relations, cutting tool wear and tool life: wear mechanisms, wear criterion, Taylor's tool life equation, facing test, variables affecting tool life; Machinability and its measures, economics of machining.	11
2.	**Advanced Manufacturing Processes:** Process principle, equipment, analysis and applications of advanced machining processes such as Abrasive Jet Machining, Ultrasonic Machining, Water Jet Machining, Electro Chemical Machining, Chemical Machining, Electro-Discharge Machining, Wire Electro Discharge Machining, Electron Beam Machining, and Laser Beam Machining, rapid prototyping and rapid tooling: introduction of solid-based (FDM, LOM), liquid-based (SLA, SGC), powder-based (3DP, BPM) RP processes.	11
3.	**Finishing and Superfinishing Processes:** Principles and applications of honing, superfinishing, lapping, polishing, buffing, peening, and burnishing	4
4.	**Metrology:** Introduction, inspection types and principles, radius and taper measurement, measurement of screw threads and gears. Limits, fits, and dimensional and geometrical or form tolerances, computer vision system based measurement, coordinate measuring machines, measurement of form tolerances, measurement of surface roughness: surface roughness terminology, different methods of surface roughness measurement	9

5.	**Jigs and Fixtures:** Usefulness of Jigs and Fixtures**,** Design principles of jigs and fixtures, Principles of location and clamping, Types locating and clamping devices, Few simple design of Jigs and Fixtures : lathe, milling, boring, s haping, br oaching, g rinding, a ssembly a nd w elding f ixtures, Economics of Jigs and Fixtures..	**7**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	DeGarmo, E.P., Black, J.T., Kohser, R.A., "Materials and Processes in Manufacturing", Prentice Hall of India	1997
2.	Ghosh, A., and Mallik, A.K., "Manufacturing Science" Affiliated East-West press Pvt. Ltd.	1985
3.	Lal, G .K., " Introduction to M achining S cience" N ew A ge International Publishers	1996
4.	Chua, C .K., and L eong, L .F., " Rapid Prototyping: P rinciples a nd Applications in Manufacturing" John Wiley & Sons Ltd.	1997
5.	Gupta, I.C., "Text Book of Engineering Metrology" DhanpatRai Publishing Co.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-303** Course Title: **Principles of Industrial Engineering**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS:0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Autumn** 7.Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: To acquaint the students to the tools and techniques of industrial engineering.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Industrial Engineering:** Introduction to industrial engineering. Functions of organization, Elements of organization, Principles of organization, Types of organization and their selection.	6
2.	**Plant Layout and Material Handling:** Site selection, types of layout, factors affecting layout, plant building, flexibility and expandability, Principles of material handling, types and selection of materials handling equipment's.	8
3.	**Production Planning and Control:** Functions, forecasting, routing, operations planning; Gantt chart, work order, dispatching and follow-up; CPM and PERT techniques.	8
4.	**Inventory Control:** Scope, purchasing and storing, economic lot size; ABC Analysis.	4
5.	**Quality Control:** Statistical quality control, control charts for variables and attributes: X bar, R, p & c charts, Concepts &Scope of TQM and QFD.Acceptance Sampling: Consumers risk, Producers risk, LQL, AQL, OC curves, Types of sampling plans, AOQ, ATI.	10
6.	**Work Study:** Scope, work measurement and method study, standard data, ergonomics and its industrial applications.	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Mitra, A., "Fundamentals of Quality Control and Improvement", John Wiley & Sons, Inc,	2008
2.	Russell, R .S., Taylor, B.W.,"Operations Management", Pearson	2003

	Education	
3.	Jocobs, C.A., " Production and Operations Management", Tata McGraw Hill	1999
4.	Groover,M.P.,"Automation, Production Systems and Computer-Integrated Manufacturing", Pearson Education	2001
5.	Maynard, H.B.,"Industrial Engineering Handbook", McGraw Hill	2001
6.	BesterfieldD.H. et al ., "Total Quality Management:, Pearson Education	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-304** Course Title: **Fluid Machinery**
2. Contact Hours: **L: 3** **T: 0** **P: 2/2**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight**: CWS: 20** **PRS: 20** **MTE: 20** **ETE: 40** **PRE: 0**
5. Credits**: 3** 6. Semester**: Spring** 7. Subject Area**: DCC**
8. Pre-requisite**: Nil**
9. Objective: To provide theoretical and practical knowledge of various fluid machines and their performance.

10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Introduction :** Classification, Euler's turbomachinery equation, aerofoil and cascade theory, impulse and reaction principle, specific speed	10
2.	**Hydraulic Turbines :** Classification, Pelton, Francis, Kaplan, propeller and bulb turbines, velocity triangles, power and efficiency calculations, draft tube, cavitation, Thoma's cavitation factor, governing of impulse and reaction turbines.	08
3.	**Rotodynamic Pumps, Fans & Compressors :** Classifications, centrifugal, mixed and axial flow pumps, velocity triangles; Head, power and efficiency calculations, system losses and system head, impeller slip and slip factors, Hydraulic design of fans and compressors, internal and stage efficiency, stalling.	08
4.	**Performance Characteristics of Rotodynamic Machines:** Head, capacity and power measurement, performance characteristics, operating characteristics, model testing, similarity laws, Muschal or constant efficiency curves.	06
5.	**Hydro-static Pumps :** Principle of positive displacement pumps, working principle of reciprocating pumps, indicator diagram, slip, effect friction and acceleration, air vessels, two throw and three throw pumps. Constant and variable delivery, internal and external gear pumps, vane pumps, screw pumps, radial piston pumps, rotary piston pumps.	06
6	**Hydraulic Transmission Devices:** Fluid coupling and torque converter, hydraulic jack, press, crane, pressure accumulator and intensifier.	04
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication/ Reprint
1.	Earl Logan, Turbomachinery: Basic theory and applications, CRC Press	2009
2.	Lal, J., Hydraulic Machine; Metropolitan Book Co.	2007
4.	Gopal Krishnan & Prithviraj, A treatise on Turbomachines; scitech publications (India) pvt. Ltd	2002
5.	Douglas, J., F., Fluid Mechanics, Pearson Education Ltd.	2005
6.	Som & Bisswas, Introduction to fluid Mechanics, Tata McGrawhill 2^{nd} Edition	2004

12. List of Experiments:

(i) Performance characteristics of Pelton Turbine
(ii) Performance characteristics of Francis Turbine
(iii) Performance characteristics of axial flow Turbine
(iv) Study of a jet reaction principle
(v) Performance characteristics of ram pump
(vi) Performance characteristics of centrifugal pump

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-305** Course Title: **Heat and Mass Transfer**
2. Contact Hours: **L: 3** **T: 1** **P: 2/2**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight: **CWS: 20** **PRS: 20** **MTE: 20** **ETE: 40** **PRE: 0**
5. Credits: **4** 6. Semester: **Both** 7. Subject Area: **DCC/M**
8. Pre-requisite: **Nil**

9. **Objectives of Course**: The course has been designed to impart basic understanding of heat and mass transfer mechanisms and to enable the students to apply these in solving real problems.

10. **Details of Course:**

S. No.	Particulars	Contact Hours
1	**Introduction:** Mode of heat transfer, conduction, convection and radiation.	02
2	**Conduction:** Fourier, s, law, thermal conductivity of matter and other relevant properties, heat diffusion equation, boundary and initial conditions. One –dimensional steady- state conduction through plane wall, cylinder and sphere, conduction with thermal energy generation, heat transfer from extended surfaces. Two- dimensional steady-state conduction through plane wall.	12
3	**Convection:** Velocity, thermal and concentration boundary layers and their significance, laminar and turbulent flow, convection transfer equations, boundary layer similarity and normalized convection transfer equations, heat and mass transfer analogy, Reynolds analogy, effect of turbulence, convection in external and internal flow, free convection, boiling and condensation.	08
4	**Heat exchangers:** Heat exchangers types, overall heat transfer coefficient, analysis of parallel-flow, counter flow, multipass and cross-flow heat exchangers, effectiveness – NTU method, compact heat exchangers.	05
5	**Radiation:** Fundamental concepts, radiation intensity and its relation to	10

	emission, irradiation and radiosity, blackbody radiation, Planck distribution, Wien's displacement law, Stefan- Boltzmann law, surface emission, surface absorption, reflection, and transmission, kirchhoff's law, gray surface. Radiation exchange between surfaces, view factor, blackbody radiation exchange, radiation exchange between diffuse gray surfaces in an enclosure.	
6	**Diffusion Mass Transfer:** Fick's law of diffusion, mass diffusion equation, boundary and initial conditions, mass diffusion without and with homogeneous chemical reactions, transient diffusion.	**05**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication
1	Fundamental of Heat and Mass Transfer, Incropera and Dewitt, 5th Edn., John Wiley & Sons	2002
2	Heat Transfer A Practical Approach, Cengel, 4th Edn, Tata McGraw-Hill	2011
3	Heat Transfer, Holman J.P., Ninth Edn. Tata McGraw –Hill	2007
4	Heat Transfer, Ozisik, 2nd Edn. Tata McGraw-Hill	1987

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPARTMENT: Mechanical & Industrial Engineering

1. Subject Code: MIN-309 **Course Title: Theory of Production Processes-II**

2. Contact Hours: **L:** 3 **T:** 1 **P:** 2/2

3. Examination Duration (Hrs.): **Theory** 0 3 **Practical** - -

4. Relative Weight : CWS 20 PRS 20 MTE 20 ETE 40 PRE - -

5. Credits: 0 4 **6. Semester:** √ Autumn x Spring x Both

7. Pre –requisite: NIL **8. Subject Area: DCC**

9. Objectives of Course: This course is intended to impart fundamentals of the theory of casting, welding and forming processes and powder metallurgy.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Theory of Casting:** Cooling and solidification of castings, cooling curves, nucleation and dendrite formation, , design of gating and risering system in ferrous and nonferrous foundry practice, production of gray, malleable, and spheroidal graphite iron castings, mechanization in foundry equipments.	12
2.	**Theory of Welding:** Thermal effects in welding, structure in weld and heat affected zones, distortion and residual stresses, weldability, weld quality, welding of cast iron, stainless steel and aluminum, hard facing, brazing, soldering, and adhesive bonding.	10
3.	**Theory of Forming:** Mechanics of materials: elastic and plastic behavior, concept of stress and strain and their types, Mohr's stress and strain circle in 2-D and 3-D, stress and strain tensor, hydrostatic and deviatoric components, elastic stress-strain relations, strain energy, anisotropy of elastic behavior; Theory of Plasticity: true stress and strain, flow curve, concept of anelastic, hysteresis, and visco-elastic behavior, Bauschinger effect, Tresca and Von-Mises yield criteria, anisotropy in yielding, octahedral normal and shear stresses and strains, invariants of stress and strains, flow rules or plastic stress-strain relations.	10
4.	**Analysis of Forming Processes:** Slab method, uniform deformation energy method, limit analysis, analysis of drawing, extrusion, rolling, forging, deep drawing, and bending, forming defects, formability & workability, temperature & lubrication aspects in forming.	6

5.	**Powder Metallurgy:** Theory of powder metallurgy, manufacture of metal powders, sintering, secondary operations, properties of finished parts, design considerations and applications.	**4**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	DeGarmo, E.P., Black, J.T., Kohser, R.A., "Materials and Processes in Manufacturing", Prentice Hall of India	**1997**
2.	Heine, R.W., Loper, C.R., and Rosenthal, P.C., " Principles of Metal Casting", 21st reprint, Tata McGraw-Hill	**1997**
3.	Kuo, S., "Welding Metallurgy", John-Wiley & Sons Inc.	**2003**
4.	Dieter, G.E., "Mechanical Metallurgy", McGraw Hill Book Company	**1988**
5.	Ghosh, A., and Mallik, A.K., "Manufacturing Science", Affiliated East-West Press Pvt. Ltd.	**1985**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-310** Course Title: **Quality Management**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25 PRS: 0 MTE : 25 ETE: 50 PRE: 0**

5. Credits**: 4** 6. Semester**: Spring** 7.Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: To impart awareness regarding quality, its importance, measurement and applications in design, manufacturing and final inspection of product.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Different definitions, dimensions, and aspects of quality; Traditional and modern views of quality control; Different Philosophies by quality Gurus, seven basic and new quality control tools.	**7**
2.	**Statistical Process Control:** Theory and applications of control charts, controls charts for variables: charts for averages, ranges, and standard deviation, control charts for attributes: p and c charts, fraction defective and number of defects per unit, different adaptations of control charts, manufacturing process variability, manufacturing process capability and tolerances.	**12**
3.	**Acceptance Sampling:** Concept of acceptance sampling, sampling by attributes: single and double sampling plans; Construction and use of OC curves.	**7**
4.	**Total Quality Management:** Concept and philosophy, scope, applications, implementation, quality function deployment, six sigma, process capability, just-in-time philosophy, quality circles, quality system and Introduction to ISO 9000 and ISO 14000.	**10**
5.	**Reliability:** Concept and definition, measurement and test of reliability, design for reliability, concepts of maintainability and availability.	**6**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication

1.	Grant,E., a nd Leavenworth, R ., " Statistical Q uality C ontrol", McGraw-Hill	1996
2.	Mitra, A., "Fundamentals of Quality Control and Improvement", John Wiley & Sons, Inc,	2008
3.	Juran,J.M., "Quality Control Handbook", McGraw-Hill	1988
4.	Besterfield, D .H., B esterfield – Michna, C ., B esterfield, G ., a nd Besterfield-Sacre,M., "Total Quality Management",Pearson Education	1999
5.	Montgomery, D.C.,"Introduction to Statistical Quality Control",John-Wiley & Sons Inc.	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-311** Course Title: **Operations Research**

2. Contact Hours: **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.): **Theory: 3 Practical: 0**

4. Relative Weight**: CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0**

5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite**: Nil**

9. Objective: The course covers deterministic and probabilistic models with emphasis on formulation of problems for scientific and quantitative analysis.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Origin and development of operations research, general methodology of OR, applications of OR to industrial problems.	2
2.	**Linear Programming:** Different types of models, formulation of linear programming problems (LPPs), product-mix problems, deterministic models, graphical solution. Simplex algorithm, computational procedure in simplex method, applications of simplex technique to industrial problems. Duality and its concept, dual linear programming, application of elementary sensitivity analysis	13
3.	**Linear Optimization Techniques:** Integer programming problems (IPPs), assignment models: mathematical formulation, methods of solutions, transportation problems: methods of obtaining optimal solution degeneracy in transportation problems, transshipment problems.	15
4.	**Game Problems:** Introduction and scope of game problems in business and industry, min-max criterion and optimal strategy, solution of two-person zero-sum game, game problem as a special case of linear programming.	6
5.	**Queuing Problems:** Queuing systems and concepts, classification of queuing situations; Kendall's notation, solution of queuing problems, single channel, single stage, finite and infinite queues with Poisson arrival and exponential service time, applications to industrial problems.	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Taha,H.A., "An Introduction t o O perations Research", 6th Ed., Prentice Hall of India	2001
2.	Panneerselvam R., Operations Research, PHI	2011
3.	Hillier, F.J., Lieberman, G.J., "Introduction to Operations Research" 7th Ed., Holden Day Inc.	2001
4.	Gross, D., and Harris, C.M., "Fundamentals of Queuing Theory", 2nd Ed., John Wiely & sons, NY	1985
5.	Cheema, D.S., "Operation Research", Laxmi Publications (P) Ltd.	2005
6	Wagner, H.M., "Principles of Operations Research", Prentice Hall of India	1980

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-312** Course Title: **Operations Management**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **DCC**
8. Pre-requisite: **Nil**
9. Objective: The course is designed to provide knowledge about the shop floor and resource management activities in a manufacturing organization.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Types and characteristics of manufacturing systems, concept of manufacturing cell, system planning and design.	**3**
2.	**Operations Scheduling:** Concepts, loading, scheduling and sequencing, single processor scheduling, flow shop scheduling, job-shop scheduling, scheduling criteria; Gantt charts	**8**
3.	**Project Management:** Project management techniques; Introduction to CPM and PERT techniques, activities and events, conventions adopted in drawing networks, graphical representation of events and activities, dummy activities, identification of critical activities.	**5**
4.	**Materials Planning and Control:** Field and scope, materials planning; Inventories-types and classification; ABC analysis, economic lot size, EOQ model, lead time and reorder point, inventory control systems, modern trends in purchasing, store keeping, store operations; Introduction to MRP and MRP-II, bills of material; Introduction to ERP.	**10**
5.	**Zero Inventory Systems:** Introduction to the new manufacturing concepts; JIT, lean manufacturing and agile manufacturing, pull and push systems of production; Kanban system.	**5**
6.	**Capacity Planning:** Definition of capacity, capacity planning, capacity requirement planning, capacity available and required, scheduling order.	**7**
7.	**Supply Chain Management:** Introduction – understanding supply chain, supply chain performance, supply chain drivers and obstacles,	**4**

	planning demand and supply in a supply chain.	
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Russell, R .S., and Taylor, B.W., 'Operations M anagement", Pearson Education	2003
2.	Jocobs, C.A., "Production a nd O perations M anagement", Tata McGraw Hill	1999
3.	Ramamurthy, P. "Production and Operations Management", New Age International	2002
4.	Adam J r., E .E., and Ebert, R.J., "Production a nd O perations Management Concept, Models, and Behaviour", 5^{th} Ed., Prentice Hall of India	2001
5.	Buffa, E .S., and Sarin, R.K., "Modern P roduction / O perations Management", John Willey & Sons	1994

INDIAN INSTITUTE OF TECHNOLOGY
ROORKEE

NAME OF DEPTT./CENTRE:**Department of Mechanical andIndustrialEngineering**

1. Subject Code**: MIN-313** CourseTitle**: Work System Design**
2. Contact Hours**: L: 3 T: 0 P: 2/2**
3. Examination Duration (Hrs.)**: Theory 3 Practiceal 0**
4. Relative Weight**: CWS: 20 PRS 20 MTE: 30 ETE 20 PRE0**
5. Credits**: 4** 6. Semester**: Autumn** **7.** Subject Area**: DCC**
8. Pre– requisite**:Nil**
9. Objective**:**To introduce concepts, techniquesandtools for work study and Ergonomics
10. Details of Course:

S. No.	**Contents**	**Contact Hours**
1.	**Productivity:** Concept, obj ectives, Factors affecting productivity, Productivity m easurement, c auses of l ow p roductivity, T ools and techniques to improve productivity, work study and productivity	06
2.	**Work St udy:** Purpose, s cope a nd d evelopments, hum an a spects, techniques of work study and their scope	04
3.	**Method St udy:** Objectives a nd s cope, recording t echniques: ope ration process charts, flow process charts, two hand process chart, activity chart, other c harts, their a nalysis, flow di agram, string di agram, critical examination t echniques, de velopment, i nstallation and maintenance of improved m ethods, P rinciples of m otion e conomy, M icro M otion s tudy, Therbligs, m otion a nalysis, pr eparations of m otion f ilm a nd i ts a nalysis, SIMO charts, memo-motion study, cyclegraph and chronocyclegraph	14
4.	**Time Study:** Scope and obj ectives, concepts of measurement o f w ork i n units of t ime, T echniques of w ork m easurement, s top w atch t ime s tudy, allowances and c alculation of s tandard t ime, s tandard t ime a nd i ts applications, W ork s ampling a nd i ntroduction t o P redetermined motion time systems	12
5.	**Ergonomics**: Introduction t o i ndustrial e rgonomics, c onstituents a reas of ergonomics, m an-machine s ystem, a nthropometry and ergonomics, metabolism a nd or ganization of w ork, e rgonomic a spects i n de sign of controls and displays and their layout, light and vibration consideration in ergonomically de signed s ystem, working c onditions a nd e nvironment, ergonomics and safety	06
	Total	**42**

11. SuggestedBooks:

S. No.	NameofAuthors / Books /Publisher	Year of Publication /Reprint
1.	Introduction to Work Study by ILO.	2005
2.	Barnes, R.M., “Motion and Time Study”, John Wiley & Sons.	1980
3.	McCormick, E.J., “Human Factors in Engineering and Design”, TMH.	1976
4.	Bridger, R.S., “Introduction to Ergonomics”, CRC Press.	2008
5.	Murrel, K.F.H., “Ergonomics”, Longsman.	1971

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-325** Course Title: **Numerical Methods in Manufacturing**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits**: 4** 6. Semester**: Both** 7. Subject Area**: DEC/DHC**
8. Pre-requisite**: Nil**
9. Objective: To expose the students to in various numerical methods and modeling tools to model and simulate manufacturing and materials processing operations.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Numerical Methods:** Introduction, Linear equations, Non-linear equations, Functional approximation, Numerical differentiation, Numerical integration, Ordinary differential equations, Partial differential equations, Finite difference method, Finite element method, Finite volume method, Orthogonal collocation, Boundary integral method, Optimization	**8**
2.	**Mathematical Model Development:** Introduction, Fluid flow phenomenon, Heat transfer, Diffusion and mass transfer, Multiphase flow	**8**
3.	**Modeling of Casting & Solidification Process:** Fundamentals of casting and solidification process, Heat flow in solidification, Solidification of mushy zones, Finite element simulation of solidification problems, Modeling and formulation of casting problems, case studies, Macro-modeling of solidification; Numerical approximation methods, Discretization of governing equations, Solution of discretized equations, Application of macro-modeling of solidification	**10**
4.	**Modeling of Metal Forming Processes:** Introduction, Plasciticity fundamentals: von Mises yield criterion, Tresca yield criterion, Flow rule, Generalised stress & generalised strain increment, Plastic anisotropy, Anisotropic yield criterion, Plastic instability, Process modeling: Uniform energy method, slab method, slip-line field method, upper bound method, Visioplasticity method, Finite element method, Application of finite element method, Eulerian rigid-plastic	**10**

	FEM formulation for plane strain rolling, Governing equations	
5.	**Modeling of Welding Processes:** Weld pool heat & fluid flow, Modeling of fluid dynamics & coupled phenomenon in arch weld pools, finite element analysis of welding residual stress & distribution	**6**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Ilegbusi, Olusegun J., Iguchi, M., Wanhsiedler, W., "Mathematical and Physical Modelling of Materials Processing Operations", Chapman & Hall/ CRC Press	2000
2.	Stefanescu, D. M., "Science and Engineering of Casting Solidification", Kluwer Academic/ Plenum Publishers,	2002
3.	Lal, G. K., Dixit, P. M., Reddy, N. Venkata., "Modelling Techniques for Metal Forming Processes", Narosa Publishimg House,	2011
4.	Gupta Santosh K, Numerical Methods for Engineers, New Age International (P) Limited Publishers,	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-327** Course Title: **Reverse Engineering**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits**: 4** 6. Semester**: Both** 7.Subject Area**: DEC/DHC**
8. Pre-requisite**: Nil**
9. Objective: To t each s tudents va rious t ools a nd t echniques us ed f or t he reverse engineering processes and applications.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Scope and tasks of RE, Process of duplicating, Definition and use of Reverse Engineering, Reverse Engineering as a Generic Process	**6**
2.	**Tools and Techniques for RE:** Object scanning: contact scanners, noncontact scanners, destructive method, coordinate measuring machine, Point Data Processing: preprocessing and post processing of captured data, geometric model development, construction of surface model, solid model, noise reduction, feature identification, model verification	**14**
3.	**Rapid Prototyping:**Introduction, current RP techniques and materials, Stereo Lithography, Selective Laser Sintering, Fused Deposition Modeling, Three-dimensional Printing, Laminated Object Manufacturing, Multijet Modeling, Laser-engineered Net Shaping, Rapid Prototyping, Rapid Tooling, Rapid Manufacturing	**12**
4.	**Integration:**Cognitive approach to RE, Integration of formal and structured methods in reverse engineering, Integration of reverse engineering and reuse.	**6**
5.	Legal Aspects of Reverse Engineering: Introduction, Copyright Law	**4**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Biggerstaff T. J., “Design Recovery for Maintenance and Reuse”, IEEE Corporation.	1991
2.	Katheryn, A. Ingle, “Reverse Engineering”, McGraw-Hill.	1994

3.	Aiken Peter, “Data Reverse Engineering”, McGraw-Hill.	1996
4.	Linda Wills,“Reverse Engineering” ,Kluiver Academic Publishers.	1996
5.	Donald R. Honsa , “Co-ordinate Measurement and reverse engineering”, American Gear Manufacturers Association	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-328** Course Title: **Manufacturing System Analysis**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits**: 4** 6. Semester**: Both** 7.Subject Area**: DEC**
8. Pre-requisite**:** **Nil**
9. Objective: To teach students various tools and techniques used for the performance analysis of manufacturing systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Definitions of manufacturing with input-output model, Definition of system, Basic problems concerning systems and system design procedure, Modes of manufacturing – job/batch/flow and multi-product, small-batch manufacturing.	**4**
2.	**System Modeling Issues:** Centralized versus distributed control; Real-time vs. discrete event control; Forward vs. backward scheduling approaches with finite/infinite capacity loading; Modeling of absorbing states and deadlocks, conflicts, concurrency, and synchronization etc.	**8**
3.	**System Modeling Tools and Techniques:** Introduction to mathematical modeling, optimization, and simulation; Issues related with Deterministic and Stochastic models, continuous and discrete mathematical modeling methods-Discrete event, Monte Carlo method; Basic Concepts of Markov Chains and Processes; The M/M/1 and M/M/m Queue; Models of manufacturing systems-including transfer lines and flexible manufacturing systems, Introduction to Petri nets.	**15**
4.	**Performance Analysis:** Transient analysis of manufacturing systems, Analysis of a flexible machining center; Product flow analysis; Rank order clustering; Process flow charting; MRPI& II, Kanban, OPT, JIT-Pull and JIT-Push, Line of balance, Effects of machine failure, set-ups, and other disruptions on system performance; Calculation of performance measures-throughput, in-process inventory, due dates, MTL, Capacity, and Machine utilization etc.; Critique of high inventory, long lead time systems; Shop floor control issues.	**15**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Askin, R.G., and Standridge, C.R., “Modeling and Analysis of Manufacturing Systems”, John Wiley & Sons Inc.	1993
2.	Gershwin, S., “Manufacturing Systems Engineering”, Prentice-Hall Inc.	1994
3.	Hitomi, K., “Manufacturing Systems Engineering”, Taylor & Francis	1998
4.	Viswanadham, N., and Narahari, Y., “Performance Modeling of Automated Manufacturing Systems”, Prentice-Hall of India	1992
5.	Hopp, W.J., and Spearman, M.L., “Factory Physics: Foundation of Manufacturing Management”, McGraw Hill Inc.	1996
6.	Chang, T.C.,Wysk, R.A., and Wang, H.P., “Computer Aided Manufacturing”, Prentice Hall Inc.	1998

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-329** Course Title: **Computer Integrated Manufacturing**

2. Contact Hours : **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.) : **Theory: 3** **Practical: 0**

4. Relative Weight : **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE0**

5. Credits: **4** 6. Semester: **Both** 7. Subject Area: **DEC**
8. Pre–requisite: **Nil**

9. Objective: To provide knowledge and details of the means of computer aided manufacturing and various functions supporting the automated manufacturing.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Introduction to manufacturing systems and their performance analysis; Introduction to automation; Introduction to computer integrated manufacturing (CIM).	**04**
2	**Numerical Control (NC):** Introduction, numerical control – its growth and development, components of NC system, input devices, control systems – point to point, straight cut, and continuous path NC, open loop and closed loop NC systems, NC interpolations – linear, circular, helical, parabolic and cubic interpolation, applications of NC systems, merits and demerits.	**10**
3	**Extensions of NC:** Concepts of computer numerical control (CNC), machining center, and direct numerical control (DNC), and their advantages.	**06**
4	**Robotics:** Robot anatomy and related attributes, robot control systems – limited sequence, playback with point to point, playback with continuous and intelligent control; End effectors – gripper, tools; Sensors in robotics – tactile sensors, proximity, optical sensors and machine vision; Applications of industrial robots, robot programming.	**06**
5	**Material Handling and Storage:** Overview of material handling equipments, automated material handling equipments – AGVs, conveyor systems, performance analysis of material handling systems, automated material storage systems – ASRS and carousel storage, analysis of automated storage systems.	**06**
6	**Manufacturing Support Functions:** Introduction to group technology (GT), computer aided process planning (CAPP), material requirement planning (MRP), capacity planning, scheduling etc.	**10**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication / Reprint
1	Groover, M. P., "Automation, Production systems and Computer Integrated Manufacturing", 3rd Ed., Prentice-Hall.	2007
2	Singh, N., "Systems Approach to Computer Integrated Design and Manufacturing", John Wiley & Sons.	1996
3	Chang,T.-C., Wysk,R. A. and Wang, H.-P. "Computer Aided Manufacturing", 3rd Ed., Prentice Hall.	2005
4	Rembold,U., Nnaji,B. O. and Storr A., "Computer Integrated Manufacturing", Addison Wesley.	1994
5	Besant,C. B. and Lui,C. W. K., "Computer Aided Design and Manufacture", Ellis Horwood Ltd.	1991
6	Rao,P. N., Tiwari,N. K. and Kundra,T.K., "Computer Aided Manufacturing", Tata McGraw Hill.	1993
7	Koren, Y. "Computer Control of Manufacturing Systems", McGraw Hill.	1983
8	Lynch, M., "Computer Numerical Control for Machining", McGraw-Hill.	1992
9	Sava,M. and Pusztai,J., "Computer Numerical Control Programming", Prentice Hall.	1990

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-330** Course Title: **Ergonomics**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs.): **Theory: 3 Practical: 0**
4. Relative Weight**: CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0**
5. Credits**: 4** 6. Semester**: Both** 7. Subject Area**: DEC/DHC**
8. Pre-requisite**: Nil**
9. Objective: The main objective of the course is to impart an understanding of the man-machine system. The course deals with the study of the different aspects of physiology and psychology in the work system design.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Introduction and relevance to work system design, importance of ergonomics in present day scenario, Definition & fundamentals of ergonomics:, historical perspectives, objectives and functions	8
2.	**Anthropometry:** Human body, anthropometrics, postures; Stand, sitting, squatting and cross-legged postures, anthropometric measuring techniques, body supportive devices, vertical and horizontal work surface, design of an ergonomic chair	12
3.	**Human factors:** Behavioral aspects, cognitive issues, mental work load, human error	4
4.	**Ergonomic Design:** Design methodology and criteria for designing, design for improving occupational safety and reduction in fatigue and discomfort, work system design, environmental factors, visual issues in design, case studies	12
5.	**Case studies**: Design modifications in existing products from the ergonomics point of view	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Singh, S (Edt), Ergonomics Interventions for Health and Productivity, Himanshu Publications, Udaipur, New Delhi	2007

2.	Chakrabarti D., Indian Anthropometric Dimensions for ergonomic design practice, National Institute of Design, Ahmedabad	1997
3.	Salvendy G. (edit), Handbook of Human Factors and ergonomics, John Wiley & Sons, Inc.,	1998
4.	Dul, J. and Weerdmeester, B. Ergonomics for beginners, a quick reference guide, Taylor & Francis	1993
5.	Green, W.S. and Jordan, P .W, Human Factors in Product Design, Taylor & Francis	1999

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-331** Course Title: **Total Quality Management**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits**: 4** 6. Semester**: Both** 7.Subject Area**: DEC/DHC**
8. Pre-requisite**: Nil**

9. Objective:To development unde rstanding on t ools, t echniques a nd t he phi losophies concerning t he a pplication of t he T otal Q uality M anagement (TQM) in m anufacturing a nd service industry.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Fundamentals:** Evolution of Q uality: Inspection, Q uality C ontrol, Quality Assurance and Total Q uality M anagement, Customer-Orientation: Internal & E xternal C ustomer C oncept, Quality Philosophies of Deming, Juran, Crosby, Ishikawa, Taguchi; Tools and improvement cycle (PDCA). Life cycle approach t o qua lity costs prevention; A ppraisal and F ailure costs. V arious T QM m odels. Relationship between quality and environment.	10
2.	**Human Resources Management:** Organizational, Communicational and T eam r equirements. Types of t eams, Quality circles, Empowerment, Human resource policies in TQM, Group dynamics	6
3.	**Tools and Techniques** Seven QC tools (Histogram, Check sheets, Ishikawa diagrams, Pareto, Scatter di agrams, Control c harts), Quality Function Deployment, Statistical process control, Process capability, JIT and Elimination of waste, Total P roductive M aintenance, 5-S. T aguchi's c oncept of quality loss function.	10
4.	**Systems and Procedure:** Importance, Standardization (National and International) Quality Systems, Quality Manuals, Quality Information Systems and documentation, Auditing, Basics of ISO-9000 and ISO 14000: Relevance and misconceptions.	8
5.	**Implementation:** Quality s trategy a nd pol icy, M otivation and leadership t heories. C ontinuous vs br eakthrough i mprovements, Management of c hange, Q uality award m odels a nd r ole of s elf-	8

	assessment, Benchmarking, Implementation barriers, TQM practices.	

11. Suggested Books:

S. No.	**Name of Books / Authors**	**Year of Publication**
1.	Besterfield, D C and Besterfield C Total Quality Management, Pearson Education Asia, New Delhi	1999
2.	Mohanty R P and Lakhe R R Handbook of Total Quality Management, Jaico Publishers	2000
3.	Berk, J. and Berk, S. Total Quality Management: Implementing Continuous Improvement. New York: Sterling Publishing	1993
4.	Logothetis, N. Managing forTotal Quality. New York: Prentice Hall	1992
5.	Bossert, J. L. Quality Function Deployment – A Practitioner's Approach, NY: Marcel Dekker	1994
6.	Taguchi, G., A. Elsayed, and T. Hsiang Quality Engineering in Production Systems, NY: McGraw Hill	1989

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-332** Course Title: **Industrial Hazards and Safety**
2. Contact Hours : **L: 3 T: 0 P: 0**
3. Examination Duration (Hrs.) : **Theory: 3 Practical: 0**
4. Relative Weight : **CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE:0**
5. Credits: 4 6. Semester: Both 7. Subject Area: DEC/DHC

8. Pre – requisite: Nil

9. Objectives of Course:

The course is planned in such a manner that the students can build on the foundation laid in the basic course on Industrial Hazards and Safety. The course will highlight in detail various Industrial Hazards with emphasis on different types of safety measures.

10. Details of Course:

S.No	Particulars	Contact Hours
1	**PHYSICAL HAZARDS** Noise, properties of sound, occupational damage, risk factors, sound measuring instruments, noise control programmes. Ionizing radiation, types, effects, monitoring instruments, control programmes, OSHA standard - non-ionizing radiations, effects, types, radar hazards, microwaves and radio-waves, lasers, TLV- cold environments, hypothermia, wind chill index, control measures- hot environments, thermal comfort, heat stress indices, acclimatization, estimation and control.	9
2	**CHEMICAL AND NUCLEAR HAZARDS** Recognition of chemical hazards- types, and concentration, Exposure vs. dose, TLV - Methods of evaluation, process or operation description, field survey, sampling methodology, Air Sampling instruments, Types, Measurement Procedures, Instruments Procedures, Gas and Vapour monitors, dust sample collection devices, personal sampling. Methods of Control - Engineering Control, Nuclear hazards, Disposal of nuclear wastes, Safety measures In nuclear plants	9
3	**BIOLOGICAL AND ERGONOMICAL HAZARDS** Classification of Biohazardous agents – examples, bacterial agents, rickettsial and chlamydial agents, viral agents, fungal, parasitic agents, infectious diseases - Biohazard control Programmes, employee health Programmes-laboratory safety programmes-animal care and handling-biological safety cabinets – building design. Work Related Musculoskeletal Disorders –carpal	9

	tunnel syndrome (CTS) - Tendon pain-disorders of the neck- back injuries.	
4	**OCCUPATIONAL HEALTH AND TOXICOLOGY** Concept and spectrum of health - functional units and activities of occupational health services, pre - employment and post-employment medical examinations - occupational related diseases, levels of prevention of diseases, notifiable occupational diseases, their effects and prevention. Industrial toxicology, local, systemic and chronic effects, temporary and cumulative effects, carcinogens entry into human systems.	**8**
5	**OCCUPATIONAL PHYSIOLOGY** Man as a system component – allocation of functions – efficiency – occupational work capacity – aerobic and anaerobic work – evaluation of physiological requirements of jobs – parameters of measurements – categorization of job heaviness – work organization – stress – strain – fatigue – rest pauses – shift work – personal hygiene.	**7**
	Total	**42**

11. Suggested Books:

S.No	**Name of Book / Authors / Publisher**	**Year of Publication**
1	"Hand book of Occupational Safety and Health", National Safety Council, Chicago.	1982
2	"Encyclopedia of Occupational Health and Safety", Vol. I and II, International Labour Office, Geneva,	1985
3	"Occupational Safety and Health Management" by Thomas J. Anton, 2nd Ed.	1989
4	"Occupational Safety Management and Engineering" by Willie Hammer and Dennis Price, ISBN: 0-13-896515-3	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-333** Course Title: **Industrial Management**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory 3** **Practical0**
4. Relative Weight**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits**: 4** 6. Semester**: Both** 7. Subject Area**: DEC/DHC**
8. Pre-requisite**:** **Nil**
9. Objective: This course introduces the study of equilibrium and deformation in components, and structures for engineering design.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Basic concepts of management, scientific management, types of management.	10
2.	**Organizational Structures:** Types of organizations, Functions and objectives of industrial organizations, Ownership of Industries; Proprietorship, partnership, joint stock companies, public and private undertakings, co-operative organizations, comparison of different organization structures.	12
3.	**Personnel Management:** Functions, wage and salary administration, job evaluation, satisfactory wage plan, merit rating and evaluation plans.	10
4.	**Industrial Safety:** Occupational safety, engineering safety design and safety programmes; Safety aspects in work system design,	10
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of

		Publication
1.	J. Russell (Joseph Russell) Smith, " The Elements of Industrial Management", HardPress	2012
2.	Rieske, David W., Asfahl and C. Ray, "Industrial Safety and Health Management", 6th Ed., Prentice Hall Professional Technical Ref.	2009
3.	Gavriel Salvendy, "Handbook of Industrial Engineering: Technology and Operations Management", John Wiley & Sons, Inc.	2001
4.	Herman B. Henderson, Albert E. Haas, "Industrial Organization and Management Fundamentals", Industrial Press, The University of California.	1961

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-334** Course Title: **Facilities Design**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**:** **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Both** 7.Subject Area**: DEC/DHC**

8. Pre-requisite**:** **Nil**

9. Objective: To impart the knowledge about fundamentals of different aspects of facility location, facility layout, and material handling for an enterprise.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Factory Planning:** Introduction, factors to be considered	2
2.	**Plant Location and Site Selection:** Levels of plant location, rural, urban and suburban location of plants, factors influencing the plant location, optimum plant location, location theories.	8
3.	**Plant Layout:** Introduction of production system, scope, objectives, importance, and types of plant layout, characteristics of a good plant layout, factoring affecting plant layout, procedure of developing a plant layout, installation and evaluation of plant layout, optimum plant layout.	10
4.	**Group Technology:**Definition, objectives, planning, part families and machine cell formation, evaluation of machine cells, types of GT layout, benefits of GT, implementation of GT.	10
5.	**Line Balancing:** Definitions, heuristic and analytical methods of balancing the assembly and production line, single and mixed model line balancing, alternatives to line balancing.	5
6.	**Materials Handling:** Definition, scope, objectives, principles, importance, factors in materials handling problem, analysis of materials handling, types and selection of materials handling equipment's, aids and techniques in materials handling equipment selection.Planning of material flow, advantages of planned material flow, flow planning principles, flow patterns, analysis of material flow.	7
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Francis, R.L., McGinnis, L.F., and White, J.A.,“Facility Layout and Location: An Analytical Approach”, Prentice Hall of India	2004
2.	Meyers, F.E., and Stephens, M.P., “Manufacturing Facilities Design and Material Handling”, Prentice-Hall, Inc.	2000
3.	Groover,M.P.,“Automation, Production Systems and Computer-Integrated Manufacturing”,2nd Ed., Pearson Education Inc. Delhi	2001
4.	Sule,D.R.,“Manufacturing Facilities-Location, Planning, and Design”, PWS Publishing Company	1984
5.	Tompkins,J.A., White, J.A.,Bozer,Y.A.,Frazelle, E.H.,Tanchoco, J.M., and Tervino,J.,“Facilities Planning”,2nd Ed., John Willey & Sons	1996

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-335** Course Title: **Concurrent Engineering**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Both** 7.Subject Area**: DEC/DHC**

8. Pre-requisite**:** **Nil**

9. Objective: To make the learners aware on the importance, concept, tools and techniques of concurrent engineering.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Concurrent engineering concepts, sequential versus concurrent engineering, importance of concurrent engineering, benefits of concurrent engineering.	8
2.	**Design for Manufacturing and Assembly:** Mathematical modeling between design and manufacturing, design for manufacturing and assembly approach, concurrent product design, material balance equation, cost equation, average manufacturing lead time.	13
3.	**Design for X :** Design for quality, pseudo measure of product optimality, quality function deployment, improvement in unit cost and quality of manufactured products.	13
4.	**Implementation and Case Studies:** Difficulties associated with performing concurrent engineering, life cycle costing, case studies.	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Andreasen, M.M., Kahler, S., Lund, T., and Swift, K., "Design for Assembly", Springer Verlag	1988
2.	Molloy, O., Tilley, S., and Warman, E.A., "Design for Manufacturing and Assembly Concepts, Architectures and Implementation", Chapman & Hall	1998
3.	Wang, B.,"Integrated Product, Process and Enterprise Design", Chapman & Hall	1997
4.	Benhabib, B., "Manufacturing Design, Production, Automation and Integration", Marcel Dekker Inc.	2003
5.	Huang, G.Q., "Design for X Concurrent Engineering Imperatives", Chapman & Hall	1996
6.	Boothroyd, G., Dewhurst, P., and Knight, W., "Product Design for Manufacture and Assembly", Marcel Dekker Inc.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-336** Course Title: **Financial Management**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Both** 7.Subject Area**: DEC/DHC**

8. Pre-requisite**: Nil**

9. Objective: To provide de tailed i nsight of t he f inancial r equirements i n i ndustriesbesides techniques of financial planning, control and managerial decisions.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Nature an d Sc ope:** Function of f inance, jobs and objectives of a financial manager, various forms of business organizations, **sourceof f inances**: s hort te rm f inances- term c redit, accrued expenses and deferred income, bank f inance for w orking c apital; long t erm finances- common s hares, r ight i ssues, debentures, preference shares, lease financing, term loan.	**12**
2.	**Financial A ccounting:**Purpose, f unctions, di fference be tween financial and management accounting,Purpose, objective of Financial Statement Analysis, ratio analysis: types of ratio, liquidity ratio, leverage ratio, profitability ratios, and activity ratios.	**8**
3.	**Cost:** Nature a nd c lassification of c osts i n a m anufacturing company, costing concepts, cost a llocation,Break-even analysis (BEA), ope rating l everage, effect of ch ange i n pr ofit, utility a nd limitation of BE Analysis.	**8**
4.	**Capital B udgeting (CB):** Meaning, i mportance and di fficulties o f CB, kinds of capital budgeting decisions, cash in flow and out flow estimates. Capital structure,Concepts, needs, d etermination, a nd dimension of w orking c apital m anagement, estimation of w orking capital needs, financing current assets.	**8**
5.	**Financing and D ividend D ecision:** Meaning a nd m easure of financial l everage, effect on t he s hare hol ders return, dividends, dividend pol icy, practical cons ideration, constraints of pa ying	**6**

	dividends, advantages and disadvantages of bonus shares etc.	
	Total	**42**

11. Suggested Books:

S. No.	**Name of Books / Authors**	**Year of Publication**
1.	Bose, D.C., "Fundamental of Financial Management", Prentice Hall	2006
2.	Martin, K., Scott Jr., P., "Financial Management Principles and Applications", 10th Ed., Academic Internet Publishers	2006
3.	Higgins, R.C., "Analysis for Financial Management", 8th Ed., McGraw-Hill/Irwin	2005
4.	Brigham, E.F., and Ehrhardt, M.C., "Financial Management: Theory and Practice with Thomson ONE",11th Ed., South-Western College Pub.	2004
5.	Horne, J.C.V., "Financial Management Policy", Pearson	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-337** Course Title: **Processing of Non-Metals**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits: **4** 6. Semester: **Both** 7. Subject Area: **DEC/DHC**

8. Pre-requisite: **Nil**

9. Objective: The main objective of the course is to impart an understanding of the manufacturing science and engineering of non-metals.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Classification of engineering materials and processing techniques, structure and properties of non-metals	**3**
2.	**Processing of Glass and ceramics** : Glass structure and properties, glass melting and forming, glass annealing, Ceramic powder preparation, synthesis of ceramic powders, fabrication of ceramic products from powders: pressing, casting, vapour phase techniques, sintering, finishing, machining. ceramic coatings	**10**
3.	**Processing of Plastics:** thermoplastics and thermosets, Processing of Plastics: Extrusion. Injection moulding. Thermoforming. Compression moulding. Transfer moulding. General behavior of polymer melts, Machining of plastics	**8**
4.	**Processing of polymer matrix composites**: Classification of composite materials, properties of composites hand lay-up, autoclaving, filament winding, pultrusion, compression molding, pre-pegging, sheet molding compounds etc., process capability and application areas of various techniques	**10**
5.	**Ceramic matrix composites:** mechanical properties of ceramic matrix composites, different processing techniques for ceramic matrix composites, process capability and applications of various techniques	**6**
6.	**Secondary processing of composite materials:** Need of secondary operations, different type of secondary operations, machining and drilling of non-metals, machining induced damage, different methods of reducing the damage on account of secondary processing	**5**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Kalpakjian, S.,"Manufacturing Processes for Engineering Materials," 3rd Ed., Addison – Wesley	1997

2.	Strong,A.B., " Plastics: Materials and Processing," Pearson Prentice Hall	2006
3.	Mathews, F.L., and R awlings,R.D., " Composite M aterials: Engineering and Science," Woodhead Publishing	1999
4.	Peters S.T. "Handbook of Composites", 2nd Ed., Chapman Hall	1998

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-338** Course Title: **Measurement & Instrumentation**
2. Contact Hours: **L: 3** **T: 1** **P: 2/2**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight: **CWS: 20** **PRS: 20** **MTE: 20** **ETE: 40** **PRE: 0**
5. Credits: **4** 6. Semester: **Both** 7. Subject Area: **DEC/DHC**
8. Pre-requisite: **Nil**

9. Objectives of Course: The course is designed to give the undergraduate students the basic knowledge about the measurement systems and its components. Further, the various other issues related to above aspects have been discussed.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Generalized Configuration of Measuring System :** Functional elements of a basic measuring system; different types of measurands, description of functional elements. Input-output configuration of a measuring system. Interfering and modifying inputs; methods for correction for interfering and modifying inputs.	06
2	**Characteristics of Instruments :** Objective of studying the characteristics of the instruments. Static characteristics – accuracy, precision, error, sensitivity, hysterisis, threshold, drift, span, static stiffness etc. Dynamic Characteristics – time domain and frequency domain characteristics terms. Input-output Impedance's and meaning of impedance mismatching. Concept of mechanical loading.	04
3	**Measurement System Behaviour :** Description of mathematical model for the generalized configuration of a measurement system. Response characteristics of the system – Amplitude, frequency and phase response. Order of the systems, response of zero, first and second order systems to step, ramp and sinusoidal inputs. Transfer function method to study the response of the system.	07
4	**Uncertainty Analysis :** Classification of errors systematic errors, random errors, illegitimate errors and statistical analysis of experimental data, computation of maximum and rss error .	03

5	**Principles of Transduction and Transducers :** Description of various types of transduction principles. Transducers based on variable resistance, variable inductance, variable capacitance and piezo-electric effects. Displacement transducers - wire wound potentiometers, LVDT, strain gages, strain gage designation system. Diaphragm type Pressure Transducers and other pressure measuring techniques. Design of accelerometers and their applications. Temperature and flow measurement techniques, ultrasonic measurements. Signal conditioners - filters, low, high, band pass and charge amplifiers.	**18**
6	**DAS and Signal Analysis :** Data acquisition system via computers. The components of Data acquisition system, DAS Hardware, selection criteria for choosing a DAS. Techniques for signal analysis.	**04**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication
1	Doeblin E O, and Dhanesh N M, "Measurements System Application and Design", 6th Ed., McGraw Hill	**2011**
2	Mechanical Measurement; Beckwith and Buck; Wesley;	2002
3	Theory and Design for Mechanical Measurements; Richard S. Figiliola, 4th Edn., Wiley India	2005
4	Instrumentation for Engineering Measurements; James W. Dally, W.F. Rilley and K.G. McConnel; John Wiley (2nd Edn.)	2003
5	LAB View Manual	2012

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Departmentof Mechanical & Industrial Engineering**

1. Subject Code: **MIN-339** Course Title: **Heat Exchangers**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Both** 7.Subject Area**: DEC/DHC**

8. Pre-requisite**: Graduate level course on Heat and Mass Transfer and Fluid Mechanics**.

9. Objective: The course has been designed to make the students capable to select and design various types of heat exchangers used in industries.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Introduction:**Heat exchanger types and construction,heat transfer and fluid flow fundamentals.	**6**
2	**Types of heat exchangers:** Derivations for counter flow and parallel flow heat exchangers, LMTD and ε-NTU method, double pipe heat exchangers, crossflow heat exchangers, shell-and-tube heat exchangers, TEMA standards.	**6**
3	**Design Strategy:**General design considerations and approaches, design strategies,material selection and fabrication processes, cost estimation,optimum design.	**8**
4	**Design of Single Phase Heat Exchangers:** Liquid to liquid, gas to gas and liquid to gas heat exchangers.	**6**
5	**Design of Two Phase Heat Exchangers:**Steam generators, condensers,principle of cooling towers.	**6**
6	**Design of Compact Heat Exchangers:** Definition, types, design parameters, design calculations for liquid-air heat exchangers.	**8**
7	Introduction to micro, nano and PCB type heat exchangers, familiarization with heat exchanger design softwares, computer aided design.	**2**
	Total	**42**

11. Suggested Books:

S. No.	Author(s) /Title / Publisher	Year of Publication/ Reprint
1	Shah, R. K. and Seculic, D. P.,“Fundamentals of Heat Exchanger Design”, Wiley India.	2012
2	Kakac, S. and Liu, H., “Heat Exchangers: selection, rating and thermal design” CRC Press.	2012
3	Hesselgreaves, J.E.,“Compact Heat Exchangers: selection, design and operation”,Pergamon.	2001
4	Kays, W. M. and London, A. L., “Compact Heat Exchangers”, Krieger Publishing Company.	1998
5	Webb,R. L. and Kim, N.H.,“Principles of Enhanced Heat Transfer”, Taylor & Francis.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical & Industrial Engineering**

1. Subject Code: **MIN-340** Course Title: **Refrigeration &Air-conditioning**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Autumn/Spring** 7.Subject Area**: DEC/DHC**
8. Pre-requisite**: Nil**

9. Objective: To introduce the basic principles of refrigeration and air conditioning processes and relevant equipment associated with the process. Load calculation in an air-conditioning system.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Review of basics thermodynamics and history of refrigeration and air-conditioning	1
2	**Air cycle refrigeration :**Carnot Cycle; Bell Coleman Cycle; Aircraft Refrigeration: Simple Cycle, Boor Strap cycle, Regenerative Cycle, Reduced Ambient cycle, DART.	4
3	**Refrigerants :** Important refrigerants and their properties; leak detection; charging of refrigerants, selection of refrigerant compressors. CFCs and Ozone Hole; Ozone-safe Refrigerants, Global Warming and refrigerants.	2
4	**Vapour Compression Cycle :** Carnot vapor compression Cycle; T-s and P-h diagrams of vapour compression refrigeration cycle; Departure of actual vapor compression cycle from theoretical cycle. Compressor volumetric efficiency. Analysis of actual cycle, second law analysis of vapour compression cycle. Effect of suction and discharge pressure, subcooling and superheating on performance. Compound vapour compression system with intercooling for single and multiple evaporator. Cascading.	7
5	**Vapour Absorption Refrigeration Systems :** Aqua-ammonia absorption refrigeration system; Lithium bromide-water absorption systems; properties of aqua-ammonia solution, p-t-x chart; enthalpy concentration chart. Three fluid Electrolux system.	3
6	**Water Refrigeration :**Introduction; Principle of Operation; Steam Jet Refrigeration; Centrifugal Refrigeration; Merits and Demerits of steam jet refrigeration; Characteristics of Steam Jet Refrigeration	2
7	**Non-conventional Refrigeration Systems :** Vortex and Pulse Tube Refrigeration Systems; Thermoelectric Refrigeration Systems	2

8	**Psychrometrics :** Introduction to Air conditioning; Psychrometric processes: evaporative cooling, humindifier efficiency; cooling and dehumidification by chilled water spray and cooling coils; bypass factor; chemical dehumidification; sensible heat factor; apparatus dew point. Elements of comfort air conditioning.	**6**
9	**Infiltration and Ventilation :** Basic concepts ant terminology; Driving mechanism of infiltration and ventilation; Indoor air quality; natural ventilation; Residential air leakage; Residential ventilation; Residential ventilation requirements.	**4**
10	**Cooling Load Calculations :** Introduction; Health and comfort criterion; Thermal Comfort; Design conditions; Estimation of heat loss and heat gain in a building: HB and RLF method.	**8**
11	**Space Air Distribution :** Room air distribution; total, static and velocity pressures; friction loss in ducts; dynamic loss in ducts; air duct design: equal friction method, static regain method, velocity reduction method.	**3**
	Total	**42**

11. Suggested Books:

S. No.	**Author(s) / Title / Publisher**	**Year of Publication/ Reprint**
1	Stoecker, W.F., and Jones, J.W., "Elementary Refrigeration & Air conditioning", McGraw Hill	2002
2	Dosset, R.J., Principles of Refrigeration, Pearson Education Asia	2002
3	Arora, C.P.,"Refrigeration and Air conditioning", Tata-McGraw Hill	2005
4	Prasad, M., "Refrigeration and Air conditioning", New Age International	2005
5	ASHRAE Handbook (Fundamentals)	2013

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Departmentof Mechanical & Industrial Engineering**

1. Subject Code: **MIN-341** Course Title: **Thermal System Design**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Both** 7.Subject Area**: DEC/DHC**

8. Pre-requisite**:** **Nil**

9. Objective: This c ourse provides t he ba sic unde rstanding of m odeling a nd designingthe thermal systems like power plant, HVAC etc.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Introduction:**Thermal s ystems, engineering de sign, workable a nd op timal designs.	4
2	**Design C riteria:**Maximum efficiency a nd e nergy c onservation, minimum cost/losses, multi-criteria, functional reliability of system components.	8
3	**Modeling and S imulation of T hermal S ystems:** Types o f m odels w ith examples,mathematical modeling of processes and components, system models, identification of operating variables; simulation techniques.	12
4	**Optimization:** Maximum a nd m inimum c onditions, optimization parameters, levels of opt imization, mathematical r epresentation of pr oblem, optimization procedures including introduction to some non-traditional methods.	12
5	**Economic C onsiderations:**Present a nd future w ork f actors, gradient f actors, rates of return, life cycle cost.	6
	Total	**42**

11. Suggested Books:

S. No.	Author(s) /Title / Publisher	Year of Publication/ Reprint
1	Hodge, B. K.and Taylor, R. P.,"Analysis and Design of Energy Systems", Prentice Hall.	1999
2	Suryanarayana, N. V. and A rici,O.,"Design and Simulation of Thermal Systems", Penguin Books Ltd.	2004
3	Jaluria, Y.,"Design and Optimization of Thermal Systems", CRC Press.	2007
4	Burmeister, L.C., "Elements of Thermal Fluid Systems", Prentice Hall.	1998
5	Bejan, A., Tsaatsaronis,G. and Moran, M.,"Thermal Design and Optimization", Wiley.	1996
6	Stoecker, W. F., "Design of Thermal Systems", Tata McGraw Hills.	2011

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPARTMENT: Mechanical & Industrial Engineering

1. Subject Code: **MIN-342** Course Title: **Environnemental Pollution & Control**

2. Contact Hours : **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.) : **Theory: 3** **Practical: 0**

4. Relative Weight : **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits: **4** **6.** Semester : **Both**
7. Pre – requisite: Nil

8. Subject Area: **DEC**

9. Objectives of Course:
Objective of the course is to expose students about the pollution caused by the thermal power plants, automobiles and transport systems; and possible control measures to reduce the environmental pollution.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Introduction :** Nature and extent of pollution problem, types of pollution.	2
2	**Air Pollutants :** Air pollutants, oxides of nitrogen, sulphur oxides, particulate matter, oraganic compounds, carbon monoxide; their harmful effects.	4
3	**Air Pollution Sources :** Stationary sources, emission from stacks, mobile sources, pollutant formation in SI and CI engines and gas turbines.	6
4	**Air Pollution Control :** Stack emission control, inertial devices, electro-static propitiators, particulate scrubbers, dry and wet methods, filters. IC Engine pollution control devices, thermal reactors, catalytic converters, particulate traps.	10
5	**Thermal Pollution :** Nature of thermal pollution; effect of thermal pollution on ecology, thermal plume, regions of plume, parameters relevant to thermal plume and their limit. Mechanics of condenser water discharge from thermal power plants.	10
6	**Global Atmospheric Changes :** Green house effect, green house gases, Ozone depletion and control.	8
	Total	**42**

11. Suggested Books:

S.	Name of Books / Authors / Publisher	Year of

No.		Publication
1	Air Pollution: Its Origin and Control; Kenneth Wark, Cecil F. Warner, Wayne T. Davis; Prentice Hall(3^{rd} Edn.) ; ISBN-10: 0673994163 , ISBN-13: 978-0673994165	**1997**
2	Internal C ombustion E ngine F undamentals; J ohn B enjamin H eywood; McGraw Hill; ISBN-10: 0071004998, ISBN-13: 978-0071004992	**1989**
3	Energy and the Environment; Robert A. Ristinen, Jack P. Kraushaar; Wiley; (2^{nd} Edn.); ISBN-10: 0471739898, ISBN-13: 978-0471739890	**2005**
4.	Air P ollution Control E ngineering; Norman C. Pereira, Norman C. Pereira, Wei Yin Chen (Editors); Springer-Verlag; ISBN: 1588291618, ISBN-13: 9781588291615	**2004**

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPARTMENT: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN- 343** Course Title: **Power Plants**
2. Contact Hours : **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits: **4** 6. Semester : **Both** 7. Pre-requisite: **Nil**

8. Subject Area: **DEC**

9. Objectives of Course: To explain the working methodology of different power plants being used for generation of electrical energy.

10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Introduction:** Energy sources for generation of electric power, energy policy of India, present status and future trends, major power plants in India.	4
2.	**Thermal Power Plants:** Selection of site, general layout of the plant, major components- Boilers, Economisers, Super-heaters, Air pre-heaters, fuels, fuel and ash handling equipment's, High pressure Boilers, steam turbines, station heat balance and plant efficiency.	8
3.	**Diesel Power Plant:** Diesel engine, engine performance and operation, super charging, Diesel Electric power plant layout.	4
4.	**Gas Turbine Power Plants:** Gas turbine power plants, basic cycles, cycle calculation, the ideal and real operating cycles, components and layout.	4
5.	**Hydro Power Plants:** Classification of hydro-plants, selection of site, rain fall and run off, calculation of storage capacity, plant layout, estimation of power available, selection of hydraulic turbines and their governing.	6
6.	**Nuclear Power Plants:** Introduction, Atomic structure and radio-activities nuclear reactions, binding energy, Nuclear Reactors, Types of reactors, Pressurized water reactors, boiling heater reactors, Heavy water-cooled and moderated (CANDU) reactor, Gas-cooled reactors, Liquid metal cooled reactors, Indian Nuclear power installations, comparison between Nuclear and Thermal plants.	6
7.	**Non-Conventional Power Plants:** Geothermal power plants, Tidal power plants, Wind power plants, solar power plants, M.H.D. Generators, OTEC	4

8.	**Power Plant Economics & environmental aspect:** Plant investment costs, fixed charges, Operation cost, energy cost, depreciation and operating costs on the selection of equipments, incremental cost, comparison of fixed and operating costs, greenhouse effect, thermal pollution, other pollutants.	**6**
Total		**42**

11. Suggested Books:

S. No.	**Author(s) / Title / Publisher**	**Year of Publication / Reprint**
1.	Black & Veatch, "Power plant Engineering", CBS Publisher.	2005
2.	El-Wakil, M.M., "Power plant Technology", McGraw-Hill Book Co.	2002
3.	Nag, P.K., "Power plant engineering", Tata MacGraw Hill.	2008
4.	Modern Power Station Practical, CEGB, Pergamon Publisher.	1992
5.	Norris & Therkelsen, "Heat Power", McGraw Hill.	1999
6.	Rust, J.H., "Nuclear Power Plant Engineering", Haralson Pub. Co.	1999
7.	Potter, P.J., "Power Plant Theory & Design", Kreiger Publishing Co.	1994

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical and Industrial Engineering Department**

1. Subject Code: **MIN-344** Course Title: **Industrial Combustion**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Both** 7. Subject Area**: DEC/DHC**

8. Pre-requisite**:** **-**

9. Objective: **The course deals with the principles underlying the industrial combustion equipment**.

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10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Industrial Combustion, requirements and applications	**2**
2.	**Combustion Fundamentals :** **i Thermodynamics of Combustion:** Combustion Stoichiometry, evaluating enthalpy of reacting systems, enthalpy of formation, energy balance for reacting systems, enthalpy of reaction and heating values. Adiabatic flame temperature. Equilibrium criteria, chemical potential, equation of reaction equilibrium, equilibrium constant, equilibrium composition and flame temperature**.**	**6**
	ii Chemistry of Combustion Rate laws and reaction orders, elementary reactions, reaction Molecularity, temperature and pressure dependence of reaction rate, Arrhenius law, chain reactions, and reaction mechanisms. Combustion characteristics of hydrocarbons. NO_x formation and its control.	**7**
	iii Flame Processes: Different types of flames, laminar flame structure, laminar flame speed, effect of various chemical and physical parameters on flame speed, Flammability Limits, Stability Limits. Turbulent Premixed Flames: Applications, Turbulent Flame Speed, Structure of Turbulent Flames, Flame Stabilization, Turbulent	

	Nonpremixed Flames.	**7**
3.	**Gas Fired Furnaces & Boilers** Gas fired furnaces, Energy Balance and Efficiency, Fuel Substitution, Gas burners, Classifications, Design factors, Heat Transfer From Burners	**7**
4.	**Oil fired Furnaces & Combustion Systems** Spray formation and droplet behavior, droplet size distribution, Fuel Injectors, Oil fired systems, Spray combustion in furnaces and boilers. Emissions from oil fired furnaces and boilers	**6**
5.	**Coal Fired Combustion Systems :** Combustion mechanism of solid fuels, Grate burning systems, traveling vibrating grate spreader stokers, pulverized coal burning systems, Fluidized bed combustion, atmospheric pressure fluidized bed combustion systems, circulating and pressurized fluidized bed systems. Emissions from grate burning systems, pulverized coal and fluidized bed combustion boilers.	**7**
	Total	**42**

11. Suggested Books:a

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	Ragland, K. W. and Bryden, K. M., "Combustion Engineering," CRC Press	2011
2.	Baukal, C. E., "Industrial Burners Handbook" CRC Press;	2003
3.	Fawzy, E .M. and Saad, E . H ., " Fundamentals and Technology of Combustion," CRC Press	2002
4.	Basu, P., K. C., Jestin Louis, "Boilers and Burners Design and Theory," Springer	1999
5.	Glassman, I. and Yetter, R. "Combustion 4th Edition", Academic Press	2008
6.	Oka S., "Fluidized Bed Combustion", Marcel & Dekker	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-345** Course Title: **Compressible Flow**

2 Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Both** 7.Subject Area**: DEC/DHC**

8. Pre-requisite**:** **Nil**

9. Objective: To impart knowledge of compressible flows essential for the design of nozzles, gas turbines, blowers, compressors, aero-planes, rockets and automobiles.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Velocity of sound, distinction between incompressible, compressible, subsonic, supersonic, transonic and hypersonic flows; Mach number, Mach angle and Mach cone.	4
2.	**One Dimensional Isentropic Flow:** General features, adiabatic and isentropic flow of a perfect gas, choking in isentropic flow, operation of nozzles under varying pressure ratios, applications of isentropic flow.	8
3.	**Normal Shock Waves:** Distinction between normal and oblique shock waves, governing relations of the normal shock, Rankine-Hugoniot relations, formation of shock waves, operating characteristics of convergent-divergent nozzles.	9
4.	**Viscous Compressible Flow:** Governing equations, adiabatic viscous flow in constant area ducts, Fanno lines.	6
5.	**Frictionless Compressible Flow:** Governing equations, full potential equation, flow through constant area ducts with heat transfer, Rayleigh lines.	7
6.	**Steady Isothermal Flow in Long Pipe-lines:** Governing equations and features of steady isothermal flow in long pipelines.	4
7.	**Simulation:** Introduction to CFD tools for simulation of compressible flows.	4
	Total	**42**

11. Suggested Books:

S. No.	Author(s) / Title / Publisher	Year of Publication
1.	Liepmann, H.W., and Roshko, A., “Elements of Gas Dynamics”, Dover Publications	2002
2.	John, J.E.A., and Keith, T.G., “Gas Dynamics”, 3^{rd} Ed., Prentice-Hall	2006
3.	Anderson Jr., J.D., “Modern Compressible Flow: With Historical Perspective”, 3^{rd} Ed., Tata McGraw-Hill	2012
4.	Zucrow, M.J., and Hoffman, J.D., “Gas Dynamics”, John Wiley & Sons	2001
5.	Rathakrishnan, E., “Gas Dynamics”, 4^{th} Ed., Prentice-Hall of India	2012
6.	Oosthuizen, P.H. and Carscallen, W.E. “Introduction to Compressible Fluid Flow”, 2^{nd} Ed., CRC Press	2013

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical and Industrial Engineering Department**

1. Subject Code: **MIN-346** Course Title: **Waste Heat Recovery Systems**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weight**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits**: 4** 6. Semester**: Both** 7. Subject Area**: DEC/DHC**
8. Pre-requisite**:** **Basic course on Heat transfer**
9. Objective: The c ourse de als w ith t he s ources of w aste he at, a nd e quipment us ed f or t he utilization of waste heat.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction : Waste Heat, Sources of waste heat, high temperature heat recovery applications, waste heat recovery calculations.	**5**
2.	Recuperators: G as t o gas h eat ex changers, recuperators, rotary regenerator, air pre-heaters, Heat pipe exchangers.	**12**
3.	Regenerators: Gas or liquid to liquid Regenerators, Finned tube heat exchangers, shell and tube he at ex changers, waste he at boi ler, Heat pumps..	**12**
4.	Viscous Compressible Flow: Governing equations, adiabatic viscous flow in constant area ducts, Fanno lines.	**6**
5.	Economics: W aste H eat recovery e conomics general con cepts, case studies, examples	**5**
6.	Case Studies: Case Studies of some industrial problems. .	**8**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication
1	Goldstick R .J.& T humann A ., "Principles of W aste H eat R ecovery" Faimont Press, Digitised Version	2008

2	Ganapathy, V ., " Industrial B oilers a nd he at r ecovery generators. D esign applications and calculations." CRC	2002
3	Olszewski M., "Utilization of Reject Heat", Marcel & Dekker Inc.	1980
4	Matsula K ., K anasha, Y., F ushimi, C ., S utsummi K a nd K ishimoto, A ., "Advanced energy savings and its applications in Industry", Springer	2013
5	Goldstick R .J.& T humann A ., " Waste H eat R ecovery H andbook," , Fairmont Press	1986

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical & Industrial Engineering**

1. Subject Code: **MIN-349** Course Title: **Fire Dynamics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Autumn/Spring** 7.Subject Area**: DEC/DHC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce students to the fundamental concepts of fire dynamics a base-level understanding of the principals of fire dynamics, compartment fire and smoke movement.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Fuels and combustion processes; physical chemistry of combustion in fires; summary of the heat transfer equations of conduction, conection and radiation	3
2	**Premixed Flames:** Limits of flammability; structure of premixed flame; heat loss and measurement of burning velocity; variation of burning velocity with composition, temperature, pressure, suppressant and turbulence.	6
3	**Diffusion Flames and Fire Plumes:** Laminar and turbulent jet flames; flames from natural fire: buoyant plume, fire plume, upward flow; interaction of fire plume with compartment boundaries; effect of wind on fire plume	7
4	**Steady Burning of Liquids and Solids:** Burning of liquids: pool fire, burning of liquid droplets; burning of solids: synthetic polymers, wood, dusts and powders	4
5	**Frictionless Compressible Flow:** Governing equations, full potential equation, flow through constant area ducts with heat transfer, Rayleigh lines.	6
6	**Ignition and Spread of Flames:** Ignition of liquids and solids; Flame spread over liquids and solids;.	5
7	**Pre-flashover and Post-flashover Compartment Fire:** Growth of flash-over: necessary conditions; ventilation requirements; factors affecting time to flashover and fire growth; fully developed fire behavior; temperature in fully developed fire; fire resistance and fire severity.	6
8	**Production and Movement of Smoke:** Production and measurement of smoke particles; test for smoke production potential; smoke movement; smoke control systems	5
	Total	**42**

11. Suggested Books:

S. No.	Author(s) / Title / Publisher	Year of Publication/ Reprint
1.	Drysdale, D."Introduction to Fire Dynamics", John Wiley	2011
2.	Karlsson, B., Quintiere, J., "Enclosure Fire Dynamics", James; CRC Press	2000
3	Quintiere, J.G.,., "Fundamentals of Fire Phenomena",John Wiley	2006
4	Gorbet, G.E., and Pharr, J.L, Fire Dynamics; Pearson Education	2010

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-352** Course Title: **Experimental Methods in Thermal Engineering**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20** **PRS: 20** **MTE: 20** **ETE: 40** **PRE: 0**

5. Credits: **4** 6. Semester: **Both** 7. Subject Area: **DEC/DHC**

8. Pre-requisite: **Nil**

9. **Objectives of Course:** The course is designed to give the undergraduate students the basic knowledge about the measurement systems and its components. Further, the various other issues related to above aspects have been discussed.

10. **Details of Course:**

S. No.	Particulars	Contact Hours
1	**Generalized Configuration of Measuring System :** Functional elements of a basic measuring system; different types of measurands, description of functional elements. Input-output configuration of a measuring system. Interfering and modifying inputs; methods for correction for interfering and modifying inputs.	**06**
2	**Characteristics of Instruments :** Objective of studying the characteristics of the instruments. Static characteristics – accuracy, precision, error, sensitivity, hysterisis, threshold, drift, span, static stiffness etc. Dynamic Characteristics – time domain and frequency domain characteristics terms. Input-output Impedance's and meaning of impedance mismatching. Concept of mechanical loading.	**04**
3	**Measurement System Behaviour :** Description of mathematical model for the generalized configuration of a measurement system. Response characteristics of the system – Amplitude, frequency and phase response. Order of the systems, response of zero, first and second order systems to step, ramp and sinusoidal inputs. Transfer function method to study the response of the system.	**07**

4	**Uncertainty Analysis :** Classification of errors systematic errors, random errors, illegitimate errors and statistical analysis of experimental data, computation of maximum and rss error .	**03**
5	**Principles of Transduction and Transducers :** Description of various types of transduction principles. Transducers based on variable resistance, variable inductance, variable capacitance and piezo-electric effects. Displacement transducers - wire wound potentiometers, LVDT, strain gages, strain gage designation system. Diaphragm type Pressure Transducers and other pressure measuring techniques.	**08**
6	**Flow Measurement:** Flow visualization, shadowgraph; schlieren and interferometric techniques; Pitot static tubes; hot wire anemometers; Laser Doppler velometer; flow measurements using coriolis effect.	**06**
7	**Temperature and Heat Flux Measurement:** Thermoelectric sensors; electric resistance sensors; thermistors; radiations pyrometers; Temperature measuring problems in flowing fluids, dynamic compensation.	**05**
8	**DAS and Signal Analysis :** Data acquisition system via computers. The components of Data acquisition system, DAS Hardware, selection criteria for choosing a DAS. Techniques for signal analysis. Signal conditioners - filters, low, high, band pass and charge amplifiers.	**03**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication
1	Doeblin E O , and Dhanesh N M , " Measurements System Application and Design", 6th Ed., McGraw Hill	2011
2	Mechanical Measurement; Beckwith and Buck; Wesley;	2002
3	Theory and Design for Mechanical Measurements; Richard S. Figiliola, 4th Edn., Wiley India	2005
4	Instrumentation for Engineering Measurements; James W. Dally, W.F. Rilley and K.G. McConnel; John Wiley (2nd Edn.)	2003
5	Eckert R G and Goldstein R J, "Measurements in Heat Transfer", 2nd Ed., Springer	1986
6	Goldstein, R. J.,"Fluid Mechanics Measurement", Hemisphere Publishing Company	1983
7	LAB View Manual	2012

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical and Industrial Engineering Department**

1. Subject Code: **MIN-354** Course Title: **Surface Engineering**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Both** 7.Subject Area**: GSEC**

8. Pre-requisite**:** **Nil**

9. Objective: To impart knowledge of surface related phenomena and technologies.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Concept and importance, classification of surface modification techniques, advantages and their limitations.	3
2.	**Surface Degradation:** Causes, types and consequences of surface degradation, forms of wear: adhesive, abrasive, surface fatigue, corrosive, fretting, and erosive wear, classical governing laws related to wear, techniques to evaluate wear damage.	8
3.	**Materials for Surface Engineering:** Materials characteristics, their importance in surface engineering, wear resistant materials, selection of materials for engineering the surfaces for specific applications, structure and property relationship of coatings system, new coating concepts including multi-layer structures, functionally gradient materials (FGMs), intermetallic barrier coatings and thermal barrier coatings.	9
4.	**Surface Modification Techniques:** Principles and application of weld surfacing: SMAW, SAW, GMAW, thermal spraying: flame spraying, electric arc spraying, plasma spraying, detonation gun spraying, and high velocity oxy fuel (HVOF) spraying; electro	12

	deposition and electro less coatings, ion implantation, chemical vapour deposition (CVD) and physical vapour deposition (PVD).	
5.	**Laser and Microwave assisted Surface Engineering:** Laser cladding, alloying, glazing, laser and induction hardening, heat treatment of steel and remelting by laser; microwave glazing, microwave cladding.	**6**
6.	**Characterization and Quality Assurance:** Importance, introduction to different characterization techniques: physical, mechanical, and functional characterizations, surface finish, microhardness and strength.	**4**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Burakowski, T., and Wierzchon, T.,“Surface Engineering of Metals: Principles, Equipment, Technologies”, CRC Press.	1999
2.	Burnell-Grey, J.S. and Datta, P.K. (eds), “Surface Engineering Casebook”,Woodhead Publishing Limited.	1996
3.	Grainger, S., and Blunt, J. (eds.), “Engineering coatings-design and application”, Abington Publishing.	1998
4.	Rickerby, D.S., and Matthews, A., (eds), “Advanced Surface Coatings: a Handbook of Surface Engineering”, Blackie.	1991
5.	Holmberg, K., and Matthews, A., “Coatings Tribology: Properties, Techniques and Applications in Surface Engineering”, Elsevier Science B.V.	1994

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical & Industrial Engineering**

1. Subject Code: **MIN-355** Course Title: **Building Ventilation&Air-conditioning**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Autumn/Spring** 7.Subject Area**: GSEC**

8. Pre-requisite**: Nil**

9. Objective: To introduce the students to the areas of air-conditioning and ventilation in buildings; fenestration and transmission of air in the buildings.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** History of refrigeration and air-conditioning; trends in modern buildings for thermal comfort, pollution free environment and indoor traffic management	1
2	**Vapour Compression Cycle :** Carnot vapor compression Cycle; T-s and P-h diagrams of simple vapour compression refrigeration cycle; Compressor volumetric efficiency. Effect of suction and discharge pressure, subcooling and superheating on performance.	6
3	**Psychrometery:** Psychrometric properties, psychrometric chart, simple and computerized psychrometrics, psychrometric processes; Appreciation of indoor and outdoor conditions for a space in summer and winter.	5
4	**Air Conditioning Processes:** Summer and winter air-conditioning processes; Sources of thermal load in summer and winter using Load Estimation Chart; Sensible Heat Factor (SHF). Evaporative Cooling Systems.	6
5	**Infiltration and Ventilation:** Driving mechanism of infiltration and ventilation; Indoor air quality; natural ventilation; Residential air leakage; blower door test; Residential ventilation; Residential ventilation requirements.	5
6	**Fenestration:** Fenestration components; determination of energy flow; U-factor; solar heat gain and visible transmission; shading; visual and thermal controls; air leakage; day lighting; selecting fenestration: condensation resistance, occupant comfort and acceptance.	4
7	**Building Cooling Load Calculations**: Internal heat gain; system heat gain; ventilation load; cooling and heating load estimate; psychrometric calculations for heating and cooling load.	6

8	**Transmission and Distribution of Air:** AHU;Room air distribution; friction loss in ducts; dynamic loss in ducts; air duct design; space air diffusion.	**5**
9	**Design C onditions:** Comfort air conditioning and effective temperature; comfort chart; choice of supply design conditions; Climate design conditions; generating design day data; clean spaces.	**4**
	Total	**42**

11. Suggested Books:

S. No.	Author(s) / Title / Publisher	Year of Publication/ Reprint
1	Stoecker, W.F., and Jones, J.W., “Elementary Refrigeration & Air conditioning”, McGraw Hill	2002
2	Dosset, R.J., Principles of Refrigeration, Pearson Education Asia	2002
3	Arora, C.P., “Refrigeration and Air conditioning”, Tata-McGraw Hill	2005
4	Prasad, M., “Refrigeration and Air conditioning”, New Age International	2005
5	ASHRAE Handbook (Fundamentals)	2013

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical and Industrial Engineering Department**

1. Subject Code: **MIN-357** Course Title: **Combustion Science & Technology**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 3** 6. Semester**: Autumn** 7. Subject Area**: GSEC**

8. Pre-requisite**:** **-**

9. Objective: The course deals with the principles of combustion and their applications to the combustion systems**..**

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Importance of Combustion, applications, brief overview of combustion generated pollution	**2**
2.	**Thermodynamics of Combustion:** Combustion Stoichiometry, enthalpy of formation, enthalpy of reacting systems, energy balance for reacting systems, enthalpy of reaction and heating values. Adiabatic flame temperature. Equilibrium criteria, equilibrium constant, equilibrium composition and flame temperature**.**	**6**
3.	**Chemistry of Combustion** Rate laws and reaction orders, elementary reactions, reaction Molecularity, temperature and pressure dependence of reaction rate, Arrhenius law, chain reactions, and reaction mechanisms. Steady state and partial equilibrium approximations. General oxidative and explosive characteristics of fuels, chain branching and explosion criteria, Explosion limits of Hydrogen-O_2 CO-O, hydrocarbon –O_2 system, NO_x formation and its control	**8**
4.	**Flame Processes:** Rankine Hugonoit Relations, Deflagration and Detonation Different types of flames, laminar flame structure, laminar flame speed, effect of various chemical and physical parameters on flame speed, Flammability Limits, Stability Limits. Quenching and Flash Back,	

	Design of Burners Turbulent Premixed Flames: Applications, Turbulent Flame Speed, Structure of Turbulent Flames, Flame Stabilization, Turbulent Nonpremixed Flames. Combustion Process in SI engines	**10**
5.	**Diffusion Flames:** Applications of diffusion flames, structure of diffusion flames, Burke and Schumann development. Burning of condensed Phases, liquid droplet combustion in quiescent environment, effect of convection, spray combustion. Combustion in CI engines	**8**
6	**Combustion Generated Emissions:** Environmental consideration of combustion, Formation of NO_x and its control, Particulate matter, SO_x, Staged burner, catalytic converters, particulate traps	**8**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books /Publisher	Year of Publication
1.	Glassman, I. and Yetter, R. "Combustion," 4th Edition, Academic Press	2008
2.	Turns, S. R., "An Introduction to Combustion, concepts and applications," 3rd edition, McGraw Hill	2011
3.	Kuo, K. K., "Principles of Combustion," 2nd edition, John Wiley	2005
4.	Ragland, K. W. and Bryden, K. M., "Combustion Engineering," CRC Press	2011
5.	Baukal, C. E., "Industrial Burners Handbook", CRC Press;	1999
6.	Fawzy E. M., and Saad E. H., "Fundamentals and Technology of Combustion", Elsevier	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-445** Course Title: **Value Engineering**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Both** 7. Subject Area**: DEC/DHC**

8. Pre-requisite**:** **Nil**

9. Objective: To impart basic knowledge of value engineering in order to search for the key areas of improvement in products, processes, services and systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Value engineering concepts, advantages, applications in product development, process improvement, service improvement and system design, problem recognition, role in productivity	**5**
2.	**Analysis of Functions:** Anatomy of function, use, antique, cost, esteem and exchange values, primary versus secondary versus tertiary/unnecessary functions, functional analysis: FAST (Function Analysis System Technique) and quantitative evaluation of ideas, case studies.	**10**
3.	**Value Engineering Techniques:** Selecting products and operations for VE action, timing; VE programmes, determining and evaluating functions(s), assigning rupee equivalents, developing alternate means to required functions(s), decision making for optimum alternative, use of decision matrix, make or buy decisions, measuring profits, reporting results and follow up.	**18**
4.	**Implementation:** Action plan, record progress, report progress, review meetings, problems in implementation, human factors.	**3**
5.	**Managing VE:** Level of VE in the organization, size and skill of VE staff, small plant VE activity management supports; Audit of savings.	**6**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Miles, L.D., "Techniques of Value Analysis and Engineering", Eleanor Miles Walker	1989
2.	Park, R.J. "Value Engineering : A Plan for Invention", St. Lucie Press	1999
3.	Michaels, J.V., and Wood, W.P., "Design to Cost", Wiley Interscience	2004
4.	Tufty, H.G., " Compendium on Value Engineering", The Indo American Society	1983
5.	Jagannathan, "Getting More at Less Cost", Tata McGraw Hill	1992

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-500** Course Title: **Instrumentation and Measuring Systems**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20** **PRS: 20** **MTE: 20** **ETE: 40** **PRE: 0**

5. Credits: **4** 6. Semester: **Both** 7. Subject Area: **DEC/DHC**

8. Pre-requisite: **Nil**

9. Objective: The course is intended for the post graduate students of mechanical engineering disciplines to give them a thorough understanding of a measuring system, different transduction principles, error analysis response etc. and various other issues related to instrumentation system.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Significance of Measurement and Instrumentation:** Introduction; generalized configuration and functional stages of measuring systems. The transducer and its environment; an overview; sensing process and physical laws. Types of measurement problems. Transducer classification and their modeling; information, energy and incremental models	**5**
2	**Characteristics of Instruments:** Objective of studying the characteristics of the instruments. Static characteristics, Static Calibration, design and selection of components of a measuring system.	**3**
3	**Dynamic Response of Instruments:** Mathematical model of a measuring system, response of general form of instruments to various test inputs; time-domain and frequency domain analysis.	**5**
4	**Errors in Measurement and Its Analysis:** Causes and types of experimental errors; systematic and random errors. Uncertainty analysis; computation of overall uncertainty; estimation for design and selection for alternative test methods.	**4**

5	**Transducers and Transduction Principles:** Developments in sensors, detectors and transducer technology; displacement transducers; force, torque and motion sensors; piezoelectric transducers; capacity type transducers; Strain gage transducers; accelerometers, pressure transducers based on elastic effect of volume and connecting tubing.	**8**
6	**Data Acquisition and Signal Processing:** Systems for data acquisition and processing; modules and computerized data system; digitization rate; time and frequency domain representation of signals, and Nyquist criterion.	**5**
7	**Flow Measurement:** Flow visualization, shadowgraph; schlieren and interferometric techniques; Pitot static tubes; hot wire anemometers; Laser Doppler velometer; flow measurements using coriolis effect.	**6**
	Temperature and Heat Flux Measurement: Thermoelectric sensors; electric resistance sensors; thermistors; radiations pyrometers; Temperature measuring problems in flowing fluids, dynamic compensation.	**6**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication
1.	Doeblin E O, and Dhanesh N M, "Measurements System Application and Design", 6th Ed., McGraw Hill	2011
2.	Theory and Design for Mechanical Measurements; Richard S. Figiliola, 4th Edn.; 2005, Wiley India	2005
3.	Harry L T., "Transducers in Mechanical and Electronic Design", Marcel Dekker, CRC Press	1986
4.	Marangoni R D and Lienhard J H, "Mechanical Measurements by Beckwith T G", 6th Ed., Prentice Hall	2006
5.	Eckert R G and Goldstein R J, "Measurements in Heat Transfer", 2nd Ed., Springer	1986
6.	Goldstein, R. J.,"Fluid Mechanics Measurement", Hemisphere Publishing Company	1983

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-501** Course Title: **Computer Aided Manufacturing**

2. Contact Hours : **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.) : Theory **3** Practical **0**

4. Relative Weight : CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre–requisite: **Nil**

9. Objective: To provide knowledge and details of the means of computer aided manufacturing and various functions supporting the automated manufacturing.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Introduction to manufacturing systems and their performance analysis; Introduction to automation; Introduction to computer integrated manufacturing (CIM).	04
2	**Numerical Control (NC):** Introduction, numerical control – its growth and development, components of NC system, input devices, control systems – point to point, straight cut, and continuous path NC, open loop and closed loop NC systems, NC interpolations – linear, circular, helical, parabolic and cubic interpolation, applications of NC systems, merits and demerits.	10
3	**Extensions of NC:** Concepts of computer numerical control (CNC), machining center, and direct numerical control (DNC), and their advantages.	06
4	**Robotics:** Robot anatomy and related attributes, robot control systems – limited sequence, playback with point to point, playback with continuous and intelligent control; End effectors – gripper, tools; Sensors in robotics – tactile sensors, proximity, optical sensors and machine vision; Applications of industrial robots, robot programming.	06
5	**Material Handling and Storage:** Overview of material handling equipments, automated material handling equipments – AGVs, conveyor systems, performance analysis of material handling systems, automated material storage systems – ASRS and carousel storage, analysis of automated storage systems.	06

6	**Manufacturing Support Functions:** Introduction to group technology (GT), computer aided process planning (CAPP), material requirement planning MRP (MRP), capacity planning, scheduling etc.	10
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication / Reprint
1	Groover, M. P., "Automation, Production systems and Computer Integrated Manufacturing", 3rd Ed., Prentice-Hall.	2007
2	Singh, N., "Systems Approach to Computer Integrated Design and Manufacturing", John Wiley & Sons.	1996
3	Chang, T.-C., Wysk, R. A. and Wang, H.-P. "Computer Aided Manufacturing", 3rd Ed., Prentice Hall.	2005
4	Rembold, U., Nnaji, B. O. and Storr A., "Computer Integrated Manufacturing", Addison Wesley.	1994
5	Besant, C. B. and Lui, C. W. K., "Computer Aided Design and Manufacture", Ellis Horwood Ltd.	1991
6	Rao, P. N., Tiwari, N. K. and Kundra, T.K., "Computer Aided Manufacturing", Tata McGraw Hill.	1993
7	Koren, Y. "Computer Control of Manufacturing Systems", McGraw Hill.	1983
8	Lynch, M., "Computer Numerical Control for Machining", McGraw-Hill.	1992
9	Sava, M. and Pusztai, J., "Computer Numerical Control Programming", Prentice Hall.	1990

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPARTMENT: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-502** Course Title: **Robotics and Control**

2. Contact Hours : L: **3** T:**1** P: **2/2**

3. Examination Duration (Hrs.) : Theory $\boxed{3}$ Practical $\boxed{0}$

4. Relative Weight :CWS 20 PRS 20 MTE 20 ETE 40 PRE 0

5. Credits: $\boxed{4}$ 6. Semester: **Spring** 7. Subject Area: **PCC**

8. Pre–requisite: **NIL**

9. Objectives of Course: To get exposure about basic robot kinematics, dynamics, control and programming.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction**: Definition, Structure, Classification and Specifications of Robots, Industrial Robots.	02
2	**Robot Elements and Control**: Manipulators, Drives, Sensors, End Effectors, Configuration, Force/Torque Relationship, Trajectory Planning, Position Control, Feedback System, Digital Control	5
3	**Modeling of Robots**: Coordinate Frames, Mapping and Transformation; Direct Kinematic Model; Inverse Kinematics; Manipulator Differential Motion; Static Analysis; Jacobian	10
4	**Manipulator Dynamics**: Acceleration of a rigid body, mass distribution, Newtons equation, iterative Newton Euler dynamic formulation, Lagrangian formulation of manipulator dynamics, Bond graph modeling of manipulators, Trajectory Planning.	10
5	**Linear and Non Linear Control of Manipulators**: control law partitioning, trajectory following control, multi input multi output control systems, Cartesian based control scheme.	10
6	**Force Control of manipulators**: hybrid position/force control	03
7	**Robot Programming**: Robot Programming for Manufacturing and Other Applications, Robot Integration with CAD and CAM.	02
	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication
1	Craig John J., "Introduction to robotics: Mechanics & Control", Addison-Wesley	**1986**
2	Niku Saeed B., Introduction to Robotics: Analysis, Systems, Applications, PHI, New Delhi	**2001**
3	Schilling R. J., "Fundamentals of Robotics Analysis and Control", Prentice Hall Inc	**1990**
4	Mittal R. K. and Nagrath I. J., "Robotics and Control", Tata McGraw Hill, New Delhi	**2003**
5	Ghosal Ashitava, " Robotics: Fundamental Concepts and Analysis", Oxford University Press	**2006**
6	Merzouki R., Samantaray A. K., Pathak P.M., Bouamama B. Ould, Intelligent Mechatronic Systems: Modeling, Control and Diagnosis, Springer	**2013**

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-508** Course Title**: Advanced Automatic Controls**
2. Contact Hours : **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs.) : **Theory** 3 **Practical** 0
4. Relative Weight : CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 4
6. Semester: **Autumn/Spring** **7.** Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the advanced concepts of state space approach in control system stability, controllability and observability issues and synthesis of industrial control systems.
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Mathematical Models of Linear Systems**: Linear systems and state equations, linearization of non linear equations, linearizing functions, linearizing differential equations	4
2	**Linear Algebra**: Vector spaces, linear dependence and independence, bases, change of basis, rank and degeneracy, norms, Gram-Schmidt orthonormalization, subspaces and projection theorem	4
3	**State Variable Analysis**: State variable representation, conversion of state variable model to transfer function, characteristic equation, eigenvalues, eigen- vectors, conversion of transfer function to canonical state variable models, solution to state equations,	6
4	**Stability of Control Systems**: Bounded input, bounded output stability, zero input and asymptotic stability of continuous data system, Lyapunov stability, Lyapunov's direct method, external stability, relationship between stability types	6
5	**Controllability and Observability**: Controllability tests for LTI systems, modal controllability and observability, controllability and observability of time varying systems, discrete time systems	5
6	**System Realizations**: Minimal realization, specific realization, Markov parameters, balanced realizations	4
7	**State Feedback and Observers**: State feedback for SISO systems, multivariable canonical forms and feedback, observers, state estimator-	5

	multivariable case	
8	**Optimal Control and Estimation**: The principle of optimality, optimal estimator	5
9	**Pole Placement and Model Matching**: Unity feedback configuration, implementable transfer function, multi variable unity feedback system, multivariable model matching	3
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/Reprint
1	Ogata, K., "Modern Control Engineering", Prentice Hall of India.	2002
2	Raven, F.H., "Automatic control Theory", McGraw Hill.	1995
3	Kuo, B.C., "Automatic Control System", 5th, Prentice Hall of India.	1995
4	Chen, C .T., " Linear System Theory & Design", 3rd Edition, Oxford University Press.	1999
5	Harrison, H.L. and Bollinger, J. G., "Automatic Controls", International Text Book Company.	1970
6	Bay, J.S., "Fundamentals of Linear State Space Systems", McGraw Hill.	1999
7	Norman, S.N., "Control Systems Engineering", John Wiley and Sons.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-509** Course Title: **Extended Finite Element Methods**
2. Contact Hours : **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs.) : **Theory:3 Practical:0**
4. Relative Weight: CWS 25 PRS 00 MTE 25 ETE 50 PRE 00
5. Credits: **4** 6. Semester: **Autumn/Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the recent developments in field of finite element analysis for a better engineering design.
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Basic Concepts of Finite Element Methods**: Introduction, weighted residual and weak formulations, variational methods, numerical problems.	4
2	**Finite Element in 1-D**: Basis steps of finite element analysis, Applications to solid mechanics, heat transfer and fluid flow problems.	6
3	**Finite Element in 2-D**: Single variable problems in 2-D, applications to solid mechanics and heat transfer problems, numerical integration, higher order shape functions, plane stress and plane strain problems.	8
4	**Basics of Extended Finite Element Method (XFEM)**: Brief introduction, partition of unity finite element method (PUFEM), generalised finite element method (GFEM), introduction to XFEM, blending elements, concept of level sets and enrichment	8
5	**Engineering Applications**: XFEM on element level: shape functions, displacement, strain, element stiffness matrix, XFEM for weak and strong discontinuities e.g. e.g. static cracks, crack growth, bi-materials, phase change problems.	8
6	**Advanced Concepts of XFEM**: Concept of phantom nodes, tracking the crack path, embedded elements, interface elements, introduction to cohesive zone models, embedded elements, crack initiation/propagation, smeared cracks.	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books /Publisher	Year of Publication/Reprint
1	Rao, S .S., " The F inite E lement M ethod i n E ngineering", 4th Ed., Elsevier Science.	2005
2	Reddy, J.N., "An Introduction to Finite Element Methods", 3rd Ed., Tata McGraw-Hill.	2005
3	Fish, J ., and B elytschko, T ., " A F irst C ourse i n Finite E lements", John Wiley and Sons.	2007
4	Chaskalovic J ., F inite E lement M ethods for E ngineering S ciences, Springer.	2008
5	Mohammadi, S ., " Extended F inite E lement M ethod", B lackwell Publisher.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-511A** Course Title: **Modeling and Simulation**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To cover concepts, techniques and tools for modeling and simulation of thermal systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Modeling**: Concept of system, continuous and discrete systems, types of models, steps in simulation study.	2
2.	**Mathematical Preliminaries:** Review of vector calculus, Cartesian tensors, vector spaces and linear transformations; Interpolation and extrapolation; Numerical differentiation and integration.	6
3.	**Discrete and Continuous systems:** Continuous and discrete systems from fluid mechanics and heat transfer; Characteristics of discrete systems, eigenvalue problems; Characteristics of continuous systems based on differential equations; Inverse problems.	6
3.	**Mathematical Modeling of Thermal Processes**: Conservation laws, mass, momentum and energy balance; Classification of governing equations, boundary conditions; Dimensional analysis, model development for various thermal processes and system; Dynamics of thermo-fluid systems.	10
4.	**Simulation of Thermal Systems:** Numerical methods for solution of partial and ordinary differential equations; Numerical solution of linear and nonlinear algebraic equations; Numerical simulation of steady state and	12

	dynamic systems.	
5.	**Optimization of Thermal Systems:** Introduction to optimization, formulation of objective function, constrained single and multivariable optimization, dynamic integer and geometric programming.	6
	Total	**42**

Laboratory Component: Students will be required to develop mathematical models and computer programs for numerical simulation of various thermal systems.

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Jaluria, Y., "Design and Optimization of Thermal Systems", 2^{nd} Ed., CRC Press.	2007
2.	Bejan, A., Tsatsaronic, G., and Moran, M., "Thermal Design and Optimization", John Wiley & Sons.	1995
3.	Close, C. M., and Frederick, D. K., "Modeling and Analysis of Dynamic Systems", John Wiley & Sons.	2001
4.	Jaluria, Y. "Computer Methods for Engineering with MATLAB Applications", 2^{nd} Edition, CRC Press.	2011
5.	Press, W. H., Teukolsky, S. A., Vetterling, W. T. and Flannery, B. P., "Numerical Recipes: The Art of Scientific Computing", Third Edition, Cambridge University Press	2007

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-511B** Course Title: **Modeling and Simulation**

2. Contact Hours: **L: 3 T: 1 P: 2/2**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: CWS 15 PRS 15 MTE 30 ETE 40 PRE 0

5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: To cover concepts, techniques and tools for modeling and simulation of thermal systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Systems and models, examples of models, models for systems and signals.	4
2	**Physical modeling:** Principles of physical modeling, basic relationship, bond graphs, and computer aided modeling.	4
3	**Mathematical modeling:** Estimating transient response, spectra and frequency functions, parameter estimation in dynamic models, system identification as a tool for model building.	6
4	**Numerical methods:** Ordinary differential equations (ODE); Euler's Method, Trapezoidal Method, Runge–Kutta Method, Predictor–Corrector Method, Boundary Value Problems, Shooting Method, Finite Difference Method, Elliptic partial differential equations (PDE), Parabolic PDE (Explicit Forward Euler Method, Implicit Backward Euler Method, Crank–Nicholson Method, Two-Dimensional Parabolic PDE), Hyperbolic PDE (Explicit Central Difference Method, Two-Dimensional Hyperbolic PDE)	12
5	**Simulation and Simulation application:** Numerical prototyping as modeling for design and synthesis using computational tools, Introduction to techniques for validation of models, Simulation of electromechanical, thermo-mechanical, hydraulic and pneumatic elements.	10
6	**Modeling and Simulation for Optimization:** Introduction to the concept of optimization, the basic terminology and notations; modeling process; and illustration with modeling of engineering problems. Graphical solution process;	6

	problems with – bounded (single or multiple) and unbounded solutions. Local and global optima; necessary and sufficient optimality conditions for unconstrained and constrained multivariate functions.	
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1	Gordon, G., "System Simulation", Prentice Hall.	1978
2	Lennart, L. and Torkel, G., "Modeling of Dynamic Systems" Prentice Hall.	1994
3	Bhonsle, S.R. and Weinmann, K.J., " Mathematical Modeling for Design of Machine Components", Prentice Hall.	1998
4	D'Souza, A.F., and Garg, V.K., " Advanced Dynamics: Modeling and Analysis", Prentice-Hall.	1983
5	Mukherjee, A., Karmaker, R. and Samantaray, A.K., " Bond Graph in Modeling, Simulation and Fault Identification", I & K International.	2007
6	S. S. Rao; Engineering Optimization; 4th Edition, John Wiley & Sons.	2009
7	K. Deb; Optimization for Engineering Design; Prentice Hall of India.	2005
8	K. Deb; Multi-objective Optimization using Evolutionary Algorithms; John Wiley & Sons.	2003

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-515** Course Title: **Manufacturing Systems Analysis**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS **25** PRS 0 MTE **25** ETE **50** PRE 0

5. Credits: 4 6. Semester**: Spring** 7. Subject Area**: PEC**

8. Pre–requisite: **Nil**

9. Objective: To teach students various tools and techniques used for the performance analysis of manufacturing systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Definitions of manufacturing with input-output model, definition of system, basic problems concerning systems and system design procedure, modes of manufacturing – job/batch/flow and multi-product, small-batch manufacturing.	4
2	**System Modeling Issues:** Centralized versus distributed control; Real-time vs. discrete event control; Forward vs. backward scheduling approaches with finite/infinite capacity loading; Modeling of absorbing states and deadlocks; Conflicts; Concurrency, and synchronization etc.	8
3	**System Modeling Tools and Techniques:** Introduction to mathematical modeling, optimization, and simulation; Issues related with deterministic and stochastic models; Continuous and discrete mathematical modeling methods - discrete event, monte carlo method; Basic concepts of Markov chains and processes; The M/M/1 and M/M/m queue; Models of manufacturing systems - including transfer lines and flexible manufacturing systems, introduction to Petri nets.	15

4	**Performance Analysis:** Transient analysis of manufacturing systems, analysis of a flexible machining center; Product flow analysis; Rank order clustering; Process flow charting; MRPI & II, kanban, OPT, JIT-pull and JIT-push, line of balance, effects of machine failure, set-ups, and other disruptions on system performance; Calculation of performance measures - throughput, in-process inventory, due dates, MTL, capacity, and machine utilization etc.; Critique of high inventory, long lead time systems; Shop floor control issues.	15
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Askin, R. G., and Standridge, C. R., "Modeling and Analysis of Manufacturing Systems", John Wiley & Sons.	1993
2.	Gershwin, S. "Manufacturing Systems Engineering", Prentice-Hall.	1994
3.	Hitomi, K., "Manufacturing Systems Engineering", Taylor & Francis.	1998
4.	Viswanadham N. and Narahari Y. "Performance Modeling of Automated Manufacturing Systems", Prentice-Hall	1992
5.	Hopp, W. J., and Spearman, M. L., "Factory Physics : Foundation of Manufacturing Management", McGraw Hill.	1996
6.	Chang, T.-C., Wysk, R. A. and Wang, H.-P. "Computer Aided Manufacturing", 3rd Ed., Prentice Hall.	2005

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-516** Course Title: **Artificial Intelligence**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS **25** PRS 0 MTE **25** ETE **50** PRE 0

5. Credits: 4 6. Semester**: Spring** 7. Subject Area**: PEC**

8. Pre–requisite: **Nil**

9. Objective: This course is designed to provide basic knowledge of artificial intelligence. The emphasis is on the teaching of various techniques on knowledge representation and search engines with important applications of AI.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Overview of History and Goals of AI**: Artificial Intelligence -- Definition, components, scope, and application areas; Turing's test; Review of AI success and failure.	3
2	**State Spaces, Production Systems, and Search**: State space representation of problems; Problem solving using search; Definition and examples of production systems; Heuristic search techniques i.e. generate-and-test, hill climbing, best-first search, constraint satisfaction and mean-ends analysis.	8
3	**Knowledge Representation**: Definition of knowledge; Issues in knowledge representation; Procedural vs declarative knowledge and their representation; Predicate logic, production rules, semantic nets, and frames; Meta-knowledge.	9
4	**Reasoning and Inference Strategies:** Forward vs backward reasoning; Depth first, breadth first, min-max etc.; Non-monotonic reasoning; Symbolic reasoning under uncertainty; Probability and Baye's theorem; Certainty factors, Dempster-Shafer theory; Fuzzy logic etc.	10
5	**Expert Systems and their Applications**: Justification, structure, knowledge sources; Expert knowledge acquisition; Expert system languages; ES building tools/shells; Applications of AI in CAD, CAPP, process selection, GT, MRP II, adaptive control, robotics, process control, fault diagnosis, failure analysis, etc.	12
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1	Rich, E., Knight, K. and Nair, S. B., “Artificial Intelligence”, 3rd Ed., Tata McGraw Hill.	2010
2	Russell, S. and Norvig, P., “Artificial Intelligence: A Modern Approach”, 3rd Ed., Prentice-Hall.	2009
3	Dean, T. L., Allen, J., and Aloimonos, Y. “Artificial Intelligence: Theory and Practice”, Benjamin/Cummings Publishing Company.	1995
4	Genesereth, M. R. and Nilsson, N., “Logical Foundations of Artificial Intelligence”, Morgan Kaufmann.	1987

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-517** Course Title: **Automated Materials Handling Systems**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre–requisite: **Nil**

9. Objective: To introduce various automated material handling equipment and their utilization.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction of Material Handling:** Overview of MHE, consideration in MHS design, twenty principles of material handling, the unit load concept.	04
2	**Material Transport Systems:** Industrial trucks, automated guided vehicle systems, monorails and other rail guided vehicles, conveyor systems, cranes and hoists.	06
3	**Evaluation and Selection of Material Handling Layout**: Design of bins and hoppers – flow patterns, measurement of flow properties, design methods, feeders, dischargers, silos, chutes and gates; Bulk material sampling and weighing systems, blending of bulk materials, transportation interface – rail and water. monitoring and control.	14
4	**Analysis of Material Transport Systems:** Rate of deliveries, required number of vehicles, economics of material handling systems.	06
5	**Automated Storage & Retrieval Systems (AS/RS):** Functions of AS/RS, operations of AS/RS, AS/RS components, types of AS/RS, design of an AS/RS, system throughput, size parameters determination of AS/RS.	12
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication / Reprint
1	Allegri, T. H., “Material Handling Principles and Practice”, Krieger Publishing Company.	1992
2	Meyers, F. E. and Stephens, M. P. “Manufacturing Facilities Design and Material Handling”, Prentice Hall.	2000
3	Adam, N. D., Brown, T. W., Rowland, V. D. and Misenheimer, F. P., “ Warehouse & Distribution Automation Handbook”, McGraw-Hill.	1996
4	Tompkins, J. A., White, J. A., Bozer, Y. A. and Tanchoco, J. M, “Facilities Planning”, 4th Ed., John Willey & Sons.	2010
5	Sule, D. R., “Manufacturing Facilities-Location, Planning, and Design”, 3rd Ed., CRC Press.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-520** Course Title: **Advanced Thermodynamics**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0
4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0
5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge of the advanced aspects of classical thermodynamics.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Review of I and II Laws of Thermodynamics**: Transient flow analysis, entropy balance, entropy generation.	5
2.	**Exergy Analysis**: Concepts, exergy balance, exergy transfer, exergetic efficiency, exergy analysis of power and refrigeration cycles.	9
3.	**Real Gases and Mixtures**: Equations of state, thermodynamic property relations, residual property functions, properties of saturation states.	6
4.	**Thermodynamic Properties of Homogeneous Mixtures**: Partial molal properties, chemical potential, fugacity and fugacity coefficient, fugacity relations for real gas mixtures, ideal solutions, phase equilibrium, Rault's law.	8
5.	**Reacting Systems**: I and II law analysis of reacting systems, absolute entropy and the third law, fuel cells, chemical energy, exergetic efficiency of reacting systems, chemical equilibrium, equilibrium flame temperature.	14
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/Reprint
1.	Wark, K., "Advanced Thermodynamics for Engineers", John Wiley & Sons.	1995

2.	Bejan, A., "Advanced Engineering Thermodynamics", 3rd Ed., John Wiley & Sons.	2006
3.	Annamalai, K. and Puri, I.K., "Advanced Thermodynamics Engineering", CRC Press.	2001
4.	Moran, M. J., and Shapiro, H. N., "Fundamentals of Engineering Thermodynamics", 6th Ed., John Wiley & Sons	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-521** Course Title: **Advanced Fluid Mechanics**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**
4. Relative Weightage: **CWS** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**
5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge on advanced analytical tools for fluid flow analysis.
10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Review of Basic Concepts**: Concept of continuum, types of fluid, tensor analysis.	3
2.	**Basic Laws in Integral Form**: Reynold's transport theorem, mass, momentum and energy equations in integral form and their applications.	5
3.	**Differential Fluid Flow Analysis**: Continuity equation, Navier-Stokes equations and exact solutions, energy equation.	7
4.	**Ideal Fluid Flow Analysis**: Two dimensional flow in rectangular and polar coordinates; Continuity equation and the stream function; Irrotationality and the velocity potential function; Vorticity and circulation; Plane potential flow and the complex potential function; Sources, sinks, doublets and vortices; Flow over bodies and d'Alembert's paradox; Aerofoil theory and its application.	8
5.	**Low Reynolds Number Flow**: Approximation of Navier-Stokes equation, approximate solutions of Navier-Stokes equation, Stokes and Oseen flows, hydrodynamic theory of lubrication.	4
6.	**Large Reynolds Number Flow:** Prandtl's boundary layer equations, Blasius solutions, Falkner-Skan solutions, momentum integral equation, Halstein and Bohlen method, thermal boundary layers.	8
7.	**Compressible Fluid Flow**: One dimensional isentropic flow, Fanno and	7

	Rayleigh flows, chocking phenomenon, normal and oblique shocks.	
	Total	**42**

11. Suggested Books:

S.N.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Kundu, P. K., and Cohen, I. M., "Fluid Mechanics", 4th Ed., Academic Press.	2008
2.	Panton, R. L., "Incompressible Flow", 3rd Ed., John Wiley & Sons.	2005
3.	Murlidhar, K., and Biswas, G., "Advanced Engineering Fluid Mechanics", 2nd Ed., Narosa Publishing House.	2005
4.	Batchlor, G.K., "Introduction to Fluid dynamics", Cambridge University Press.	2000
5.	White, F. M., "Viscous Fluid Flow", 3rd Ed., McGraw Hill.	2006
6.	Munson, B. R., Young, D. F., and Okiishi, T. H., "Fundamentals of Fluid Mechanics". 6th Ed., John Wiley & Sons.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-522** Course Title: **Advanced Heat Transfer**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**

8. Pre-requisite: **Nil**

9. Objective: It provides the knowledge of advanced techniques for analysis of heat transfer processes in thermal systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Heat Conduction**: Fourier's law, thermal conductivity of matter, heat diffusion equation for isotropic and anisotropic media, boundary and initial conditions; One-dimensional steady-state conduction through plane wall, cylinder and sphere, conduction with thermal energy generation, heat transfer from extended surfaces, radial fins and fin optimization; Multidimensional-dimensional steady-state heat conduction; Transient conduction – lumped capacitance method and its validity, plane wall and radial systems with convection, semi-infinite solid, muti-dimensional transient heat conduction.	12
2.	**Heat Convection**: Boundary layers concepts, laminar and turbulent flows, conservation equation, non-dimensional analysis, boundary layer equations, Reynolds analogy for turbulent flows; Forced convection inside tubes and ducts – correlations for laminar and turbulent forces convection; Forced convection over exterior surfaces – bluff bodies, packed beds, tube bundles in cross flow, free jet; Natural convection; Combined free and forced convection; Combined convection and radiation.	11
3.	**Heat Transfer with Phase Change**: Nucleate, film and pool boiling, boiling in forced convection; Filmwise and dropwise condensation; Heat pipes	5

4.	**Thermal Radiation:** Fundamental concepts, radiation intensity and its relation to emission, irradiation and radiosity, blackbody radiation, Planck distribution, Wien's displacement law, Stefan-Boltzmann law, surface emission, surface absorption, reflection, and transmission, Kirchoff's law, gray surface; Radiation exchange between surfaces, Poljack's and Gehbart's methods and view factor, blackbody radiation exchange, radiation exchange between diffuse gray surfaces in an enclosure with absorbing and emitting media; Flame Radiation, solar Radiation.	10
5.	**Numerical Methods in Heat Transfer:** Finite difference method for numerical simulation of steady state and transient heat transfer problems, iterative methods for solution of multi-dimensional problems, time integration methods.	4
Total		**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/Reprint
1.	Kreith, F. and Bohn, M. S., "Principles of Heat Transfer", 6^{th} Ed., Thomson Learning.	2007
2.	Burmeister, L. C., "Convective Heat Transfer", 2^{nd} Ed., John Wiley & Sons.	1993
3.	Kays, W. M., Crawford, M. E., and Weigand, B., "Convective Heat and Mass Transfer", 4^{th} Ed., McGraw Hill.	2004
4	Ozisik, M. N., "Heat Conduction", 2^{nd} Ed., John Wiley & Sons.	1993
5.	Siegel, R., and Howell, J. K., "Thermal Radiation Heat Transfer", Taylor & Francis.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-523** Course Title: **Gas Turbines and Compressors**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **DEC/DHC**

8. Pre-requisite: **Nil**

9. Objective: It is intended to give a thorough understanding of gas turbines, compressors, gas turbine cycles, energy and fluid flow dynamics, and power plants based on gas turbines.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Development, classification and field of application of gas turbines.	**3**
2.	**Gas Turbine Cycles:** Ideal and actual cycles, multi-stage compression, reheating, regeneration, combined and cogeneration.	**6**
3.	**Energy Transfer and Fluid Flow Characteristics:** Energy transfer between fluid and rotor, axi-symmetric flow in compressors and gas turbines.	**6**
4.	**Centrifugal Compressors:** Principles of operation, compressor losses, adiabatic efficiency, slip factor, pressure coefficient, power unit, design consideration for impeller and diffuser systems, performance characteristics.	**6**
5.	**Axial Flow Compressors:** Elementary theory, vortex theory, degree of reaction, simple design, elementary air-foil theory, isolated airfoil and cascade theory, three dimensional flow, stages, stage efficiency and overall efficiency, performance characteristics.	**6**
6.	**Turbines:** Axial flow and radial flow turbines, impulse and reaction turbines, fundamental relations and velocity triangles, elementary vortex theory, limiting factors in turbine design, application of airfoil theory to the study of flow through turbine blades, aerodynamic and thermodynamic design considerations, blade	**10**

	materials, blade attachment and blade cooling.	
7.	**Gas Turbine Power Plants:** Fuel and fuel feed systems, combustion systems-design considerations a nd f lame s tabilization, r egenerator t ypes a nd de sign, gas t urbine power plant performance and matching, applications.	**5**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors / Books / Publishers**	**Year of Publication /Reprint**
1.	Saravanamuttoo, H .I.H., R ogers, G.F.C., C ohen, H . a nd Straznicky, P .V., "Gas Turbine Theory", 6th Ed., Pearson Prentice Hall.	2008
2.	Bathie, W. W., "Fundamentals of Gas Turbines", 2nd Ed., John Wiley & Sons.	1995
3.	Boyce, M. P., "Gas Turbine Engineering Handbook", 3rd Ed., Gulf Professional Publishing.	2006
4.	Lefebvre, H. and Ballal, D. R., "Gas Turbine Combustion", 3rd Ed., CRC Press.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical & Industrial Engineering**

1. Subject Code: **MIN-524** Course Title: **Two Phase Flow and Heat Transfer**

2. Contact Hours: **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.): **Theory: 3 Practical: 0**

4. Relative Weightage**: CWS: 25 PRS: 0 MTE: 25 ETE: 50 PRE: 0**

5. Credits**: 4** 6. Semester**: Autumn/Spring** 7.Subject Area**: DEC/DHC**

8. Pre-requisite**: Nil**

9. Objective: The course has been designed to give a thorough understanding of basic mechanism involved in two phase flow and heat transfer with special emphasis on boiling and condensation processes..

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction :** Types of flow; volumetric concentration; void fraction; volumetric flux; relative velocity; drift velocity; flow regimes; flow maps; analytical models.	**05**
2.	**Homogeneous F low:** One dimensional steady homogeneous equilibrium flow; homogeneous friction factor; turbulent flow friction factor.	**08**
3.	**Separated Flow:** Slip; Lockhart-Martinelli method for pressure drop calculation; pressure drop for flow with boiling; flow with phase change.	**07**
4.	**Drift Flow Model:** General theory; gravity flows with no wall shear; correction to simple theory; Armond or Bankoff flow parameters.	**08**
5.	**Boiling:** Regimes of boiling; nucleation; gas nucleation in bulk liquid; growth of bubbles; motion at a heating surface; heat transfer rates in pool boiling; forced convection boiling; heat transfer correlations; maximum heat flux or burnout; metal boiling.	**07**
6	**Condensation:** Nusselt theory; boundary layer treatment of laminar film condensation; experimental results for vertical and horizontal tubes; condensation inside a horizontal tube, condensation outside a horizontal tube.	**07**
	Total	**42**

11. Suggested Books:

S. No.	Author(s) / Title / Publisher	Year of Publication/

		Reprint
1.	Wallis, G.B., “One Dimensional Two Phase Flow,” McGraw Hill	1969
2.	Butterworth, D. and Hewitt, G.F., “Two-phase Flow and Heat Transfer”, Oxford	1977
3.	Collier, J.G., “Convective Boiling and Condensation,” McGraw Hill	1982
4.	Rohsenow, W.M., Hartnett, J.P. and Ganic, E.N. (Ed.), “Handbook of Heat Transfer Fundamentals,” McGraw Hill	1998
5.	Tong, L. S. and Tang, Y.S., “Boiling Heat Transfer and Two-phase Flow,” Taylor & Francis	1997
	Whalley, P.B., “Two-Phase Flow and Heat Transfer,” Oxford Press	1996
6.	Whalley, P.B., “Boiling, Condensation, and Gas-Liquid Flow,” Clarendon Press, Oxford	1987
7.	Chisholm, D., “Two-phase Flow in Pipe Lines and Heat Exchangers,” Longman Inc. New York.	1969

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-525** Course Title: **Solar Energy**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits: **4** 6. Semester: **Autumn/Spring** 7. Subject Area: **DEC/DHC**

8. Pre-requisite: **Nil**

9. Objective: To impart knowledge of solar energy with respect to its availability, utilization and economic viability.

10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Introduction:** Energy demand and supply, energy crisis, conventional and non-conventional energy resources, solar energy applications.	**2**
2.	**Solar radiation:** Sun, solar radiations, attenuation by atmosphere, solar radiation on earth, measurement, presentation and utilization of data.	**6**
3.	**Heat transfer concepts:** Radiation characteristics of surface and bodies, absorbance, reflectance and transmittance, selective surface, sky radiation and wind convection.	**6**
4.	**Flat plate collectors:** General description of flat plate collectors, general characteristics, performance, short term and long term performance, design.	**8**
5.	**Focusing collectors:** General description of focusing solar collectors, concentrators, receivers and orienting systems, general characteristics, performance, materials, design.	**5**
6.	**Energy storage:** Energy storage in solar process system, different types of storages, characteristics and capacity of storage medium, solar pond.	**5**
7.	**Solar heating and cooling:** Passive heating and cooling, nocturnal radiations, green house concept, ponds, active heating and cooling, solar water heaters, absorption cooling, combined solar heating and cooling systems, performance, economics of solar heating and cooling.	**4**

8.	**Solar Process Modeling:** Solar process systems and components, component models, system models.	**2**
9.	**Solar Photovoltaics:** Description and principle of working, performance characteristics, efficiency of solar cells, module design, PV systems, applications.	**4**
Total		**42**

11. Suggested Books:

S. No.	Name of Books / Authors/ Publisher	Year of Publication
1.	Duffie, J .A. a nd B eckman, W .A., " Solar E ngineering of T hermal P rocesses", 4th Ed., John Wiley & Sons, Inc.	2013
2.	Soteris A . K alogirou, " Solar E nergy E ngineering: P rocesses and S ystems", Academic Press	2009
3.	Goswami, D.Y., K reith,F., a nd K reider J ., " Principles of S olar E nergy", 2nd Ed., Taylor & Francis	2000
4.	Sukhatme, S.P. and Naik, J.K., "Solar Energy: Principles of Thermal Collection and storage", 3rd Ed., Tata McGraw - Hill Education	2009
5.	Garg, H .P., & Prakash, J .,"Solar E nergy : Fundamentals a nd A pplications", Tata McGraw - Hill Education	2012
6.	Tiwari, G .N.,"Solar E nergy Fundamentals, Design, M odelling a nd Applications", Narosa publishing House	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-526** Course Title: **Advanced Gas Dynamics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Both** 7.Subject Area**: DEC/DHC**

8. Pre-requisite**: Nil**

9. Objective: To provide knowledge of advanced topics in gas dynamics related to shock waves, perturbations and methods of characteristics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Basic E quations:** Application of the general differential e quation o f c ontinuity, momentum a nd e nergy t o c ompressible i nviscid f luids, c ompressible B ernoulli equation, irrotational flow, velocity potential and stream function.	**6**
2.	**Shock Waves in Supersonic Flow:** A review of normal shock relations, Mach waves, equations f or f inite s trength obl ique s hock waves, R ankine-Hugoniot r elations, extended Prandtl relation, hodograph shock polars, reflection and interaction of shock, curved shocks.	**7**
3.	**Small Perturbation T heory:** Linearization, s mall pe rturbation e quation, pr essure coefficient, s ubsonic f low pa st a w ave s haped wall, ge neral s olution of s upersonic flows, supersonic flow past a wave – shaped wall, elements of supersonic thin aerofoil theory.	**9**
4.	**Similarity Rules:** Similarity r ules be tween two-dimensional s ubsonic c ompressible flows a nd i ncompressible f lows, G othert r ule, P randtlGlauert r ule, a pplication t o supersonic flows.	**6**

5.	**Hodograph Method for Subsonic Flow:** Hodograph equations for two-dimensional subsonic flows, Chaplygin's equation, the tangent gas approximation of Karman and Tsien for subsonic flows, Karman-Tsien formula for pressure correction, comparison with Prandtl-Glauert rule	**7**
6.	**Method of Characteristics for Supersonic Flow:** Method of characteristics for two dimensional supersonic flows, the characteristic curves, equation of hodograph characteristics, characteristics network, computational methods.	**7**
	Total	**42**

11. Suggested Books:

S. No.	Author(s) / Title / Publisher	Year of Publication /Reprint
1.	Anderson Jr., J.D., "Modern Compressible Flow: With Historical Perspective", 3rd Ed., Tata McGraw-Hill	2012
2.	Liepmann, H.W. and Roshko, A., "Elements of Gas Dynamics", Dover Publication.	2002
3.	Rathakrishnan, E., "Applied Gas Dynamics", John Wiley & Sons.	2010
4.	John, J. E. A. and Keith, T. G., "Gas Dynamics", 3rd Ed., Prentice Hall.	2006
5.	Zucker, R. D. and Biblarz, O., "Fundamentals of Gas Dynamics", 2nd Ed., John Wiley & Sons.	2002
6.	Oosthuizen, P. H. and Carscallen, W. E. "Introduction to Compressible Fluid Flow", 2nd Ed. , CRC Press	2013

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-527** Course Title: **Computational Fluid Dynamics and Heat Transfer**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Both** 7.Subject Area**: DEC/DHC**

8. Pre-requisite**:** **Nil**

9. Objective: To impart knowledge of the basic tools for numerical simulation of fluid flow and heat transfer processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Conservation equations; Mass, momentum and energy equations; Conservative forms of the equations and general description.	**3**
2.	**Classification and Overview of Numerical Methods:** Classification into various types of equations -- parabolic elliptic and hyperbolic; Boundary and initial conditions; Overview of numerical methods.	**3**
3.	**Finite Difference Method:** Introduction, finite difference approximations, Taylor series expansion, polynomial fitting, approximation of boundary conditions, applications to conduction and advection-diffusion problems.	**5**
4.	**Finite Volume Method:** Basic methodology, finite volume discretization, approximation of surface and volume integrals, interpolation methods – central, upwind and hybrid formulations and comparison for convection-diffusion problem.	**4**
5.	**Finite Element Method:** Introduction to Rayleigh-Ritz, Galerkin and least square methods, interpolation functions, one and two dimensional elements, applications.	**4**
6.	**Methods of Solution:** Solution of finite difference equations, iterative methods, matrix inversion methods, ADI method, operator splitting, fast Fourier transform, applications.	**4**

7.	**Time integration Methods:** Single and multilevel methods; predictor-corrector methods; stability analysis; Applications to transient conduction and advection-diffusion problems.	**4**
8.	**Numerical Grid Generation:** Basic ideas, transformation and mapping, unstructured grid generation.	**3**
9.	**Navier-Stokes Equations:** Explicit and implicit methods; SIMPLE type methods; fractional step methods	**4**
10.	**Phase Change Problems:** Different approaches for moving boundary, variable time step method, enthalpy method.	**4**
11.	**Turbulence modeling:** Reynolds averaged Navier-Stokes equations, RANS modeling, DNS and LES.	**4**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors / Books / Publishers**	**Year of Publication /Reprint**
1.	Anderson, D .A., Tannehill, J .C. and Pletcher, R .H., " Computational Fluid Mechanics and Heat Transfer", 3^{rd} Ed., Taylor & Francis	2011
2.	Anderson, J.D., Jr., "Computational Fluid Dynamics", McGraw Hill.	1995
3.	Ferziger, J. H. and Peric, M., "Computational Methods for Fluid Dynamics", 3^{rd} Ed., Springer.	2003
4.	Versteeg, H. and Malalasekra, M., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", 2^{nd} Ed., Pearson Education	2007
5.	Reddy, J. N. and Gartling, D. K., "The Finite Element Method in Heat Transfer and Fluid Dynamics", 3^{rd} Ed., CRC Press.	2010
6.	Chung, T. J., "Computational Fluid Dynamics". 2^{nd} Ed., Cambridge University Press	2010
7.	Patankar, S. V., "Numerical Heat Transfer and Fluid Flow", Taylor and Francis	1980

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-528** Course Title: **Boundary Layer Theory**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **DEC/DHC**

8. Pre-requisite: **Nil**

9. Objective: The course is intended to provide of boundary layer in fluid flow and to inapt a clean clear physical understanding analytical ability for prediction; investigation and control of the boundary layers.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Introduction:** Ideal and real fluids, the concept of boundary layer; Navier- Stokes equations, the limiting cases of layer and small Reynolds number, energy equation; Exact solutions of N-S Equation	**6**
2	**Laminar Boundary Layer Equation:** Two dimensional equations; displacement and momentum thickness; general properties of the boundary layer equations; skin friction.	**8**
3	**Similarity solutions:** Wedge flow and its particular cases; flow past a cylinder; two dimensional flow in straight channel	**6**
4	**Approximate Methods:** Karman-Pohlhausen methods; Numerical methods; Axially symmetrical boundary layer: Circular jet; body of revolution; Manglers transformation	**6**
5	**Stability of laminar flow:** Transition to turbulence; Turbulent flow fundamentals	**4**
6	**Boundary Layer Control:** Different methods; flaw over a flat plate with uniform section	**4**
7	**Turbulent Boundary Layer:** Two-dimensional equation; Prandtl's mixing layer theory; Karman's hypothesis; Universal velocity distribution; flow over a flat plate; skin friction drag.	**4**
8	**Thermal Boundary layer:** Two-dimensional equations; forced and natural convection over flat plate; natural convective flow over a vertical plate; effect of Prandt'l number.	**4**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication
1	Schlichting H., “Boundary Layer Theory”, Springer-Verlag	2004
2.	Rozenhead L., “Laminar Boundary Layers”, Dover Publications	1988
3	Hinze J.O., “Turbulence”, McGraw Hill	1975
4	Kays W.M. and Crawford M.E., “Convective Heat & Mass Transfer”, McGraw Hill	1993
5.	Wellty J., Wicks C.E. and Wilson R.E., “Fundamentals of Momentum Heat and Mass Transfer”, John Wiley & Sons	2007
6	White F M, “Viscous fluid flow” 3rd Edition;McGraw hill co.	2011

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-529** Course Title: **Turbulent Flows**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Fluid Mechanics**

9. Objective: To provide essential physical understanding and analytical, experimental, modeling and computational tools for the analysis of turbulent flows.

10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Introduction:** Introduction to turbulence and equations of fluid motion.	3
2.	**Statistical descriptions of turbulent flows:** random nature of turbulence, random variables, probability distributions, and averaging techniques.	5
3.	**Experimental techniques for measurement of turbulent flows:** hot-wire and hot-film anemometry, laser Doppler Velocimetry, and Particle image velocimetry.	5
4.	**Dynamics of turbulence:** scales of turbulent motion, energy cascade, Kolmogorov hypothesis, structure function, two-point correlations, Fourier modes and velocity spectra.	7
5.	**Homogeneous and isotropic turbulence:** implications of isotropy, energy decay, energy spectrum, homogeneous shear flows.	5
6.	**Anisotropic turbulence:** wall bounded flows (channel flow, pipe flow, boundary layers) and free shear flows (jets and mixing layers), coherent structures.	7
7.	**Turbulence modeling:** RANS modeling, eddy viscosity models, algebraic Reynolds stress models and near-wall models.	5

8.	**Direct numerical simulation and large eddy simulation**: filterning, subgrid scale models (smagorinsky and dynamic models), LES in wave number space.	**5**
Total		**42**

11. Suggested Books:

S. No.	Name of Books / Authors/ Publisher	Year of Publication / Reprint
1.	Pope, S.B., "Turbulent Flows", Cambridge University Press.	2000
2.	Bernard, P., and Wallace, J.A., "Turbulent Flow", John Wiley & Sons Inc.	2002
3.	Libby, P. A., "An Introduction to Turbulence", Taylor & Francis.	1996
4.	Mathieu, J., and Scott, J., "Introduction to Turbulent Flow", Cambridge University Press.	2000
5.	Biswas, G., and Eswaran, V., "Turbulent Flows", Narosa Publishing House.	2002
6.	Piquet, J., Richards, J.A., Jia, X., "Turbulence Flows: Models and Physics", Springer-Verlag.	2001
7.	Tennekes, H., and Lumley, J.L., "A First Course in Turbulence", MIT Press.	1972

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical & Industrial Engineering**

1. Subject Code: **MIN-530** Course Title: **Cold Preservation of Food**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weightage**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits**: 4** 6. Semester**: Autumn/Spring** 7.Subject Area**: DEC/DHC**
8. Pre-requisite**:** **Nil**
9. Objective: To expose students to the various aspects of cold preservation techniques for the perishable commodities. Topics on Newer techniques of Food Preservation have also been included.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Necessity of food preservation; general techniques; cold preservation of food.	**05**
2.	**Biological Aspects:** Live and dead foods; biology of food products such as fruits, vegetables, milk, meat and fish; effect of temperature on food ingredients; respiration rates of food products; controlled atmospheric storage; diseases and deterioration of foods.	**10**
3.	**Cold Preservation of Food:** Short and long term preservation; methods of chilling, freezing and freeze drying; heat and mass transfer analysis of cooling and freezing.	**09**
4.	**Cold Storages:** Necessity and present status in the country; site selection, building constructional features, load calculation, equipment, selection, safety consideration, insurance and management of cold storages; storage of some important food products; modem trends in cold storage practices.	**10**
5.	**Refrigerated Food Handling:** Preparation for cooling/ freezing; packaging of foods; modes of transportation land, sea and air; their thermal, load and equipment; marketing of refrigerated food.	**08**
	Total	**42**

11. Suggested Books:

S. No.	Author(s) / Title / Publisher	Year of Publication/ Reprint
1	StoeckerW.F.,"Refrigeration and Air-conditioning", McGraw Hill	2002
2.	Moravek J., " Air Conditioning Systems: Principles, Equipment, and Service", AHRI, , Prentice Hall	2000
3	"ASHRAE Handbooks", ASHRAE.	2013
4	Wang, S. "Handbook of Air Conditioning and Refrigeration", Tata McGraw Hill Education	2000
5.	Arora, C.P., " Refrigeration and Air conditioning", Tata-McGraw Hill	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-531** Course Title: **Hydrodynamic Machines**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage**: CWS: 25 PRS:0 MTE: 25 ETE: 50 PRE: 0**

5. Credits**: 4** 6. Semester**: Autumn** 7.Subject Area**: PEC**

8. Pre-requisite**:** **Nil**

9. Objective: To expose students to various strategic issues related to Hydrodynamic machine such as Turbines, Pumps etc.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Introduction:** Basic fluid mechanics of turbo-machinery; the torque-momentum and the head- momentum equations; one-dimensional theory and its limitations; two- dimensional theory of flow through axial and radial-flow machines; three-dimensional effects.	**8**
2	**Classification of Hydrodynamic machines:** Classification of turbines and pumps, various forms of runners.	**2**
3	**Impulse Turbines:** General theory of impulse machines; performance characteristics; design of runner; bucket shape and size; design of nozzles; regulation mechanisms; penstock design.	**8**
4	**Reaction Turbines:** General theory of reaction machines; performance characteristics; types; Francis and Kaplan turbines; runner design; blade design; design of the spiral casing; guide vanes and draft tube design; theory of cavitation flows in hydrodynamic runners.	**10**
5	**Hydrodynamic Pumps:** Classification of pumps and various forms of pump impellers; general theory of centrifugal pumps; performance characteristics; design of casings and diffusers; cavitation effects in impellers.	**8**
6	**Hydrodynamic Transmissions:** General features; primary and secondary units of the systems; fluid couplings and torque converters; general theory; performance characteristics; basic design considerations;	**6**
	Total	**42**

11. Suggested Books:

S. No.	Author(s) /Title / Publisher	Year of Publication/ Reprint
1.	Logan, E., Turbomachinery: Basic theory and applications, CRC Press	2009
2.	Gopalakrishnan, G ., A Treatise on T urbomachines, S citech P ublication, Chennai	2002
3	Dixon, S., L., Fluid mechanics and thermodynamics of turbomachinery, 5th Ed., Elsevier	2005
4	Stepanoff, A ., J ., Centrifugal & A xial F low pu mps: Theory, de sign and Application, John Wiley	1957
5.	Daugherty, R., L., Hydraulic turbines with a chapter on Centrifugal pumps, McGraw-Hill	1920
6.	Karassik, I., J., Pump Handbook, 3rd Edition, McGraw-Hill International Edition	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Departmentof Mechanical & Industrial Engineering**

1. Subject Code: **MIN-532** Course Title: **Renewable Energy Systems**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Both** 7.Subject Area**: RASE**

8. Pre-requisite**:** **Nil**

9. Objective: This c ourse w ill provide an ex posure r egarding R enewable E nergy Systems towards sustainable development of the society.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Introduction:** Energy and development, energy demand and availability, energy crisis, conventional a nd non -conventional sources, r enewable a nd non-renewable en ergy resources, environmental i mpact of c onventional e nergy us age, basic con cepts of he at and fluid flow useful for energy systems.	**6**
2	**Solar E nergySystems:** Solar r adiations da ta, solar energy collection, storage and utilization, solar w ater he ating,solar air h eating,solar power ge neration,solar refrigeration and air conditioning, solar energy system economics.	**7**
3	**Micro A nd S mall H ydro E nergy S ystems:** Resource as sessment of m icro and small hydro power, micro, mini and small hydro power systems, economics, pump as turbine, special engines for low heads, velocity head turbines, hydrams, water mills.	**6**
4	**Biomass Energy Systems:** Availability of biomass- agro, forest, animal, municipal and other residues; Bioconversion technologies; cooking fuels, biogas, producer gas, power alcohol from biomass; Power generation,internal engine modifications and performance, system economics.	**6**
5	**Wind Energy Systems:** Wind data, horizontal and vertical axis wind mills, wind farms, performance and economics of wind energy.	**6**

6	**Geothermal Energy Systems:** Vapor dominated, liquid dominated and petrothermal systems; Hybrid systems.	**3**
7	**Energy from the Oceans:** OTEC systems, open and closed types; Wave energy conversion systems; Tidal energy conversion systems.	**4**
8	**Integrated Energy Systems:** Concept of integration of conventional and non-conventional energy resources and systems; integrated energy system design and economics.	**4**
	Total	**42**

11. Suggested Books:

S. No.	Author(s) /Title / Publisher	Year of Publication/ Reprint
1	Duffie, J.A. and Beckman, W.A., "Solar Engineering of Thermal Processes", John Wiley.	2006
2	Bungay, H.R., "Energy, the Biomass Option", John Wiley.	1981
3	Fowler, K.M., "Energy & Environment",McGraw Hill.	1984
4	Sukhatme, S.P. and Nayak, J.K., " Solar Energy: principles of thermal collection and storage", McGraw Hill.	2009
5	Boyle, G., "Renewable Energy – Power for a Sustainable Future", 2nd Ed., Oxford University Press.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical & Industrial Engineering**

1. Subject Code: **MIN-533** Course Title: **Refrigeration & Air-conditioning System Design**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Autumn/Spring** 7.Subject Area**: DEC/DHC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce the students the basic design principles of refrigeration and Air conditioning equipment and component such as evaporators, condensers, capillary tubes, expansion valves, etc.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Load C alculations:** Solar heat gains through structures; review of refrigeration and air conditioning load calculations.	3
2	**Refrigeration S ystems:** Vapour compression; multiple evaporator and compound compression system with and without inter cooling; dual compressors; cascade systems; Vapour absorption system-analysis. Solid carbon dioxide; principle of production; three stage system with water and flash inter-cooler; pressure snow chambers; regenerative liquid; binary system.	6
3	**Compressors:** Performance characteristics and capacity control of reciprocating, rotary and centrifugal compressors; screw compressors; hermetically sealed units; analysis of centrifugal compressors. Compressor Design.	5
4	**Condensers:** Water —cooled and air-cooled condensers; overall heat transfer coefficients; fouling factor; performance characteristics and design; performance and heat transfer processes in evaporative condenser.	5
5	**Evaporators:** Flooded and dry expansion type evaporators, liquid chiller, overall performance of evaporators and design of evaporators.	4
6	**Expansion D evises:** Capillary tubes; system design factors; pressure and temperature distribution; ASHRAE simplified calculation	4

	procedure. Expansion valves; operation and performance calculation of thermostatic expansion valve; application of constant pressure expansion valve.	
7	**Thermal Comfort:**Human thermoregulation; energy balance; thermal exchange with environment	**3**
8	**Indoor E nvironmental H ealth an d A ir C ontaminants:**Airborne contaminants: particles, gaseous contaminants, outdoor air ventilation and health;	**5**
9	**Pressure D rop an d H eat T ransfer:** Two phase flow; flow regimes; maps; pressure drop in evaporator and condensers; Martinelli relation	**4**
10	**Applications an d Sys tem D esign:** Ice manufacture; Design of refrigerated ware houses. datacentre and clean room.	**3**
	Total	**42**

11. Suggested Books:

S. No.	**Author(s) / Title / Publisher**	**Year of Publication/ Reprint**
1	StoeckerW.F.,"Refrigeration and Air-conditioning", McGraw Hill	2002
2.	Moravek J., "Air Conditioning Systems: Principles, Equipment, and Service", AHRI, , Prentice Hall	2000
3	"ASHRAE Handbooks", ASHRAE.	2013
4	Wang, S."Handbook of Air Conditioning and Refrigeration", TataMcGraw Hill Education	2000
5.	Arora, C.P., " Refrigeration and Air conditioning", Tata-McGraw Hill	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical & Industrial Engineering**

1. Subject Code: **MIN-534** Course Title: **Air-conditioning and Ventilation**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Autumn/Spring** 7.Subject Area**: DEC/DHC**

8. Pre-requisite**: Nil**

9. Objective: To introduce the students the basic physiological principles, comfort charts, air conditioning systems and the design of piping and ducts.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Psychrometery:** moist air properties; mass transfer and evaporation of water into moist air; theory of psychrometer; correlation of w.b.t. with temperature of adiabatic saturation; Lewis number; construction of psychrometric chart.	**6**
2	**Physiological Principles:** Comfort; thermal interchanges with environment; physiological body regulatory processes against heat or cold ; high and low temperature hazards; extreme environmental conditions; heat stress index; ASHRAE comfort standards.	**4**
3	**Simultaneous Heat and Mass Transfer:** Direct contact transfer equipment; simple air washer and indirect evaporative cooling contact mixture principle; enthalpy potential; basic equation for direct contact transfer equipment; graphical and analytical methods for heat and mass transfer analysis of air washers with heated and chilled water sprays; cooling towers.	**6**
4	**Extended Surface Heat Transfer Apparatus:** Cooling and Dehumidifying coils, Design of finned surfaces, Adsorption cooling systems.	**8**
5	**Ventilation:** Necessity; ventilation standards; natural and mechanical ventilation; forces for natural ventilation; general ventilation rules; advantages of mechanical ventilation; various methods; ejector systems ; determining ventilation requirement; use of decay equation.	**6**
6	**Air Cleaning:** Physical and chemical vitiation of air; permissible concentration of air contaminants; mechanical and electronic air	**4**

	cleaners; dry and wet filters; air sterilization; odour control.	
7	**Steam Heating Systems:** Elements of steam, water and warm-air heating systems; radiators and convectors. Design of an year-round air conditioning system.	**4**
8	**Piping and Ducts:** Pressure drops in piping and fittings; design of water and refrigerant piping; Air conditioning duct design methods.	**4**
	Total	**42**

11. Suggested Books:

S. No.	Author(s) / Title / Publisher	Year of Publication/ Reprint
1	Stoecker, W.F., and Jones, J.W., “Elementary Refrigeration & Air conditioning”, McGraw Hill	2002
2	Dosset, R.J., Principles of Refrigeration, Pearson Education Asia	2002
3	Arora, C.P.,“Refrigeration and Air conditioning”, Tata-McGraw Hill	2005
4	Prasad, M., “Refrigeration and Air conditioning”, New Age International	2005
5	ASHRAE Handbook (Fundamentals)	2013

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-535** Course Title: **Cryogenic Systems**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Spring** 7. Subject Area**: DEC/DHC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce the student to the field of low temperature engineering *(cryogenics)* which has applications in rocket propulsion, electronics, biological and medical science, food preservation, mechanical design and etc.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Introduction, Historical background, Present area involving cryogenics	**4**
2	**Low Temperature Properties of Engineering Materials:** Mechanical properties, Thermal properties, Electrical and Magnetic Properties, Properties of cryogenic fluids	**4**
3	**Gas-Liquefaction System:** Joule-Thomson effect, Adiabatic expansion, Simple Linde-Hampson system, Precooled Linde-Hampson system, Linde dual-pressure system, Cascade system, Claude system, Kapitza system, Collins helium liquefaction system,	**6**
4	**Critical Components of Liquefaction System:** Effect of heat exchanger effectiveness on system performance, Effect of compressor and expander efficiency on system performance, Effect of heat transfer to the system	**6**
5	**Cryogenic Refrigeration System:** Philips refrigerator, Importance of regenerator effectiveness for Philips refrigerator, Gifford-McMohan refrigerator	**6**
6	**Measurement Systems for Low Temperatures:** Temperature measurement, Flow rate measurement, Liquid level measurement.	**4**

7	**Cryogenic Storage and transfer Systems:** Cryogenic fluid storage vessels, insulations, cryogenic transfer systems	**4**
8	**Vacuum Technology:** Importance of Vacuum technology in cryogenics, Flow regimes in vacuum systems, Conductance in vacuum systems, Calculation of pump-down time for a vacuum systems, Components of a vacuum systems, Mechanical vacuum pumps, Diffusion pumps, Ion pumps, Cryopumping. Vacuum gauges and valves.	**8**
	Total	**42**

11. Suggested Books:

S. No.	**Author(s) / Title / Publisher**	**Year of Publication/ Reprint**
1.	Barron R.F.,"Cryogenic Systems", Oxford University Press	1985
2.	Timmerhaus K.D. and Flunn T M,"Cryogenic Process Engineering", Plenum Press	1989
3.	Fundamentals of Cryogenic Engineering, PHI	2010
4.	Cryogenic Heat Transfer, Taylor & Francis Ltd	1999
5.	Cryogenic Mixed Refrigerant Processes, Springer-Verlag New York Inc.	2008
6.	Kays, W.M., and London, A.L., "Compact Heat Exchangers", Krieger Publishing Company.	1998

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-536** Course Title: **Convective Heat & Mass Transfer**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits: **4** 6. Semester: **Both** 7. Subject Area: **RASE**

8. Pre-requisite: **Nil**

9. Objective: The course discusses exclusively the various aspects of the convective heat and mass transfer.

10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Introduction**: Concepts and Conservation Principles & Laws, Differential formulations of the basic laws: Equations of continuity, Equation of momentum, energy, mass & Entropy.	**9**
2.	**Approximate Solutions**: Integral Equation, Laminar Boundary Layers, Laminar Heat Transfer in Ducts	**8**
3.	**Natural/Free convection**: Internal & External Flow, Dimensional Analysis & Similarity Principles	**8**
4.	Turbulence fundamentals & Turbulence Boundary layer flow	**5**
6.	Boiling & Condensation	**4**
7.	Convective Mass Transfer & Molecular Diffusion	**4**
8.	Simultaneous Heat & Mass Transfer	**4**
	Total	**42**

11. Suggested Books:

S.No.	Name of Books / Authors / Publisher	Year of Publication
1.	Kays, W . M ., C rawford, M . E ., a nd W eigand, B . " Convective H eat a nd M ass Transfer", Tata McGraw Hill.	2005
2.	Latif M Jiji, "Heat Convection", 2nd Edn,, Springer	2009
3.	Bejan, A, Convection Heat Transfer, 3rd Edn, John Wiley & Son Inc	2004
4.	Kakac, S and Yener, Y, Convective Heat Transfer, 2nd Edn, CRCPress	1995
4.	Burmeister L.C., "Convection Heat Transfer", John Wiley & Son Inc.	1993
5.	Arpaci, V. S.,and Larsen, P. S., "Convection Heat Transfer", Prentice Hall, Inc.	1984

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-537** Course Title: **I.C. Engines**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits: **4** 6. Semester: **Both** 7. Subject Area: **DEC/ DHC**

8. Pre-requisite: **Undergraduate level course on Engineering Thermodynamics**

9. Objective: The course is advanced level course of IC Engines and deals with the analysis of engine processes

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Introduction:** Introduction and Historical Perspective.	2
2	**Thermodynamic analysis of I C Engines Cycle:** Properties of working fluid, thermodynamic charts, and unburned mixture charts burned mixture and, fuel air cycle analysis, Real cycles, availability analysis of engine processes.	7
3	**Gas Exchange Processes:** Inlet and exhaust processes in the four stroke cycle, volumetric efficiency quasi-static and dynamic effects, flow through valves. Scavenging in the two- stroke cycle engines scavenging parameters and models, actual scavenging processes, flow through ports. Supercharging and turbocharging, basic relationships, compressors, turbines characteristics, matching of compressor, turbines and engine characteristics.	11
4	**Combustion in SI Engines:** Essential features of the process, thermodynamic analysis of SI engine combustion, combustion process characterization, cyclic variations in combustion.	6
5	**Combustion in Compression:** Ignition Engines: Essential features of process, types of diesel combustion systems, phenomenological model of compression- ignition engine combustion. Fuel spray behaviour, spray structure, atomization, spray penetration droplet size distribution, spray evaporation, ignition delay.	8

6	**Pollutant Formation and Control:** Nature and extant of problem, Nitrogen Oxides. Kinetics of NO formation, NO_x formation in spark- ignition engines, NO_x formation in CI engines. Carbon monoxide, Unburned hydrocarbon emissions. Particulate emissions exhaust gas treatment, catalytic converters, three way catalysts, particulate traps.	**8**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication
1	Heywood J.B., "Internal Combustion Engine Fundamentals", McGraw Hill	1988
2.	Stiesch, G., "Modeling Engine Spray and Combustion Processes", Springer-Verlag.	2003
3	Ferguson C.R.,"Internal Combustion Engines", John Wiley	2000
4	Oppenheim, A.K., " Combustion in Piston Engines" Springer	2004
5.	Pundir, B.P., " I C Engines Combustion and Emissions" Narosa	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-538** Course Title: **I.C. Engine Combustion Processes Modeling**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits: **4** 6. Semester: **Both** 7. Subject Area: **DEC/DHC**
8. Pre-requisite: **Course on I.C. Engines at U.G. level / MI 537**
9. Objective: The course is intended to expose the students to the most widely used mathematical models for in-cylinder spray and combustion processes. These processes are most important for fuel economy and pollutant emissions.
10. Details of Course:

S. No.	Particulars	Contact Hours
1.	Essential features of combustion process in S.I. and C.I. engines, Flame structure and speed, spray structure, auto ignition	**4**
2.	Engine Combustion Modeling – An overview	**2**
3.	Modeling Fluid Motions in Engines, intake jet flow, swirl generation during induction squish, prechamber flows, crevice flow and blow by	**6**
4.	Modeling Flame Propagation and Heat Release in Engines, laminar burning speed, flame propagation relations, heat release in diesel engines, zero dimension burning rate function free gas jet theory, packet models	**8**
5.	Knock, fundamentals, kinetic modeling of hydrocarbon combustion, autoignition, knock models	**6**
6.	Modeling Spray, spray equation, droplet kinematics, spray atomization, droplet breakup droplet/droplet and spray wall interactions, fuel vaporization	**8**
7.	Modeling pollutant formation in SI and CI engines, Models for NOx, CO and soot formation	**8**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication
1.	Wood, H., “Internal Combustion Engine Fundamentals”, McGraw Hill Inc.	1988
2.	Stiesch, G., “Modeling Engine Spray and Combustion Processes”, Springer-Verlag.	2003
3.	Merker, G. P, “Simulating Combustion,” Springer	2006
4.	Sirignano, W. A., “Fluid Dynamics and Transport of Droplets & Sprays”, Cambridge University Press	2000
5.	Warnatz, J., Mass, U., and Dirbble, R. W.,“Combustion: Physical and Chemical Fundamentals, Modeling and simulation, Experiments, Pollutant Formation”, Springer-Verlag	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-539** Course Title: **Micro & Nano Scale Thermal Engineering**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Course on Fluid Mechanics, Heat & Mass Transfer**

9. Objective: To provide understanding of heat transfer and fluid flow at the micro-and nano-scale.

10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Introduction:** Basic statistical thermodynamics, quantum theory, and kinetic theory, Photon and electron transport processes.	**5**
3.	**Thermal characteristics**: Thermal properties at the nano scale –heat capacity & thermal conductivity, Thermoelectricity and applications.	**5**
4.	**Microfluidics**: Intermolecular forces, states of matter, liquid and gas flows, continuum assumption, governing equations, Constitutive relations, slip theory, surface tension and interfacial energy, Young-Laplace equation, wetting and contact angles, capillary flows, Electrokinetic flows.	**8**
5.	**Convection heat transfer**: Fundamentals, Laminar convection –Internal flow, Boiling and condensation, Single-phase heat transfer in micro channels, Two-phase flow heat transfer in micro channels continued.	**6**
6.	**Radiation heat transfer**: Fundamentals of thermal radiation, Radiative properties of nano materials, Nano photonics and applications.	**6**
7.	**Sensors**: Microscale thermal sensors and actuators, Nanofluids, Micro fluidic component: micro pump, micro valve, micro flow sensor, micro mixture	**8**
8.	**Micro Fabrications**: Micro fabrication techniques, Photolithography, Etching, Oxidation, spin coating, micro molding, polymer micro fabrication	**4**
Total		**42**

11. Suggested Books:

S. No.	Author(s) / Title / Publisher	Year of Publication / Reprint
1.	Zhuomin, M.Z., “Nano/Microscale Heat Transfer”, McGraw Hill.	2007
2.	Nguyen, N.T., Werely, S.T., “Fundamental & application of micro fluidics”, Artech House Inc.	2002
3.	Brian Kirby, “Micro- and Nano scale Fluid Mechanics: Transport in Micro fluidic Devices ”, Cambridge University Press.	2010
4.	Zhuomin, Z., “Microscale Energy Transport”, MacGraw hill co.	2007
5.	Tien, C.L., Majumdar, A., and Gerner, F.M., “Microscale Energy Transport”, Taylor & Francis.	2003
6.	Celata, G.P., “Heat Transfer and Transport Phenomena in Microscale”, Begell House.	2004
7.	Kakac, S., Vasiliev, L.L., B ayazitoglu, Y ., Y ener, Y ., “ Microscale H eat T ransfer: Fundamentals and Applications”, Springer-Verlag.	2005
8.	Madou, M.J.,” Fundamental of Micro fabrication”, CRC press.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-540** Course Title: **Combustion**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits: **4** 6. Semester: **Both** 7. Subject Area: **DEC/DHC**

8. Pre-requisite: **Nil**

9. Objective: To expose students to the basic principles involved in the combustion phenomenon and to enhance their understanding of various practical combustion systems and problems.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Introduction:** Importance of combustion, combustion equipment hostile fire problems, pollution problems arising from combustion.	**2**
2	**Thermodynamics of Combustion:** Enthalpy of formation, enthalpy of reaction, heating values, first and second law analysis of reacting systems, chemical equilibrium, equilibrium composition, adiabatic and equilibrium flame temperature.	**6**
3	**Kinetics of Combustion:** Law of mass action, reaction rate, simple and complex reactions, reaction order and molecularity, Arhenius Law, activation energy, Chain reaction steady state and partial equilibrium approximations. Chain explosion, Explosion limits and oxidation characteristics of hydrogen, carbon monoxide and hydrocarbons.	**8**
4	**Flames: Premixed Flames:** structure and propagation of flames in homogeneous gas mixtures; simplified Rankine Hugoniot relations; properties of hugoniot curve; analysis of deflagration and detonation branches, properties of Chapman Jouguet wave. Laminar flame structure; theories of flame propagation and calculation of flame speeds, flame speed measurements. Stability limits of laminar flames; flammability limits and quenching distance; bumer design. Mechanisms of flame stabilization in laminar and turbulent flows; flame quenching. Diffusion flames; comparison of diffusion with premixed flame. Combustion of gaseous fuel jets Burke and shumann development.	**12**

5	**Burning of Condensed Phase:** General mass burning considerations, combustion of fuel droplet in a quiescent and convective environment. Introduction to combustion of fuel sprays.	**6**
6	**Ignition:** Concepts of ignition, chain ignition, thermal spontaneous ignition, forced ignition.	**4**
7.	**Combustion Generated Pollution & its Control:** Introduction, nitrogen oxides thermal fixation of atmospheric nitrogen prompt NO, thermal NO_x formation and control in combustors Fuel NO_x and control, post —combustion destruction of NO_x, Nitrogen dioxide carbon monoxide oxidation — quenching, hydro carbons, sulphur oxides	**4**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication
1.	Glassman, I..,"Combustion", 4th edition Academic Press	2008
2.	Turns, S. R., " An Introduction to Combustion, concepts and applications," 3rd edition, McGraw Hill	2011
3	Kuo, K. K., "Principles of Combustion," 2nd edition, John Wiley	2008
4	Law, C.K., "Combustion Physics," Cambridge University Press	2006
5.	Williams F.A.,"Combustion Theory", Addison Wesley	1993

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-541** Course Title: **Bio – fluid Mechanics**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Fluid Mechanics**
9. Objective: To provide an understanding fluid dynamical phenomena in biological systems in general, and human physiological system (such as cardio-vascular, pulmonary, ocular, renal and musculo-skeletal) in particular.
10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Introduction:** Overview of basic anatomy and physiology from fluid flow perspective.	**4**
2.	**Review of basic equations and constitutive models**: mass and momentum conservation, models for non-Newtonian fluids.	**4**
3.	**Blood rheology and mechanics of circulation:** composition, structure and flow properties of blood, structure, flow and pressure characteristics of the blood flow in cardio-vascular system, flow of non-Newtonian fluids in elastic tubes.	**7**
4.	**Arterial wave propagation**: oscillatory and pulsatile flow, pulse waves, behaviour at bifurcations, wave propagation in flexible tubes.	**7**
5.	**Flow through the pulmonary system:** structure and function of pulmonary system, fluid exchange processes, fluid mechanics of breathing.	**5**
6.	**Flow and lubrication in musculo-sketetal system:** hemodynamics of red blood cells, synovial fluid in joints.	**5**
7.	**Flow through the porous media**: oxygen diffusion from blood to tissues, flow in ocular and renal system.	**5**
8.	**Computational biofluid mechanics:** computational methods for flow and wave propagation through elastic tubes, flow through porous media	**5**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication / Reprint
1.	Fung, Y. C., "Biomechanics: Circulation", Springer-Verlag.	2010
2.	Chandran, K. B., Yoganathan, A.,and Rittgers, S., "Fluid Mechanics in the Human Circulation", Pearson Education.	2005
3.	Humphrey, J. D., and Delange, S. L., "An Introduction to Biomechanics", Springer-Verlag.	2004
4.	Fournier, R. L. L., "Basic Transport Phenomena in Biomedical Engineering, CRC press, 3rd Edition.	2011
5.	Mazumdar, J. N., "Biofluid Mechanics", World Scientific.	1992
6.	Pedley, T. J., "Fluid Mechanics of Large Blood Vessels", Cambridge University Press.	2008
7.	Caro, C. G., Pedley, T. J., Schroter, R. C., Seed, W. A., "Mechanics of the Circulation", Cambridge University Press.	2012

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-542** Course Title: **Energy Management**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits: **4** 6. Semester: **Autumn/Spring** 7. Subject Area: **DEC/DHC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge of concepts and techniques required for energy management.
10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Introduction:** Energy scenario, various forms of energy, energy management and its importance, recent trends in energy conservation.	3
2	**Energy Auditing and Instrumentation:** Definition, methodology, analysis of past trends (plan data), closing the energy balance, laws of thermodynamics, measuring instruments, portable and online instruments.	8
3	**Energy Economics:** Simple payback period, time value of money, IRR NPV, life cycle costing, cost of saved energy, cost of energy generated.	6
4	**Monitoring and Targeting:** Defining monitoring and targeting, elements of monitoring and targeting, data and information, analysis techniques, energy consumption, production, cumulative sum of differences.	4
5	**Energy Efficiency in Thermal Utilities:** Boilers, steam system, furnaces insulation and refractories, FBC boilers, cogeneration, waste heat recovery.	10
6	**Energy Efficiency in electrical Utilities:** Electrical systems, electric motors, compressed air system, HVAC and refrigeration systems, fans and blowers, pumps and pumping systems, cooling towers, lighting system, diesel generating system.	11
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication
1.	Witte, L .C., S chmidt, P.S., B rown, D .R.,"Industrial E nergy M anagement a nd Utilization", Hemisphere Publishing Corporation. Springer-Verlag	1988
2.	Clive Beggs, "Energy: Management, Supply and Conservation", Routledge	2012
3.	Capehart, B.L ., T urner, W.C., K ennedy, W.J., " Guide t o E nergy M anagement", 7th Ed., Fairmont Press.	2011
4.	Turner, W.C. and Doty, S., "Energy Management Handbook", 7th Ed., Fairmont Press.	2009
5.	Kreith, F . a nd Y ogi G oswami, D ., " Handbook of Energy E fficiency a nd R enewable Energy", CRC Press.	2007

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-543** Course Title: **Fluid Power Engineering**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weightage**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits**: 4** 6. Semester**: Both** 7. Subject Area**: DEC**
8. Pre-requisite**: Nil**
9. Objective: To provide the basic knowledge of hydraulic and pneumatic power systems.
10. Details of Course:

S. No.	**Particulars**	**Contact Hours**
1.	**Introduction :** Types of Fluid power control systems and its components, Physical properties of hydraulic fluids and governing equations	**05**
2.	**Pumps and Valves :** Classification, Working and performance of gear, vane, piston pumps and their selection, Pressure intensifiers, Direction control valves, Pressure control valves, Flow control valves, Servo valves, Pressure switches,	**08**
3.	**Hydraulic Actuators:** Linear and rotary actuators, Gear, vane and piston motors, Performance of Hydraulic motors, Hydrostatic transmission	**05**
4.	**Hydraulic Circuit Design and Analysis:** Control of single-acting and double-acting cylinders, Study of various circuits like regenerative, unloading counterbalance, speed control etc., maintenance of hydraulic circuits.	**04**
5.	**Pneumatic Control Systems:** Air preparation and components, Compressors and conditioners, Air control valves and actuators.	**05**
6	**Pneumatic Circuit Design and Analysis:** Design considerations, Pressure and energy loss, Basic pneumatic systems, Vacuum and accumulator systems, Circuit analysis.	**04**
7	**Fluid Logic Control System:** Principles, Basic fluidic devices, fluid, sensors, Boolean algebra, fluidic control of fluid powers systems.	**05**
8	**Electrohydraulic Servo Control System :** Electric components and controls, Dual cylinder sequence circuits, Electro hydraulic servo system and their analysis, Programmable logic controllers.	**06**
	Total	**42**

11. Suggested Books:

S. No.	Author(s) / Title / Publisher	Year of Publication/ Reprint
1	Anthony Esposito, Fluid Power with Applications, 6th Edition, Pearson Prentice Hall, New Delhi	2007
2.	S. R. Mazumdar, Oil Hydraulic Systems- Principles and Maintenance, 25th Reprint, Tata McGraw Hill New Delhi	2012
3.	Dudley A., Pippenger and John J. Pease, Basic Fluid Power, Prentice Hall Inc., New Jearsy.	1987
4.	S. R. Mazumdar, Pneumatic Systems- Principles and Maintenance, 28th Reprint Tata McGrawHill New Delhi	2012
5	Introduction to Fluid Logic - E.C. Fitch & J.B. Surjaatmadja, McGraw-Hill Inc, USA	1978
6	Pneumatic and Hydraulic Systems- W. Bolton, Butterworth and Heinemann, Oxford	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Departmentof Mechanical & Industrial Engineering**

1. Subject Code: **MIN-544** Course Title: **Design of Heat Exchangers**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage**:** **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Both** 7.Subject Area**: DEC/DHC**

8. Pre-requisite**:** **Nil**

9. Objective: This course will provide a thorough understanding of construction, design, performance and testingof Heat Exchangers.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Introduction:** Fundamentals of heat transfer and fluid flow in heat transfer passages; Classification, constructional details, two and multi-fluid heat exchangers, extended surfaces.	4
2	**Design of Heat Exchangers:** Engineering design,steps for designing, feasible/workable design,optimum design, economics, probabilistic approach to design,sizing and rating problems; LMTD and ε-NTU approach of design,design of tubular, shell &tube, finned (radial and longitudinal), regenerative and compact heat exchangers.	12
3	**Optimum Design:** Criteria for optimisation of heat exchangers, constraints, feasible and optimum design, optimization based on volume, weight, cost, entropy generation and thermoeconomics; Brief introduction to some traditional and non-traditional optimisation techniques.	12
4	**Performance Behaviour:** Design vs.simulation, steady state performance,effectiveness,transient performance, fouling, non-uniformities in temperature and flow,effect of property variation, three-fluid/ multifluid heat exchanger behaviour.	8
5	**Testing:** Steady state and transient testing technique, j & f characteristics, empirical relations, experimental vs. numerical approach.	6
	Total	**42**

11. Suggested Books:

S. No.	Author(s) /Title / Publisher	Year of Publication/ Reprint
1	Kays, W .M., a nd London, A .L., " Compact Heat E xchangers", K rieger Publishing Company.	1998
2	Rosenhow, W.M., H artnett, J.P. and C ho, Y.I., " Handbook of H eat Transfer", McGraw Hill.	1998
3	Kraus, A.D., Aziz, A. and W elty, J.R., "Extended Surface H eat T ransfer", WileyIndia.	2013
4	Rao, S.S., "Optimization theory and applications", 3rd Ed. John-Wiley.	1996
5	Hesselgreaves, J.E., "Compact H eat E xchangers: s election, design and operation", Pergamon Press.	2001
6	Webb,R. L. andKim,N. H., "Principles of Enhanced Heat Transfer", Taylor & Francis.	2005

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-545** Course Title: **Fuel Cells**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical:0**
4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **DCC/DHC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the basics of fuel cell operation and their applications.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Basic principle and operation of Hydrogen fuel cells, types of fuel cells.	**4**
2.	**Fuel Cell Thermodynamics**: Free energy change of a chemical reaction, heat of reaction, reversible and net output voltage, theoretical fuel cell efficiency, effect of pressure	**8**
3.	**Fuel Cell Electrochemistry**: Electrode kinetics, Butler-Volmer equation, voltage losses, cell potential-polarization curve, fuel cell efficiency.	**6**
4.	**Transport Mechanisms**: Fuel cell charge transport, electron conductivity of metals, ionic conductivity of polymer electrolytes, fuel cell mass transport- fuel cell mass balance, diffusive and convective mass transports, heat transfer – fuel cell energy balance, heat management	**9**
5.	**Fuel Cell Components**: Materials, properties, processes, membrane, electrodes, bipolar plates, stack design, hydrogen and oxygen supply systems, PEM fuel cell	**9**
6.	**Fuel Cell Applications**: Automobiles, stationary power, fuel cells and hydrogen economy, medium and high temperature fuel cells	**6**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication /Reprint
1.	Barbir, F., “PEM Fuel Cells: Theory and Practice”, Academic Press.	2005
2.	Larminie, J. and Dicks, A., “Fuel Cell Systems Explained”, John Wiley & Sons.	2003
3.	Spiegel, C ., “ PEM F uel C ell Modeling a nd S imulation us ing M ATLAB”, Academic Press.	2008
4.	Sammes, N. M., “Fuel Cell Technology – Reaching towards commercialization”, Springer.	2006
5.	Gregor, H., “Fuel Cell Technology Handbook”, CRC Press.	2003
6.	Srinivasan, S., “Fuel Cells – From Fundamentals to Applications”, Springer.	2006

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-550** Course Title: **Advanced Machine Design**
2. Contact Hours : **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs.) : **Theory** 3 **Practical** 0
4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: The course is intended to train the graduates in methods of failure analysis and design of machine parts against likely failures, using advanced concepts and also to design for reliability.
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction**: Review of failure theories, their scope of applications under different loading and environmental conditions, Hertzian contact stresses and their effect on load carrying capacities of members, effect of small inelastic strains and residual stresses on load carrying capacity, theory of limit design; Machinery construction principles.	12
2	**Designing against Fracture**: Linear elastic fracture mechanics approach, theories of brittle fracture, fundamental aspects of crack growth and fractures, use of fracture in design.	10
3	**Designing against Fatigue and Creep**: Causes and interpretation of failures, influence of various factors, low cycle and high cycle fatigue, cumulative damage theories, acoustical and thermal fatigue, corrosion and fretting fatigue, pitting of gears, fatigue strength of joints, components and structures; creep behavior; the mechanical equation of state, an elastic and plastic creep, rupture theory, analysis of tensile creep data, creep in high temperature low cycle fatigue, creep analysis of thick walled cylinders and rotating discs.	10
4	**Design for Reliability**: Application of statistics to material properties, fatigue and reliability, early chance and wear out failures, reliability prediction against chance and wear out failures, probabilistic approach to design and its comparison with safety factor approach, reliability prediction of series, parallel and stand by systems.	10
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication /Reprint
1	Faupel, J.H., and Fisher, F.E., “Engineering Design”, Wiley-Interscience.	1981
2	Burr, A.H., “Mechanical Analysis and Design”, Elsevier.	1982
3	Smith, N., “Advances in Creep Design”, Applied Science.	1971
4	Bazovsky, I., Reliability Theory & Practice, Courier Dover Publications.	2004
5	Haugen, E.B., Probabilistic Approach Design, John Wiley.	1968
6	Yotaro Hatamura and Yoshio Yamamoto, “The Practice of Machine Design” Oxford University Press.	1999
7	Kai Cheng, “Machining Dynamics: Fundamentals, Applications and Practices” Springer.	2008

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-551** Course Title: **Dynamics of Mechanical Systems**
2. Contact Hours : **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs.) : **Theory** **3** **Practical** **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4** 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre-requisite: **Nil**
9. Objective: To impart knowledge of principles governing the motion of mechanical systems and to develop their skills in analysis and control of their motion.
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Basic concepts**: Inertial coordinate system, fundamental laws of motion, mechanics of particles and system of particles, principles of linear and angular momentum, work-energy principles.	4
2	**Lagrangian dynamics**: Degrees of freedom, generalized coordinates and generalized forces, holonomic and non-holonomic constraints, Lagrange's equation from d'Alembert's principles, application of Lagrange's equation for conservative and non-conservative autonomous systems with holonomic and non-holonomic constraints, applications to systems with very small displacements and impulsive motion; Hamilton principle from d'Alembert's principle, Lagrange equation from Hamilton's principle.	10
3	**Multi-body dynamics**: Space and fixed body coordinate systems, coordinate transformation matrix, direction cosines, Euler angles, Euler parameters, finite and infinitesimal rotations, time derivatives of transformations matrices, angular velocity and acceleration vectors, equations of motion of multi-body system, Newton-Euler equations, planer kinematic and dynamic analysis, kinematic revolute joints, joint reaction forces, simple applications of planer systems.	15
4	**Stability of motion**: Fundamental concept in stability, autonomous systems and phase plane plots, Routh's criteria for stability, Liapunov's method, Liapunov's stability theorems, Liapunov's function to determine stability of the system.	7
5	**Control system dynamics**: Open and close loop systems, block diagrams, transfer functions and characteristics equations, proportional integral and derivative control	6

	actions and their characteristics.	
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1	Ginsberg, J.H., "Advanced Engineering Dynamics", Harper and Row.	1988
2	Meirovitch, L., "Methods of Analytical Dynamics", McGraw Hill Inc.	1970
3	Harold Josephs and Ronald Huston, "Dynamics of Mechanical Systems", CRC Press.	2002
4	Katsuhiko Ogata, "System Dynamics",4th Ed., Prentice Hall;	2003
5	Robert L. Woods and Kent L. Lawrence, "Modeling and Simulation of Dynamic Systems", Prentice Hall.	1997
6	Ramin S. Esfandiari and Bei Lu, "Modeling and Analysis of Dynamic Systems", CRC Press.	2010
7	Dean C. Karnopp, Donald L. Margolis, and Ronald C. Rosenberg, "System Dynamics: Modeling and Simulation of Mechatronic Systems", 4th Ed., Wiley.	2006
8	Richard A. Layton, "Principles of Analytical System Dynamics" (Mechanical Engineering Series), Springer.	1998

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPARTMENT: Mechanical & Industrial Engineering

1. Subject Code: **MIN-552** Course Title: **Advanced Mechanics of Solids**
2. Contact Hours : **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs.) : **Theory** 3 **Practical** 0
4. **Relative Weightage :CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0
5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **PCC**
8. Pre – requisite: **Nil**
9. Objectives of Course: The course aims at providing advanced concepts in behavior of solids under various loading conditions and to train the graduates in analyzing the resulting stresses and deformations.
10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Mathematical Preliminaries**: Scalars, vectors and matrix variables, index notation and the related rules, Cartesian tensors and their algebra, co-ordinate transformation, transformation rules for the n^{th} order tensors, elements of tensor calculus and the related theorems (divergence, Stokes' and Green's), principal value theorem, eigenvalues and eigenvectors, invariants of a 2^{nd} order tensor.	4
2	**Kinetics of Deformation:** Types of forces (point, surface and body), traction vector, state of stress at a point, Cauchy's relation and its proof, conservation of linear and angular momentum, stress equilibrium equations, symmetry of stress tensor, stress transformation, principal stresses and the associated planes, 3D Mohr's circle representation, planes of maximum shear, octahedral planes, hydrostatic and deviatoric stress, first and second Piola-Kirchoff stress tensors and their properties.	8
3	**Kinematics of Deformation**: Material and spatial co-ordinates, Eulerian and Lagrangian description of motion; deformation and displacement gradients, Green-Lagrange and Almansi strain tensor; Cauchy's small strain tensor and the rotation tensor, geometrical interpretation of strain components and sign convention, principal strains and directions, strain invariants, octahedral strain, maximum shear strain, volumetric strain, strain compatibility equations.	8

4	**Constitutive Modeling**: Thermodynamic principles, first and second law of thermodynamics, Generalized Hooke's law for isotropic materials, elastic constants and their relations, anisotropic, hyperelastic and viscroelastic material models, strain hardening, constitutive relations for elasto-plastic materials, flow and hardening rules.	8
5	**Boundary Value Problems in Linear Elasticity**: Field equations and boundary conditions, Navier equations, Beltrami-Michell stress compatibility conditions, 2D approximations (plane stress and plane strain) and solution strategies.	6
6	**Variational Principles in Solid Mechanics**: Elements of variational calculus, extremum of a functional, Euler-Lagrange equation and its application, types of boundary conditions, principle of virtual work, Principle of total potential energy and complementary potential energy, Ritz method, time-dependent problems and Hamilton's principle for continuum.	8
Total		**42**

11. Suggested Books:

S. No.	**Name of Authors/ Books / Publisher**	**Year of Publication**
1	Sadd, M .H., " Elasticity Theory Applications and Numerics", Elsevier Academic Press.	**2005**
2.	Boresi, A.P., Sidebottom, O. M., "Advanced Mechanics of Materials", 5th Ed., John Wiley and Sons	**2007**
3	Singh, A.K., "Mechanics of Solids", PHI Learning Private Limited	**2011**
4	Timoshenko, S .P., and Goodier, J.M., " Theory of Elasticity", 3rd Ed., McGraw Hill	**2004**
5.	Srinath, L.S., "Advanced Mechanics of Solids",Tata McGraw Hill Education Private Limited	**2009**
6.	Fung, Y.C., " Foundations of Solid Mechanics", Prentice Hall Inc.	**1965**

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-553** Course Title: **Industrial Tribology**
2. Contact Hours : **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0
4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0
5. Credits: 4 6. Semester: **Autumn/Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: The course has been designed to give an understanding of tribological phenomena, industrial lubricants and additives.
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction**: Tribological consideration, nature of surfaces and their contact. Introduction, physico-mechanical properties of surface layer; Geometrical properties of surfaces, method of studying surface; Contact of smooth surfaces, contact of rough surfaces. Role of friction, laws of static friction, causes of friction; Adhesion. Adhesion theory, laws of rolling friction, friction of metals and nonmetals, friction measurement; Wear definitions, types of wear, mechanism of wear, factors affecting wear behavior, measurement of wear a brief introduction of wear test equipments, wear in plastics.	10
2	**Industrial Lubricants and Their Additives**: Functions of lubricants, types of lubricants and their industrial uses; Solid lubricants and their functions, liquid mineral lubricants, synthetic liquid lubricants, greases, properties of liquid and grease lubricants, viscosity, Newtonian and Non-Newtonian lubricants, temperature and pressure dependence measurement, other properties of lubricants; Lubricant additives, general properties and selection for machines and processes; Oil reclamation and preventive maintenance for lubricants.	8
3	**Fluid-Film Lubrication**: Fluid mechanics concepts, equations of continuity and motion; Generalized Reynold's equation with incompressible and compressible lubricants; Hydrodynamic lubrication, Tower's experiment, finite bearings, partial journal bearings, solution of finite bearings using Galerkin, finite difference and FEM.	7
4	**Dynamically loaded journal bearings:** Solution of the generalized Reynold's equation for infinite and short bearing, load carrying capacity, Sommerfield	7

	numbers, journal centre locus, whirling; Hydrostatic lubrication-- basic concepts, applications, compensated thrust and journal bearings and their solution using FEM, controlling flow with restrictors, design of restrictors for compensated bearings.	
5	**Gas Lubrication**: Types of gas bearings and their characteristics; Reynolds equation for iso-thermal, polytropic and adiabatic supporting gas films; Introduction to porus bearing permeability, solution of thrust and journal bearings.	5
6	**Bearing Design and Selection of Bearings**: Comparative performance of various modes of lubrication, and bearing selection; Design of slideway bearing and hydrostatic thrust bearing, fixed type hydrodynamic and hydrostatic journal bearings, materials for sliding bearings; Bearing types, selection of rolling elements bearing, bearing life, bearing load, bearing selection.	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books/ Publisher	Year of Publication/ Reprint
1	Conner, J.J. and Boyd, J., "Standard Handbook of Lubrication Engineering", McGraw Hill.	1968
2	Stachowiak, G. and A W Batchelor, A. W., "Engineering Tribology", 3rd Ed, Butterworth-Heinemann.	2005
3	Khonsari, M. M. and Booser, E. R., "Applied Tribology: Bearing Design and Lubrication", 2nd Ed, Wiley.	2008
4	Kudish, I. I. and Covitch, M. J., " Modeling and Analytical Methods in Tribology", Chapman and Hall/CRC.	2010
5	Bhushan, B., "Principles and Applications of Tribology", Wiley.	1999

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-554** Course Title**: Computer Aided Mechanism Design**

2. Contact Hours : **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 6. Semester: **Autumn/Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: The course aims at providing the basic concepts of analysis and design of mechanisms.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction**: Review of concepts related to kinematic analysis of mechanisms, degrees of freedom, Grashof's and Gruebler's criteria, transmission and deviation angles, mechanical advantage.	6
2	**Kinematic Synthesis of Mechanisms**: Type, number and dimensional synthesis, spacing of accuracy points, Chebyshev polynomials, path motion and function generation, graphical synthesis with two, three, and four prescribed positions and points.	8
3	**Analytical Synthesis Techniques**: complex number modeling, dyad and standard form equation, Freudenstein's equation for three point function generation, coupler curves, Robert's law, cognates of linkages.	8
4	**Path Curvature Theory**: Fixed and moving centrode, inflection points and inflection circle, Euler-Savary equation, Bobillier and Hartmann's construction.	8
5	**Dynamic Force Analysis**: Introduction, inertia forces in linkages, kinetic-static analysis by superposition and matrix approaches and its applications, introduction to spatial mechanisms.	6
6	**Software usages:** Modelling, analysis and synthesis of various mechanisms using software packages	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books/ Publisher	Year of Publication /Reprint
1	Hall, A.S., "Kinematic and Linkage Design", Prentice Hall Inc.	1978
2	Sacks, E. and Joskowicz, L., "The Configuration Space Method for Kinematic Design of Mechanisms", MIT Press.	2010
3	Erdman, A. G. and Sandor, G. N ., " Mechanism D esign: A nalysis a nd Synthesis", 3rd Ed, Prentice Hall.	1996
4	Shabana, A. A., "Computational Dynamics", 3rd Ed., Wiley.	2010
5	Shabana, A . A ., "Dynamics of M ultibody S ystems", 2nd Ed., Cambridge University Press.	2003
6	Eckhardt, H. D., "Kinematic Design of Machines and Mechanisms", McGraw-Hill.	1998
7	Sandor G.N., and Erdman A.G., "Advanced Mechanism Design: Analysis and Synthesis Vol.2", Prentice Hall Inc	1984

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-555** Course Title: **Experimental Stress Analysis**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): Theory **3** Practical **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4** 6. Semester: **Autumn/Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: The course aims at providing fundamental concepts and applications of the most conventional experimental stress analysis methods used in practice.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction**: Importance of experimental methods and their scope, whole field and point by point methods.	2
2	**Photoelasticity**: Nature of light, photoelastic effect and polarized light, permanent and temporary birefringence, types of polariscopes and their basic elements, optics of plane and circular polariscope, isoclinics and isochromatics, stress optic law and secondary principal stresses; Photoelastic model materials their properties and selection, preparation of models, transition from model to prototypes, measurement of relative retardation and fringe order, compensation techniques, separation of principal stresses by oblique incidence, shear difference and numerical integration of Laplace's equation.	8
3	**Photoelastic methods:** Calibration methods and determination of stress trajectories from isoclinic data; Basic elements of three dimensional photoelasticity, stress freezing and slicing the model and interpretation of the resulting fringe patterns, fringe sharpening and fringe multiplication techniques; Photoelastic methods to determine stress intensity factors.	4
4	**Birefringent Coatings**: Surface stress determinations using birefringent coatings, sensitivity of biregringent coatings; Reinforcing, thickness and other effects of photoelastic coatings; Separation of principal stresses; Birefringent coating materials and applications; Photoelastic stress and strain gauges.	6

5	**Scattered Light Photoelasticity**: Scattering phenomenon and polarization associated with scattering, scattered light technique to solve general three dimensional problem; Scattered light polariscope.	5
6	**Moire Method of Strain Analysis**: Moire phenomenon and formation of Moire fringes; Geometric and displacement approach for in-plane problems, Moire grating production, printing and photography.	5
7	**Brittle Coatings**: Introduction, coating stresses; Brittle coating failure theories; Factors affecting analysis of coating data; Crack patterns due to direct and relaxation loading; Refrigeration technique, calibration methods and scope of application of brittle coating method.	6
8	**Digital Image Processing**: Fringe multiplication, fringe thinning and fringe clustering through data acquisition by DIP methods; Phase shifting, polarization stepping and Fourier transform techniques phase unwrapping and optical enhanced tiling, use of colour image processing techniques for data acquisition in digital photoelasticity.	6
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors / Books / Publisher**	**Year of Publication /Reprint**
1	Phillips, E.A., Durelli, A.J. and Tsao, C.H., "Analysis of Stress and Strain", McGraw Hill.	1958
2	Daily, J.W. and Riley, W.F., "Experimental Stress Analysis", McGraw Hill.	1991
3	Durelli, A.J. and Riley, W.F., "Introduction to Photomechanics", Prentice Hall.	1965
4	Frocht, M.M., "Photoelasticity (Vol. I and II)", John Wiley.	1948
5	Ramesh, K., "Digital Photoelasticity: Advanced Techniques and Applications", Springer-Verlag.	2000
6	James W. Dally and William F. Riley, "Experimental Stress Analysis", College House Enterprises.	2005
7	James F. Doyle, "Modern Experimental Stress Analysis: Completing the Solution of Partially Specified Problems", Wiley.	2004
8	Pramod K. Rastogi, "Photomechanics"(Topics in Applied Physics),Springer.	2000

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-556** Course Title: **Dynamics of Road Vehicles**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): Theory **3** Practical **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4** 6. Semester: **Autumn/Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To provide fundamental engineering principles underlying the control, stability, handling and cornering behavior of road vehicles.
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction to Vehicle Dynamics**: Various kinds of vehicles,motions, mathematical modelling methods; Multibody system approach and Lagrangian formulations, methods of investigations, stability concepts.	4
2	**Mechanics of Pneumatic Tyre**: Tyre construction, physics of tyre traction on dry and wet surfaces, tyre forces and moments, SAE recommended practice, rolling resistance of tyres, ride properties of tyres.	10
3	**Performance Characteristics**: Equation of motion and maximum tractive effort, aerodynamic forces and moments, vehicle power plant and transmission characteristics, prediction of vehicle performance, operating fuel economy, braking performance, antilock braking systems.	8
4	**Handling and Stability Characteristics**: Steering geometry; steady state handling characteristics, steady state response to steering input, transient response characteristics directional stability, effects of tyre factors, suspension, braking and vehicle parameters on stability and handling.	8
5	**Vehicle Ride Characteristics**: Human response to vibration, vehicle ride models, road surface profile as a random function; frequency response function, evaluation of vehicle vertical vibration in relation to ride comfort criterion.	7
6	**Experimental Testing:** Instruments for vehicle measurements, recording and evaluation methods, test methods and measurement procedures for vehicle dynamics, interpretation of test results and correlation between measured values and subjective evaluation of the vehicle handling.	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication /Reprint
1.	Wong, J.Y., “Theory of Ground Vehicles”, John Wiley.	2001
2.	Gillespie, T.D., “Fundamental of Vehicle Dynamics”, S.A.E.	1992
3	Rao, V. D., “Road Vehicle Dynamics”, SAE International.	2008
4	Rajesh, R., “Vehicle Dynamics and Control”, Springer.	2005
5	Hans, T., “The Dynamics of Vehicles on Roads and on Tracks”, Taylor and Francis,	2003
6	Barnard, R. H., “Road Vehicle Aerodynamic Design: An Introduction”, 2^{nd} Ed., Mechaero Publishing.	2001
7	Wong, J. Y., “Theory of Ground Vehicles”, 4^{th} Ed., Wiley.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-557** Course Title: **Finite Element Methods**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Autumn/Spring** 7. Subject Area: **PEC**

8. Pre–requisite: **NIL**

9. Objective: To provide the basic concepts of finite element method and its applications to wide range of engineering problems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Basic Concepts**: Introduction, Weak formulations, Weighted residual methods, Variational formulations, weighted residual, collocation, subdomain, least square and Galerkin's method, direct method, potential energy method	8
2.	**One-Dimensional Analysis**: Basis steps, discretization, element equations, linear and quadratic shape functions, assembly, local and global stiffness matrix and its properties, boundary conditions, applications to solid mechanics, heat and fluid mechanics problems, axisymmetric problems	8
3.	**Plane Truss**: Local and global coordinate systems, stress calculations, example problems	3
4.	**Beams**: Introduction, Euler-Bernoulli beam element, numerical problems	3
5.	**Scalar Field Problems in 2-D**: Triangular and rectangular elements, constant strain triangle, isoparametric formulation, higher order elements, six node triangle, nine node quadrilateral, master elements, numerical integration, computer implementation, Numerical problems	10
7.	**Plane Elasticity**: Review of equations of elasticity, stress-strain and strain-displacement relations, plane stress and plane strain problems	4
8.	**Bending of Elastic Plates**: Review of classical plate theory, plate	6

	bending elements, triangular and rectangular elements, Shear deformation plate theory, numerical problems	
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors / Books / Publisher**	**Year of Publication**
1.	Huebner K.H., Dewhirst, D. L., Smith, D. E., and Byrom, T. G., "The Finite Element Method for Engineers", 4th Ed., John Wiley and Sons	**2001**
2.	Rao, S. S., " The Finite Element Method in Engineering", 4th Ed., Elsevier Science	**2005**
3.	Reddy, J.N., "An Introduction to Finite Element Methods", 3rd Ed., Tata McGraw-Hill	**2005**
4.	Fish, J., and Belytschko, T., "A First Course in Finite Elements", 1st Ed., John Wiley and Sons	**2007**
5.	Chaskalovic J., "Finite Element Methods for Engineering Sciences", 1st Ed., Springer	**2008**

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-558** Course Title: **Fracture Mechanics**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): Theory **3** Practical **0**
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: **4** 6. Semester: **Autumn/Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the mechanics of anisotropic material, and provide insight into different failure mechanisms typical of anisotropic and heterogeneous systems
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction to Fracture Mechanics**: Introduction to the realm of fracture and back ground history of development of fracture mechanics; Discrepancy between theoretical and real strength of materials, conventional failure criteria based on stress concentration and characteristic brittle failures, Griffith's work.	5
2	**Linear Elastic Fracture Mechanics (LEFM) Based Design Concepts:** Crack deformation modes and basic concepts, crack tip stresses and deformation, stress intensity factor (SIF) and its criticality in different modes, superposition of SIFs, LEFM design concept applications; Concept of energy release rate, equivalence of energy release rate and SIF.	10
3	**Fracture toughness:** Fracture toughness and its laboratory determination procedure, test specimen size requirement etc.; Effect of temperature and loading rate on fracture toughness; Fatigue and fatigue crack propagation laws, fatigue life calculations under constant and variable amplitude loading, mixed-mode fatigue crack propagation.	10
4	**Strain Energy Density Failure Criterion**: Introduction, volume strain energy density, basic hypothesis and application of energy density based failure criteria for two and three dimensional linear elastic crack problems.	7
5	**Elastic Plastic Fracture Mechanics Based Design Criteria**: Design criteria for non-brittle materials; plastic zone corrections, crack opening displacement (COD), J-contour integral and crack growth resistance (R-curve) concepts.	10

	Total	42

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1	Gdoutos, E.E., "Fracture Mechanics: An Introduction", 2nd Ed., Springer.	2005
2	Broek, D., "Elementary Engineering Fracture Mechanics", 3rd Ed., Springer.	1982
3	Kumar, P., "Elements of Fracture Mechanics", Wheeler Publishing.	1999
4	Anderson, T. L., "Fracture Mechanics: Fundamentals and Applications", 3rd Ed., CRC Press.	2005
5	Shukla, A., "Practical Fracture Mechanics in Design", 2nd Ed., CRC Press.	1989
6	Bazant, Z. P. and Cedoliin, L., "Stability of Structures: Elastic, Inelastic, Fracture and Damage Theories", World Scientific Publishers.	2010

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-559** Course Title: **Computer Aided Design**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits**:** 4 6. Semester**: Autumn/Spring** 7. Subject Area**: PCC**

8. Pre–requisite: **Nil**

9. Objectives of Course: The course aims at providing the basic concepts and elementary tools of CAD.

10. Details of Course:

S. No.	**Contents**	**Contact Hours**
1	**Introduction**: The design process, elements of CAD	01
2	**Principles of Software Design**: Characteristics of good software, data structures, algorithm design, flow chart, coding, top-down programming, modular programming, structural coding, testing of the software.	03
3	**Computer Graphics**: Graphics display, transformations, visualizations, computer animation.	03
4	**3D Modeling and Viewing**: Coordinate systems, sketching and sketch planes; Modeling aids and tools; Layers, grids, clipping, arrays, editing.	03
5	**Curves Modeling:** Analytical and synthetic curves, curve manipulations.	07
6	**Surface Modeling:** Surface representation and surface analysis, analytical and synthetic surfaces, surface manipulations, NURBS.	07
7	**Solid Modeling**: Geometry and topology, solid entities, solid representation, fundamental of solid modeling, half spaces, boundary representation, constructive solid geometry, sweeps, solid manipulations.	07
8	**Features**: Feature entities, feature representation, three dimensional sketching, parametrics, relations, constraints, feature manipulation.	03
9	**Mass properties**: Geometric and mass properties evaluation, assembly modeling, product data exchange	04
10	**Optimization technique**: Single variable optimization, multi-variable optimization, Johnson's method of optimum design, genetic algorithm.	04
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1	Zeid, I., "Mastering CAD/CAM", Tata McGraw Hill.	2007
2	Onwubiko, C ., " Foundation of C omputer A ided D esign", West P ublishing Company.	1989
3	Hsu, T . R . a nd S inha, D . K ., " Computer A ided D esign: A n Integrated Approach", West Publishing Company.	1991
4	Dimarogonas, A. D., "Computer Aided Machine Design", Prentice Hall.	1988
5	Mortenson, M. E., "Geometric Modeling", 3rd Ed., Industrial Press.	2006

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-560** Course Title: **Mechanics of Composite Materials**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0
5. Credits: 4 6. Semester: **Autumn/Spring** 7. Subject Area**: PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the mechanics of anisotropic material and to provide insight into different failure mechanisms typical of anisotropic and heterogeneous systems.
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction**: Composite materials, characteristics, classification, advantages and typical problems.	2
2	**Unidirectional Lamina**: Introduction, longitudinal strength and stiffness, transverse strength and stiffness, failure modes, thermal expansion and transport properties.	6
3	**Short Fibre Composites**: Theories of stress transfer, modulus and strength of short fibre composites.	4
4	**Analysis of an Orthotropic Lamina**: Hook's law, stress-strain relation for lamina with an arbitrary orientation, strength of a lamina subjected to biaxial stress field.	6
5	**Analysis of Laminated Composites**: Classical lamination theory, thermal stress in laminates.	12
6	**Special Design Considerations**: Analysis after initial failure, inter-laminar stress, free edge effect, design of joints, elementary fracture mechanics concepts related to composite materials.	8
7	**Experimental Characterization**: Uni-axial tension test, compression test, in-plane shear test, three and four point bending test, determination of interlaminar shear strength.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1	Agarwal, B .D. a nd B routman, L.J., “ Analysis a nd P erformance of F ibre Composites”, 3rd Ed., John Wiley & Sons.	2006
2	Jones, R.M., “Mechanics of Composite Materials”, Taylor & Francis.	1998
3	Ashbee, K .H.G. and A shbee, H.G., “ Fundamental P rinciples of F ibre R einforced Composites”, 2nd Ed., CRC Press.	1993
4	Daniel, I.M. a nd Ishai, O ., “ Engineering M echanics of C omposite Materials”, 2nd Ed., Oxford University Press.	2007
5	Christensen, R .M., “ Mechanics of C omposite Materials”, Dover Publications.	2005
6	Kaw, A. K., “Mechanics of Composite Materials”, 2nd Ed., CRC Press.	2005

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-561** Course Title: **Advanced Mechanical Vibrations**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory **3** Practical **0**

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: **4** 6. Semester: **Autumn/Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To provide detail knowledge about nonlinear and random vibration with fault diagnosis of machinery.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Review of free and forced vibrations with and without damping.	3
2	**Isolation:** Vibration isolation and transmissibility; Un-damped vibration absorbers.	4
3	**Multi degree of freedom system**: Generalized coordinates and coordinate coupling; Orthogonality of modes, Free and forced vibration of multi-degree of freedom systems with and without viscous damping; Lagrange's equation; Holzer's method. Solution of Eigen value problem, transfer matrix and modal analysis.	12
4	**Stability criterion:** Self excited vibrations; Criterion of stability; Effect of friction on stability.	4
5	**Non linear vibration:** Free vibrations with non-linear spring force or nonlinear damping; Phase plane; Energy curves; Lienard's graphical construction; Method of isoclines.	5
6	**Vibration of continuous system:** Vibrations of strings; Free and forced longitudinal vibrations of prismatic bars; Ritz and Galerkin methods.	6
7	**Random vibration:** Mathematical descriptions of stochastic processes; Stationary and ergodicity; Gaussian random process, correlation functions and power spectral density.	4
8	**Diagnostic techniques:** Introduction to diagnostic maintenance and signature analysis.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication /Reprint
1	Rao, S.S., "Mechanical Vibrations", 4th Ed., Pearson Education.	2007
2	Meirovitch, L., "Fundamental of Vibrations", Mc-Graw Hill.	2001
3	Inman, D.J., "Vibration and Control", John Willey & Sons.	2002
4	Tamadonni, S. and Kelly, G.S., "Mechanical Vibrations", Mc-Graw Hill.	1998
5	Rao, J. S., "Vibration Condition Monitoring of Machines", Tata Mc-Graw Hill.	2006

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-562** Course Title: **Noise Control in Mechanical Systems**

2. Contact Hours : **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.) : **Theory** 3 **Practical** 0

4. Relative Weightage :CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Autumn/Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To impart fundamental knowledge of the subject on noise control problems in mechanical systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction**: Sound vs noise; Time and frequency domain representation, hearing mechanism -- assessment of noise, its units, human response to noise of different types- stead, fluctuating and impulsive, physiological effects of noise, control of noise, need, concepts and options, and its relation to vibrations.	6
2	**Homogeneous Wave Equation**: Linearized wave equation, acoustic velocity potential acoustic impedance, plane wave propagation, intensity, energy density and power, Simple Source models, monopole, dipole, quadrupole and linear, effect of proximity of rigid boundaries, directivity patterns.	6
3	**Inhomogeneous Wave Equation and Aerodynamic Noise Theory**: Effect of solid bodies in flow, vortex flow; Ray Acoustics-- propagation of sound outdoors, divergence, excess attenuation factors, effects of wind, temperature gradient and turbulence anomalous propagation, shadow zones, ground and terrain effects, harriers, cuttings and elevation.	7
4	**Wave-Structure Interaction**: Sound radiation from plates infinite and bounded; radiation ratio, sound transmission through layered media, behavior of infinite and finite panels, coincidence phenomena and design curves, sound transmission loss, fluid loading on structure, impact noise, introduction to statistical energy analysis.	6
5	**Instrumentation**: Sound measuring equipment, microphones, preamplifiers, sound level meters, recorders, frequency analysers statistical measurements, FFT analysers.	5

6	**Noise Control Principles**: Control strategies and limitations, integrated approach to low noise design, typical mechanical noise sources, mechanism of noise generation– vibration, impact, flow excitation, control of solid borne and air-home noise, concept of impedance mismatch, filters, silencers, damping, enclosure, absorbers, active noise control principle.	8
7	**Case Studies**: Noise control in reciprocating and rotating machinery, and fluid flow systems: e.g., gears, bearing, piping systems, automobiles, aircrafts, refrigeration and air conditioning systems elements, machine tools, presses etc., environmental noise control and receiver protection.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication /Reprint
1	Faulkner, L.L, "Handbook of Industrial Noise Control", Industrial Press.	2001
2	Lyon, R.H., "Machinery Noise and Diagnostics", Butterworths.	1995
3	Norton, M.P., " Fundamentals Noise and Vibration Analysis", Cambridge University Press.	1989
4	Rahn, C. D., "Mechatronic Control of Distributed Noise and Vibration", Springer.	2001
5	Fuller, C. C., Elliott, S.J., and Nelson, P. A., "Active Control of Vibration", Academic Press.	1996
6	Moser, M., Zimmermann, S. and Ellis, R., " Engineering Acoustics: An Introduction to Noise Control", 2nd Ed., Springer.	2009

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-563** Course Title: **Mechatronics**

2. Contact Hours: **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits: 4 6. Semester: **Autumn/Spring** 7. Subject A rea: **PEC**

8. Pre–requisite: **Nil**

9. Objective: The course deals with basic principles of Mechatronics involving sensors, actuators, control systems, and microprocessor systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction**: Definition of mechatronics, measurement system, control systems, microprocessor based controllers, mechatronics approach.	2
2	**Sensors and Transducers**: Sensors and transducers, performance terminology, photoelectric transducers, flow transducers, optical sensors and transducers, semiconductor lasers, selection of sensors, mechanical / electrical switches, inputting data by switches.	7
3	**Actuators**: Actuation systems, pneumatic and hydraulic systems, process control valves, rotary actuators, mechanical actuation systems, electrical actuation systems.	5
4	**Signal Conditioning**: Signal conditioning, filtering digital signal, multiplexers, data acquisition, digital signal processing, pulse modulation, data presentation systems.	4
5	**Microprocessors and Microcontrollers**: Microcomputer structure, microcontrollers, applications, programmable logic controllers.	8
6	**Modeling and System Response**: Mathematical models, bond graph models, mechanical, electrical, hydraulic and thermal systems, dynamic response of systems, transfer function and frequency response, closed loop controllers.	9
7	**Design and Mechatronics**: Input/output systems, computer based modular design, system validation, remote monitoring and control, designing, possible design solutions, detailed case studies of mechatronic systems used in photocopier, automobile, robots.	7
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication /Reprint
1	Bolton, W., "Mechatronics", Longman.	1999
2	Alciatore, D. G. and Histrand, M. B., "Introduction to Mechatronics", Tata McGraw Hill.	2003
3	Shetty, D. and Richard, A.K., " Mechatronics System Design", PWS Pub. Boston.	1997
4	Mahalik, N., " Principles, Concept and Applications: Mechatronics", Tata McGraw.	2003
5	Bishop, R.H. "Mechatronics Handbook", CRC Press.	2002
6	Bolton, W., "Mechatronics: A Multidisciplinary Approach", 4th Ed., Prentice Hall.	2009
7.	Merzouki R., Samantaray A. K., Pathak P.M., Bouamama B. Ould, Intelligent Mechatronic Systems: Modeling, Control and Diagnosis, Springer	2013

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code**: MIN-565** Course Title**: Smart Materials, Structures and Devices**
2. Contact Hours **:** **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.)**: Theory** **3** **Practical** **0**
4. Relative Weightage**:** CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits**:** **4** 6. Semester**: Autumn/Spring** 7. Subject Area: **PEC**
6. Pre-requisite: **Nil**
7. Objective: To impart knowledge on analysis of smart materials for various applications such as sensors, actuators and controllers with reference to various structures and devices.
8. Details of Course:

S. No.	Contents	Contact Hours
1	**Intelligent Materials**: Primitive functions of intelligent materials; Intelligence inherent in materials; Materials intelligently harmonizing with humanity; Intelligent biological materials.	2
2	**Smart Materials and Structural Systems**: Actuator materials; Sensing technologies; Microsensors; Intelligent systems; Hybrid smart materials; Passive sensory smart structures; Reactive actuator-based smart structures; Active sensing and reactive smart structures; Smart skins.	4
3	**Electro–Rheological Fluids**: Suspensions and electro, reheological fluids; The electro- rheological phenomenon; Charge migration mechanism for the dispersed phase; Electro rehological fluid actuators.	4
4	**Piezoelectric Materials**: Background; Piezoelectricity; Industrial piezoelectric materials; Smart materials featuring piezoelectric elements.	3
5	**Shape Memory Materials**: Background on shape memory alloys; Applications of shape memory alloys; Continuum applications: structures and machine systems; Discrete applications; Impediments to applications of shape memory alloys; Shape memory plastics.	4
6	**Fiber Optics**: Overview; Light propagation in an optical fiber; Embedding optical fibers in fibrous polymeric thermosets; Fiberoptic strain sensors.	3
7	**The Piezoelectric Vibrations Absorber Systems**: Introduction; The single mode absorber, theory, design solution, extension including viscous modal damping,	7

	the electromechanical coupling coefficient, inductance, experimental results; The multimode absorber, derivation of transfer function, design solution, self-tuning absorber, performance function, control scheme.	
8	**Modeling of Shells:** Derivation of the basic shell equations, equation of motion, equations for specific geometries and cylindrical shell.	10
9	**Modeling of plates and beams:** Plate equations and beam equations.	5
	Total	**42**

11. Suggested Books:

S. No.	**Name of Authors / Books / Publisher**	**Year of Publication /Reprint**
1	Gandhi, M. V. and Thompson, B. S., "Smart Materials and structures", Chapman & Hall.	1992
2	Banks, H. T., Smith, R. C. and Qang, Y. W., "Smart Material structures: Modeling, Estimation and Control", John Wiley & Sons.	1996
3	Gabbert, U. and Tzou, H. S., "Smart Structures and Structronic System", Kluwer Academic Publishers.	2001
4	Preumont, A., " Vibration Control of Active Structures", Kluwer Academic Publishers.	2002
5	Cheng, F. Y., Jiang, H. and Lou, K., "Smart Structures: Innovative Systems for Seismic Response Control", CRC Press.	2008

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code:**MIN-566** Course Title: **Computer Aided Analysis of Mechanical Systems**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS 25 PRS 0 MTE 25 ETE 50 PRE 0

5. Credits**:** 4 6. Semester**: Spring** 7. Subject Area**: PEC**

8. Pre–requisite: **Nil**

9. Objectives: To introduce computer-based design tools for analyzing the kinematics and dynamics of mechanical systems.

10. Details of Course:

S. No.	Particulars	Contact Hours
1	**Introduction**: Introduction to mechanical systems analysis.	2
2	**Kinematic Modeling**: Modeling the kinematics of mechanical systems; Vector loop methods, vector chain methods.	4
3	**Solution of Kinematic Models**: Solution of kinematic models for displacements, velocities, accelerations; Direct analytical solutions of position, velocity, acceleration problems; Numerical solution of position problem; Matrix method solutions of velocity and acceleration problems.	8
4	**Dynamic Modeling**: Modeling the dynamics of mechanical systems; Newton-Euler methods to define dynamic constraints between forces, moments, and accelerations, energy methods to define dynamic constraints between input and output links.	6
5	**Solution of Dynamics Models:** Solution of inverse dynamics models for joint-link forces and torques, solution of forward dynamics models using numeric integration, model formulation into standard format for solution, Euler's method of integration, Runge-Kutta methods of integration, modeling and analysis of the Trebuchet mechanism.	14
6	**Advanced Dynamic Analysis & Simulation**: Bond graph modeling of dynamic systems, generation of system equations, causality, and simulation.	8
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1	Norton R., “Design of Machinery”, McGraw-Hill	1992
2	Palm W. J., “Introduction to MATLAB 6 for Engineers”, McGraw-Hill	2000
3	Nikravesh, P . E ., “ Computer-Aided Analysis of M echanical Systems”, Prentice Hall.	1988
4	Haug, E . J ., “Computer A ided A nalysis a nd O ptimization of Mechanical System Dynamics”, Springer-Verlag.	1984
5	Mukherjee, A., Karmaker, R. and Samantaray, A.K., “Bond Graph in Modeling, Simulation and Fault Identification”, I & K International.	2007

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-567** Course Title: **Computer Graphics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre–requisite: **Nil**

9. Objective: The course aims is to provide the basics of Computer Graphics needed for CAD/ CAM applications.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Role of Computer Graphics in CAD/CAM, configuration of graphic workstations, menu design and Graphical User Interfaces (GUI), customization and parametric programming.	04
2	**Geometric Transformations and Projections:** Vector representation of geometric entities, homogeneous coordinate systems, fundamentals of 2D and 3D transformations: Reflection, translation, rotation, scaling, and shearing, various types of projections.	08
3	**Curves:** Modeling planar and space curves, analytical and synthetic approaches, non-parametric and parametric equations.	08
4	**Surfaces:** Modeling of bi-parametric freedom surfaces, Coons, Bezier, B-spline, and NURBS surfaces, surface manipulation techniques.	08
5	**Geometric Modeling:** Geometric modeling techniques, wireframe modeling, solid modeling: B-Rep, CSG, hybrid modelers, feature based, parametric and variational modeling.	10
6	**Data Structure in Computer Graphics:** Introduction to product data standards and data structures, data-base integration for CIM.	04
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1	Rogers, D. F., and Adams, J. A., "Mathematical Elements for Computer Graphics", McGraw Hill.	1989
2	Faux, I. D. and Pratt, M. J., "Computational Geometry for Design and Manufacture", Ellis Horwood Ltd.	1979
3	Mortenson, M. E., "Geometric Modeling", 3rd Ed., Industrial Press.	2006
4	Zeid, I., "CAD/CAM: Theory and Practice", Tata McGraw Hill.	1998
5	Choi, B. K., "Surface Modeling for CAD/CAM", John Wiley & Sons	1991

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-568** Course Title: **Advanced Robotics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): Theory 3 Practical 0

4. Relative Weightage: CWS **25** PRS 0 MTE **25** ETE **50** PRE 0

5. Credits: 4 6. Semester**: Spring** 7. Subject Area**: PEC**

8. Pre–requisite: **Nil**

9. Objective: To impart knowledge of robotic vision systems, robot modeling, trajectory planning, manipulator control, and design and control issues of mobile robots, space robots etc.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Review, forward and inverse kinematics, dynamics	02
2	**Robots with Flexible Elements**: Robots with Flexible Joints, Robots with Flexible Links	04
3	**Parallel Mechanisms and Robots:** Definitions, Type Synthesis of Parallel Mechanisms, Kinematics, Velocity and Accuracy Analysis, Singularity Analysis, Workspace Analysis, Static Analysis and Static Balancing, Dynamic Analysis, Design	06
4	**Mobile Robots:** **Wheeled mobile robots:** mobile robot kinematics, Mobility of Wheeled Robots, State-Space Models of Wheeled Mobile Robots, Wheeled Robot Structures, sensors for mobile robots, planning and navigation **Legged robots:** Analysis of Cyclic Walking, Control of Biped Robots Using Forward Dynamics, Biped Robots in the ZMP Scheme, Multilegged Robots, Performance Indices	08
5	**Cooperative Manipulators**: Kinematics and Statics, Cooperative Task Space, Dynamics and Load Distribution, Task-Space Analysis, Control	03
6	**Advanced Robots:** Modeling and control of space robots, underwater robots	06
7	**Control of Manipulators:** Manipulator control problem; Linear and non linear control schemes; PID control scheme; Force control.	04

8	**Image Processing and Analysis with Vision Systems**: Acquisition of images, digital images, image processing techniques, noise reduction, edge detection, image analysis, object recognition by features, application of vision systems	05
9	**Fuzzy Logic Control:** Crisp values v/s fuzzy values, fuzzy sets: Degrees of membership and truth, fuzzification, fuzzy inference rule base, defuzzification, simulation of fuzzy logic controller, application of fuzzy logic in robotics	04
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books / Publisher	Year of Publication/ Reprint
1	Niku, S. B., "Introduction to Robotics: Analysis, Systems, Applications", Prentice Hall.	2001
2	Angeles, J., " Fundamentals of Robotic Mechanical Systems: Theory, Methods and Algorithms", Springer	2003
3	Craig, J. J., " Introduction to Robotics: Mechanics & Control", Addison Wesley.	1989
4	Siegwart, R., Nourbakhsh, I. R., "Introduction to Autonomous Mobile Robots", MIT Press.	2004
5	Xu, Y. and Kanade, T., "Space Robotics: Dynamics and Control", Kluwer Academic Publishers.	1993
6	Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer	2013
7	Siciliano, Bruno, Khatib, Oussama, Handbook of Robotics, Springer	2008
8	Merzouki R., Samantaray A. K., Pathak P.M., Bouamama B. Ould, Intelligent Mechatronic Systems: Modeling, Control and Diagnosis, Springer	2013

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-569** Course Title: **Expert Systems Design**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): Theory 3 Practical 0
4. Relative Weightage: CWS **25** PRS **0** MTE **25** ETE **50** PRE **0**
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre–requisite: **Nil**
9. Objective: To cover concepts, techniques and tools for developing expert systems for various engineering systems.
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction**: Overview: Evolution and characteristics of knowledge-based systems.	02
2	**Introduction to Expert System Languages:** CLIPS (C language integrated production system) and JESS (java expert system shell).	06
3	**Pattern Matching**: Basic and advanced pattern matching techniques.	04
4	**Modular Design and Control**: Salience, phases and control facts, modules and execution control	04
5	**Knowledge Representation**: Productions, semantic nets, schemata, frames, logic and set.	04
6	**Methods of Inferences**: Inference rules, resolution system, forward and backward chaining.	04
7	**Reasoning under Uncertainty**: Hubert Dreyfus " From Socrates to Expert Systems: The Limits and Dangers of Computational Rationality" -- CSUS Library video collection, hypothetical reasoning and backward induction, temporal reasoning and Markov chains, uncertainty in inference chains; Probability-based techniques: Objective probability, experimental probability, subjective probability, Bayes' theorem, inexact or heuristic reasoning; Inexact reasoning: uncertainty and rules, certainty factors, Dempster-Shafer theory.	12

8	**Design of Expert Systems**: Approximate reasoning, fuzzy expert systems.	06
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1	Giarratano, J. C. and Riley, G. D., "Expert Systems: Principles and Programming", 4^{th} Ed., Course Technology.	2004
2	Gonzalez, A ., a nd Dankel, D., " The E ngineering of K nowledge-Based Systems", Prentice Hall.	1994
3	Jackson, P ., " Introduction t o E xpert Systems", 3^{rd} Ed., Addison Wesley.	1998
4	Akerkar, R . and Sajja, P ., "Knowledge-Based Systems", Jones & Bartlett Publishers.	2009

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-573** Course Title: **Design for Manufacturability**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **TE** 25 **PRE** 50 0

5. Credits**:** 4 6. Semester**: Both** 7.Subject Area**: DEC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce students about inter-relationship between various design, manufacture and assembly related activities.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Introduction to Design for Manufacturability (DFM), fundamentals of manufacturing technology and the interrelationship between design and manufacturing processes. Organizational changes in DFM.	10
2.	**Concurrent Engineering:** Need for concurrent engineering, industrial practices of concurrent engineering.	8
3.	**Automation**: Automation of design and manufacturing functions in CIM, computer aided process planning, Design for X, approaches to DFM.	7
4.	**Design Knowledge Representation**: Design, manufacturing, and re-design considerations, Design and manufacturing knowledge representation.	10
5.	**Evaluation of Manufacturability**: Evaluation of the manufacturability of a part design, various methods for defining manufacturability index, interpretation of MI value.	10
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Boothroyd G ., D ewhurst P ., a nd K night W ., " Product D esign f or Manufacture and Assembly", 2nd Edition, Marcel Dekker.	**2002**
2.	Bralla J. G., "Design for Manufacturability Handbook", 4th edition, McGraw Hill.	**1998**
3.	Huang G. Q., "Design for X: Concurrent Engineering Imperatives", Chapman & Hall.	**1996**
4.	Kusiak A., "Concurrent Engineering: Automation, Tools, and Techniques", Wiley.	**1993**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code**: MIN-574** Course Title**: Maintenance Management**

2. Contact Hours **: L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.) : **Theory** **3** **Practical** **0**

4. Relative Weightage :**CWS** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

5. Credits: **4** 6. Semester : Both 7.Subject area: **DEC/DHC**

8. Pre – requisite: **Nil**

9. Objective**:** To expose students about the various policies, strategies, and schedules of maintenance applicable in Indian Industries.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Importance of maintenance, Objectives, duties, functions and responsibilities of maintenance engineering department, Organization and structure of maintenance systems.	04
2	Maintenance Policies and Planning: Maintenance strategies, advantages and disadvantages of each strategy, Planned maintenance procedure, advantage of planned maintenance, Scientific maintenance, Safety in maintenance.	06
3	System Reliability**:** Quantitative estimation of reliability economies of introducing a standby unit into the production system, Optimum design configuration of a series/parallel system, Breakdown time distribution.	06
4	Maintenance Activities**:** Optimal overhaul/repair or replacement policies for equipment subject to breakdown, Budgeting and control, Production maintenance integration.	04
5	Replacement Decisions: Economic models, block replacement policy, age replacement policy, replacement policies to minimize downtime, Economics of preventive maintenance.	08
6	Maintainability and Availability: Economics of maintainability and reliability, Maintainability increment, Equipment and mission availability.	08
7	Maintenance Organization: Computer applications in maintenance management, automatic chalk out equipment kits capabilities and limitations, Management information system for maintenance.	06
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication
1	Dhillon B.S., "Engineering Maintenance: a Modern Approach". 1 edition, CRC.	**2002**
2	Kelly A., "Maintenance Planning and Control", Butterworth-Heinemann.Ltd, London.	**1983**
3	Niebel B.W., "Engineering Maintenance Management", Marcel Dekker, New York.	**1994**
4	Cliffton R. H.,"Principle of Planned Maintenance", McGraw Hill Inc. New York.	**1983**
5	Heintzelman J. E., "Handbook of Maintenance Management", Prentice-Hall Inc., Englewood Cliffs, New Jersey.	**1976**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code:**MIN-575** Course Title: **Product Design and Development**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Both** 7. Subject Area**: DEC**

8. Pre–requisite: **Nil**

9. Objective: To expose the students to the concept of design for X, concurrent engineering, reverse engineering, and rapid prototyping techniques.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Product Design**: Traditional and modern design processes; Organization objectives; Innovation, creation, and diffusion techniques; Evaluation of new product ideas – functional, technological, ecological, legal.	06
2	**Product Modeling and Reverse Engineering:**Wireframe modeling; Surface modeling – boundary representation; Solid modeling – CSG; Concept of reverse engineering.	08
3	**Product Data Exchange**: Neutral file formats for product data exchange–DXF, IGES, STEP.	06
4	**Concurrent Engineering**:Concept of concurrent engineering; Design for X; Design for manufacturability (DFM); Design for assemblability (DFA); Design for reliability (DFR); Design for quality (DFQ).	10
5	**Rapid Prototyping Methods:** Liquid based RP methods – stereolithography apparatus (SLA), solid ground curing (SGC), solid creation system (SCS), etc.; Solid based RP methods: Fused deposition modeling (FDM), laminated object manufacturing (LOM), etc.; Powder based RP methods– selective laser sintering (SLS), 3D printing (3DP), ballistic particle manufacturing (BPM), etc.	12
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication/ Reprint
1	Andrearsen, M. M., and Hein, L., "Integrated Product Development", Springer.	1987
2	Huang, G. Q., "Design for X: Concurrent Engineering Imperatives", Chapman and Hall.	1996
3	Chitale, A. K. and Gutpa, R. C., " Product Design and Manufacturing", Prentice Hall.	1997
4	ZeidI., "CAD/CAM: Theory and Practice", Tata McGraw Hill.	1998
5	Mortenson, M. E., "Geometric Modeling", 3^{rd} Ed., Industrial Press.	2006
6	Boothroyd G., Dewhurst P., and Knight, " Product Design for Manufacture and Assembly", 2^{nd} Ed., Marcel Dekker.	2002
7	Chua, C. K and. Leong, K. F., "Rapid Prototyping: Principles and Applications in Manufacturing", John Wiley & Sons.	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT.CENTER: **Mechanical and Industrial Engineering**

1. Subject Code**: MIN-576** Course Title**: Machine Tool Design and Numerical Control**
2. Contact Hours**:** **L: 3** **T:1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weightage: **CWS:25** **PRS:0** **MTE:25** **ETE: 50** **PRE:0**
5. Credits: **4** 6. Semester: **Both** 7. Subject Area: **DEC/DHC**
8. Pre – requisite**: Nil**
9. Objective: To introduce various components of numerically controlled machine tools and their application in automated manufacturing systems.
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Machine Tool Design**: General requirements; Electrical and hydraulic drives of machine tools; Layout of gear boxes; Hydraulic, electric and mechanical stepless speed regulations; Design and analysis of guideways; Bed; Column and Spindle.	16
2	**Numerical Control (NC):** Introduction to numerical control; Components of NC systems; Open and close loop NC; Types of numerical control: Point-to-point, straight cut, and continuous path NC; Drives and controls; NC-tape coding standards.	04
3	**NC Part Programming Methods**: Structure of NC part program; NC word formats; Introduction to G and M codes; Manual programming methods; Computer-assisted programming methods; APT part programming.	10
4	**Extensions of NC**: Concepts of CNC, machining center, and DNC; CNC and DNC efficiency; Tooling for NC/CNC.	04
5	**CNC Part Programming**: Tool motion commands; Tool length offset; Cutter diameter compensation command; fixed cycle command; Scaling; rotation; Mirror image; Macros programming etc.	08
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication/ Reprint
1.	Mehta N. K.,” Machine Tool Design and Numerical Control”, 3rd Edition Tata McGraw Hill	2012
2.	Koren Y., “Computer Control of Manufacturing Systems”, McGraw	1983
3.	Rapello R. G. “Essentials of Numerical Control”, Prentice Hall Inc. Englewood	1986
4.	Chen S, and Lin J., “Computer Numerical Control: From Programming to	1994
5.	Sava M., and Pusztai J., “Computer Numerical Control Programming”, Prentice	1990
6.	Rao P. N., Tewari N. K, and Kundra T. K., “Computer Aided Manufacturing”,	1993
7.	Steve K. and Gill A., “ CNC Technology and Programming”, McGraw	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical and Industrial Engineering**

1. Subject Code: **MIN-577** Course Title: **Industrial Automation**

2. Contact Hours : **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.) : **Theory** **3** **Practical** **0**

4. Relative Weightage **:CWS** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

5. Credits: **4** 6. Semester: Both 7. Subject Area: **DHC/DEC**

8. Pre – requisite**: Nil**

9. Objective: This course aims to expose the students to the concepts of automation theory and its applications in various fields of manufacturing.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Basic Concepts: Introduction of Mechanization and Automation, Classification and Strategies of Automation, Reasons for and Arguments against Automation. Mechanical, Electrical, Hydraulic, and Pneumatic Devices and Controls	06
2	High Volume Manufacturing or Hard Automation: Automated Flow Lines, Types of Automatic Transfer Mechanisms, Design and Fabrication Considerations, Analysis of Automated Flow Lines.	06
3	Assembly Automation: Assembly Systems and their Types, Manual Assembly Lines and Line Balancing, Automated Assembly Lines and their Types, Automatic Assembly Transfer Systems, Automatic Feeding and Orienting Devices:- Vibratory and Mechanical Feeders and their types, Orientation of Parts, Performance and Economics of Assembly Systems, Feasibility Study for Assembly Automation.	16
4	Design for Assembly: Design for Manual Assembly, Design for High-Speed Automatic Assembly, Design for Robot Assembly	04
5	Flexible Automation: Introduction of Group Technology (GT), Steps in Implementing GT, Part Families and Machine Cell Formation, Introduction of Flexible Manufacturing Systems (FMS).	06
6	Programmable Automation: Brief Introduction of Numerical Control (NC), Computer Numerical Control (CNC), Machining Centers, Programmable Robots, Direct Numerical Control (DNC), and Adaptive Control.	04
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication
1	Groover M.P., "Automation, Production systems and Computer Integrated Manufacturing", 2^{nd} Edition, Prentice Hall.	**2005**
2	Boothroyd G., "Assembly Automation and Product Design", 2^{nd} Edition, Marcel Dekker CRC.	**1992**
3	Boothroyd G., Dewhurst P., Knight W. and Marcel Dekker, "Product Design for Manufacture and Assembly", 2^{nd} Edition, Taylor & Francis.	**2002**
4	Boothroyd G., Poli C., Murch L. E., "Automatic Assembly", Marcel Dekker, New York.	**1982**
5	Tergan V., Andreev I. and Lieberman B., "Fundamentals of Industrial Automation", 1^{st} Edition, Mir Publishers.	**1986**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-578** Course Title: **Computer Aided Process Planning**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.) : **Theory** **3** **Practical** **0**

4. Relative Weightage**: CWS** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

5. Credits: **4** 6. Semester: **Both** 7. Subject Area: **DEC**

8. Pre– requisite: **Nil**

9. Objective: To impart knowledge on the integration of design and manufacturing functions leading to the concepts of process planning.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: traditional process planning, product design evaluation, various steps in process planning.	5
2.	**Group Technology**: Introduction, advantages, part families, classification and coding systems, production flow analysis, design of machine cells.	10
3.	**Concepts Related to Process Planning**: Machinability data system, cutting condition optimization.	5
4.	**Automated Process Planning**: Advantages of automated process planning, various approaches to process planning; Variant process planning, its features and different stages, different variant systems; Generative and semi-generative process planning, its features, design strategies, planning, modeling and coding scheme, decision mechanisms; Process capability analysis, intelligent process planning system; Artificial intelligence -- overview and application in process planning; Various recent process planning systems; Case studies.	12
5.	**Interfaces of Process Planning**: Integrating with loading, scheduling, MRP II, and capacity planning and other shop floor functions.	10
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Chang, T.C. and Wysk, R.A, “An Introduction to Automated Process Planning”, Prentice-Hall.	1985
2.	Gallagher, C.C and Knight, W.A., “Group Technology: Production Method in Manufacturing”, Ellis Horewood.	1986
3.	Nilsson, N.J., “Principles of Artificial Intelligence”,Springer Verlag.	1982
4.	Cornelius,L.T, “Computer Aided and Integrated Manufacturing Systems: Manufacturing Processes”, World Scientific Publishing Company.	2003

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-579** Course Title: **Information Systems & Data Management**

2. Contact Hours **:** **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.) : **Theory** **3** **Practical** **0**

4. Relative Weightage: **CWS** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

5. Credits: **4** 6. Semester: Both 7. Subject Area **: DEC/DHC**

8. Pre – requisite: **Nil**

9. Objective: To expose the students to various information systems and to familiarize with data based systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: role of information system, the function of information system, determination of informational need.	**4**
2.	Information processing concepts: historical perspective, today's status, systems approach and analysis, concepts of data and information, data collection, data or information, data and information storage, data processing and information generation, transmission of data and information and the information economics of information.	**10**
3.	Information system analysis: overview of system, management and formal information systems, hierarchical and system approach to information systems design and their applications, tailoring the information system to meet specific information requirements using filtering monitoring, interrogative and external methods.	**14**
4.	Data base management system: introduction to data base concepts, difference between a file system and a data base systems, goals of DBMS including data independence consistency, data security and integrity; DBMS models, hierarchical network and relation, data description and query language, physical database design, case studies, system R, Ingress, IDMS etc.; introduction to distributed database, concurrency control bases recovery etc.	**14**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication
1.	Henry Luces C., "Information Systems Concepts for Management", McGraw Hill International Book Co.	**1978**
2.	Burch J.G. and Strater F. R., "Information Systems Theory and Practice", Hamilton Publishing Co.	**1989**

3.	Walker D. W., "Computer Based Information System An Introduction", Pergamon Press.	**1989**
4.	Cardenas A. F., "Database Management Systems".	**1985**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical and Industrial Engineering**

1. Subject Code: **MIN-580** Course Title: **Welding Science**

2. Contact Hours : **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.) : **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 6. Semester: Both 7. Subject Area: **DEC/DHC**

8. Pre–requisite: **Nil**

9. Objective: To expose the students to the field of Welding Engineering and to let them understand the concepts, processes, affecting parameters related to welding. The course deals with fundamentals of arc welding processes, metal transfer and weldability of metals as well.

10. Details of Course:

S. No.	Contents	Contact Hours
1	Introduction: Welding as compared with other fabrication processes, Classification of Welding Processes	02
2	Physics of Welding Arc: Welding arc, arc initiation and maintenance, voltage distribution along the arc, cathode and anode drops, Arc column, Thermionic and non thermionic cathode, Theories of cathode and anode mechanisms, arc characteristics, arc efficiency, heat generation at cathode and anode Effect of shielding gas on arc, isotherms of arcs, arc blow.	10
3	Metal Transfer: Mechanism and types of metal transfer in various arc welding processes, factors controlling melting rate in various welding processes.	04
4	Welding Power Sources: Basic characteristics of power sources for various arc welding processes, arc length regulation in mechanized welding processes, Transformer, rectifier and generators, Duty cycle and power factor, Static and dynamic characteristics of power sources.	05
5	Welding Processes: Critical review of MMA; TIG. MIG and CO_2 welding processes, plasma arc, submerged arc welding, electro- gas and electro-slag welding; resistance welding. Theory and mechanism of solid state welding; technique and scope of friction welding, diffusion welding; cold pressure welding and ultrasonic welding, scope and application of electron beam and laser welding processes.	12
6	Heat Flow in Welding: Calculation of peak temperature; width of Heat Affected Zone; cooling rate and solidification rates; weld thermal cycles; residual stresses and their measurement; weld distortion and its prevention.	04

7	Weldability of Metals: Effects of alloying elements on weld ability, welding of plain carbon steel, stainless steel, Cast Iron and aluminium.	05
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication
1	"Welding Handbook", 7th Edition-Volume l to 5, American Welding Society.	**1982**
2	Houdlecroft P.T., "Welding Process Technology", Cambridge University Press.	**1977**
3	Udin H, Fruk F and Wulff J, "Welding for Engineers", John Wiley.	**1978**
4	Rossi E., "Welding Technology", Mc-Graw Hill.	**1969**
5	Baldev, R., "Welding Technology for Engineers", ASM International	**2006**
6	Bowditch, W.A., Bowditch M. A., Bowditch, K. E., "Welding Technology Fundamentals", 4th Edition, Goodheart-Willcox Pub.	**2009**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-581** Course Title: **Manufacturing Resources Management**
2. Contact Hours: **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weightage**: CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**
5. Credits**: 4** 6. Semester**: Both** 7.Subject Area**: DEC/DHC**
8. Pre-requisite**: Nil**
9. Objective: To introduce various types of resources in manufacturing systems, their importance and management.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Production as input output system; Resources of production; Forecasting and resources planning.	**5**
2.	**Material Management**: Definition and scope; Functions; Types of materials; Analytical structure of inventory models; Material requirement planning (MRP); Inventory control systems; Purchase management; Storekeeping and issue of materials; Material handling; Just in Time (JIT) and Kanban systems.	**7**
3.	**Human Resources Management**: Objective; function; organizational planning and development; staffing policies and process; training and executive development; wage and salary policies and administration; motivation; employee services; employee record; labor relations; collective bargaining; personnel research.	**10**
4.	**Production Management**: Direct and indirect; Machines and equipment planning; jigs and tools planning, material handling equipment planning; Planning of land, roads, building, warehouses etc.; General vs special purpose equipment; Economic analysis; Equipment replacement; Capital resources planning; Method of allocation of resources.	**10**
5.	**Production Information Management**: Management of production technology; information systems; Management Information Systems (MIS); Strategic Information System (SIS); Information networking; Parts oriented production information systems.	**10**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Hitomi K., "Manufacturing System Engineering", 2nd Edition, Viva Books.	1996
2.	Hitomi K, "Manufacturing Systems Engineering: A Unified Approach to Manufacturing Technology, Production Management and Industrial Economics", 2nd Edition, CRC Press.	1996
3.	Groover, M. P., "Fundamentals of Modern Manufacturing: Materials,	2010

	Processes, and Systems",4th Edition, Wiley	
4.	Gary Dessler, "Personnel Management", 4th Edition, Reston Publishing.	1988
5.	Nauhria R. N. and Rajneesh Prakash, "Management of Systems", Wheeler Publishing.	1995
6.	Thomas Vollman E., William Berry L. and Clay Whybark D., "Manufacturing Planning and Control Systems", 5th Edition, Galgotia Publishing.	1997

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code**: MIN-582** Course Title: **Flexible Manufacturing Systems**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.) : **Theory** **3** **Practical** **0**

4. Relative Weightage **: CWS** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

5. Credits: **4** **6.** Semester**: Both** **7**. Subject Area: **DEC**

8. Pre – requisite**: Nil**

9. Objective**:** To introduce the concepts of flexibilities and its importance in batch manufacturing, va rious t ypes of F MS c onfigurations a nd t heir pl anning a nd control.

10. Details of Course**:**

S. No.	Contents	Contact Hours
1.	**Introduction**: Definition and classification of ma nufacturing s ystems, fundamentals of a utomated pr oduction cycle, ne ed of flexibility, con cept of flexibility, various types of flexibility, measures of flexibility.	7
2.	**Flexible M anufacturing System (FMS) T ype**: Introduction of FMS, definition of F MS, t ypes of FMS, applications of FM S, FMS configuration, FMS host operator interface.	10
3.	**FMS Planning an d C ontrol**: Functional r equirements of F MS equipments, f unctions of F MS hos t c omputer, hos t s ystem de sign, planning, scheduling of FMS, FMS simulation, Databases in FMS, GT in FMS, cell design and layout design, CAPP in FMS.	14
4.	**Material h andling in F MS**: Material ha ndling pr inciples i n F MS, applications of robots in FMS.	6
5.	**Case St udies**: Cases o n FMS ins tallation a nd imp lementation –acceptance testing and maintenance	5
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication /Reprint
1.	Groover, M. P., "Automation, Production System and CIM", 2nd Ed., Prentice Hall.	2000
2.	Rankey, P., "Design and Operations of FMS", North-Holland Publishing.	1983
3.	Warnecke, H. J. (Ed.), "Flexible Manufacturing System", Springer.	1985
4.	Bonetto, R., "FMS in Practice", North Oxford Academic Publishers.	1988

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTER: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-583** Course Title**: Materials Management**

2. Contact Hours**: L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.)**: Theory** 3 **Practical** 0

4. Relative Weightage**: CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 **6.** Semester**:** Both **7.** Subject Area: **DEC/DHC**

8. Pre – requisite**: Nil**

9. Objective**:** The aim of this course is to introduce to the students the basic concepts of purchase and supply of materials for the production process in an industry.

10. Details of Course**:**

S. No.	Contents	Contact Hours
1	**Introduction**: Operating environment:, scope, and issues	04
2	Material Requirement Planning**:** Introduction, Bills of material, Material requirement plans and planning process.	06
3	**Capacity M anagement:** Definition of capacity, capacity planning, Capacity requirement planning, capacity available and required, Scheduling order, make plan	06
4	**Production A ctivity and Control:** Data requirements, order preparation, scheduling, load leveling, Scheduling bottlenecks, production reporting.	06
5	**Purchasing, forecasting, and Inventory fundamentals**: Establishing specifications, selecting suppliers, price determination, demand management, demand forecasting, principle of forecasting, forecasting techniques, seasonality, tracking the forecast, inventory and flow of materials, supply and demand pattern, functions of inventories, ABC, VED and FSN system of selective inventory, EOQ, variation of EOQ models, period order quantity, quantity discount.	16
6	**Just i n t ime M anufacturing**: JIT philosophy, JIT environment, Manufacturing planning and control in JIT environment, MRP, Kanban, theory and constraints.	04
	Total	**42**

11. Suggested Books**:**

S. No.	Name of Books / Authors / Publisher	Year of Publication
1	Handfield R.B. and Nichols E.L., Jr "Introduction to Supply Chain Management", Prentice-Hall Inc.	1999
2	Bowersox D. J. and Closs D. J., "Logistical Management: The Integrated Supply Chain Process", McGraw-Hill, New York.	1996
3	Leenders M.R. and Fearon H.E., "Purchasing and Materials Management", 11th Edition, Irwin Burr Ridge, Illinois.	1997
4	Arnold J. R. T. and Chapman S. N., "Introduction to Materials Management", 4th Edition, Pearson Education Asia.	2001

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical & Industrial Engineering**

1. Subject Code: **MIN-584** Course Title**: Operations Research**

2. Contact Hours **:** **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.) : **Theory:** **3** **Practical:** **0**

4. Relative Weightage **:CWS** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

5. Credits: **4** 6. Semester: Both 7. Subject Area: **DEC/DHC**

8. Pre-requisite**: Nil**

9. Objective**:** To expose the students to various optimization techniques for· formulating and solving various industrial problems and to develop their skills to design production and services unit as a whole.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: definition and scope of OR; techniques and tools; model formulation; general methods for solution; classification of optimization problems; optimization techniques.	**2**
2.	Linear optimization models: complex and revised simplex algorithms; duality theorems; sensitivity analysis; assignment, transportation and transshipment models; traveling salesman problem as an assignment problem; integer and parametric programming; goal programming.	**12**
3.	Game problems: minimax criterion and optimal strategy; two person zero sum game; games by simplex dominance rules.	**6**
4.	Waiting line problems: classification of queuing situations; Kendall's notation, Poisson arrival with exponential or Erlang service time distribution; finite and infinite queues; optimal service rates; application of queuing theory to industrial problems.	**8**
5.	Dynamic programming: characteristic of dynamic programming problems (DPPs); Bellman's principle of optimality; problems with finite number of stages; use of simplex algorithm for solving DPPs.	**6**
6.	Non- linear programming: one dimensional minimization methods; unconstrained optimization techniques; optimization techniques- characteristics of a constrained problem; indirect methods; search and gradient methods.	**8**
	Total	**42**

11**.** Suggested Books:

S. No.	Name of Books / Authors / Publisher	Year of Publication
1.	Taha H. A., “An Introduction to Operations Research”, 6th Edition, Prentice hall of India;.	**2001**
2.	Hillier F. J. and Lieberman G.J., “Introduction to Operations Research”, 7th	**2001**

	Edition Holden Day Inc.	
3.	Loomba N.P., “Linear Programming”, 2nd Edition, Mcmillan Publishing Inc. New York.	**1976**
4.	Wagner H. M., “Principles of OR with Applications to Managerial Decisions”, 2nd Edition, Prentice Hall.	**1975**
5.	Giffin, Walter G., “Queueing Basic Theory and Applications”, Grid Inc., Ohio.	**1978**

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INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-585** Course Title: **Supply Chain Management**

2. Contact Hours : **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.) : **Theory: 3** **Practical: 0**

4. Relative Weightage : **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 6. Semester: Both 7. Subject Area: **DEC/DHC**

8. Pre – requisite: **Nil**

9. Objective: To provide an insight into functioning and networking of supply chain decisions for the success of a business. The course will provide foundation for design, analysis and performance metrics and to frame a sound supply chain network in the country.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction**: Understanding supply chain, supply chain performance; supply chain drivers and obstacles.	4
2	**Planning Demand and Supply in a Supply Chain**: Demand forecasting in supply chain, aggregate planning in supply chain, planning supply and demand; managing predictable variability, Economic Order Quantity Models, Reorder Point Models, Multi-echelon Inventory Systems.	12
3	**Planning and Managing inventories in a Supply Chain**: Managing economies of supply chain, managing uncertainty in a supply chain, determining optimal levels of product availability.	6
4	**Transportation, Network Design and Information Technology**: Transportation aspects in a supply chain, facility Decision, Network design in a supply chain, Information technology and its use in supply chain.	10
5	**Coordination in Supply Chain and effect of E- Business:** Role of Coordination and E-business in a supply chain; financial evaluation in a supply chain.	10
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1	Hopp W. J., Spearman M. L. and Irwin, “Factory Physics: Foundations of Manufacturing”, McGraw-Hill Inc. New York.	**1996**
2	Viswanadham N., “Analysis of Manufacturing Enterprises”, Kluwer Academic Publishers, UK.	**2000**
3	Sridhar Tayur, Ram Ganeshan and Michael Magazine (editors), “Quantitative Models for Supply Chain Management”, Kluwer Academic Publishers, UK.	**1999**
4	Handfield R.B. and Nochols E.L.Jr., “Introduction to Supply Chain Management”, Prentice Hall Inc. Englewood- Cliff, New Jersey.	**1999**
5	Viswanadham N. and Narahari Y., “Performance Modeling of Automated Manufacturing Systems”, Prentice Hall of India, New Delhi.	**1998**
6	Chopra S. and Meindel P., “Supply Chain Management: Strategy, Planning, and Operation”, Prentice Hall of India, New Delhi.	**2002**
7	Shapiro J. F., Duxbury Thomson Learning, “Modeling the Supply Chain”, Duxbury Thomson Learning Inc., Duxbury, Pacific Grove.	**2001**
8	Levi D. S., Kaminsky P. and Levi E. S., “Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies”, McGraw Hill Inc. New York.	**2000**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical & Industrial Engineering**

1. Subject Code: **MIN-586** Course Title: **Metal Forming**

2. Contact Hours : **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.) : **Theory:** **3** **Practical:** **0**

4. Relative Weightage : **CWS** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

5. Credits: **4** 6. Semester: Both 7. Subject Area: **DEC/DHC**

8. Pre – requisite: Nil

9. Objective: The course aims to explain the advanced scientific theoretical aspects of metal forming processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: stress/strain, strain-rate characteristics of materials, yield criteria of metals, c1assification of metal working processes, formability and theory of sheet metal working, friction and lubrication in metal working operation, theories of friction and lubrication; assessment of friction at interface.	**9**
2.	Process analysis: various methods of analyzing the metal working processes (slip-line field theory; upper bound solution; stab methods).	**3**
3.	Mechanics of forming processes: rolling- determination of rolling pressure, roll separating force, driving torque and power, and power loss in bearings; forging-determination of forces in strip forging and disc forging; drawing- determination of force and power, determination of maximum allowable reduction; deep drawing force analysis, analysis of tube drawing process with fixed and moving mandrel, tandem tube drawing; bending- determination of work load and spring back; extrusion- determination of work load from stress analysis and energy consideration, power loss, hydrostatic extrusion; punching and blanking- mode of metal deformation and failure, two-dimensional deformation model and fracture analysis, determination of working force.	**20**
4.	Hydrostatic extrusion: comparison with conventional extrusion; pressure required to extrude, variables affecting the process.	**4**
5.	High speed forming: classification, comparison of low and high speed forming operation problems in high speed forming operation, introduction to high forming process such as explosive forming, electrical and mechanical high speed forming techniques.	**6**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Rowe, and Geoffrey W, “An Introduction to Principles of Metal Working”, St. Martin Press.	**1965**
2.	Avitzur B., “Metal Forming Analysis”, Mc Graw Hill.	**1980**
3.	Polukhin V.P., “Mathematical Simulation and Computer Analysis of Thin Strip Rolling Mill”, MIR Publishers.	**1975**
4.	Jhonson W.and Meller P.B., “Plasticity of Mechanical Engineers”, Van Nostrand.	**1983**
5.	“High Velocity Working of Metals”, ASTME.	**1964**
6.	Ghosh A. and Mallik A. K., “Manufacturing Science”, Affiliated East-West.	**2000**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-587** Course Title: **Metal Casting**
2. Contact Hours : **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.) : **Theory: 3** **Practical: 0**
4. Relative Weightage : **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0
5. Credits: 4 6. Semester: Both 7. Subject Area: **DEC/DHC**
8. Pre – requisite: **Nil**
9. Objective: To explain the advanced scientific theoretical aspects of metal casting processes.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Features of casting problem, a survey and scope of foundry industry.	3
2.	**Solidification**: Solidification of pure metals and al1oys, nucleation and growth in alloys, solidification of actual castings, progressive and directional solidification, centerline feeding resistance, rate of solidification, Chvorinov's Rule, electrical analog of solidification problem; Fluidity**-** measurement of fluidity, effects of various parameters on fluidity	8
3.	**Risering an d G ating S ystem**: Riser design, risering curves, NRL method of riser design, feeding distance, risering of complex casting, risering of alloy other than steel, recent developments in riser design by the application of geometrical programming; Gating systems and their characteristics, the effects of gates on aspiration, turbulence and dross trap, recent trends.	5
4.	**Pattern and Casting Design**: Pattern design, recent developments in pattern design, materials and construction; Casting design considerations- review of casting design, recent trends.	9
5.	**Melting, Molding and C ore Making Processes**: Selection and control of melting furnaces, boiling, refining and pouring, recent trends in cupola design; Review and critical comparison of various established processes, recent developments e.g. low pressure and ferrous die casting, high pressure molding, full mold process, flaskless molding, hot and cold box molding, ceramic shell molding, V-process, continuous casting, squeeze and pressed casting, Nishiyama process, Shaw process, Anitoch process etc.	6
6.	**Internal S tresses, Defects and Sur face F inish**: Residual stresses, hot tears and cracks in castings, stress relief, defects and their causes and remedies, various parameters affecting surface finish and related defects e.g. rough casting, sand bum-	7

	on sand bum-in and metal penetration, facing and washes, mold wall movement, vapor transpol1 zones, expansion scabbing etc; Gases in metal- methods of elimination and control of dissolved gases in castings.	
7.	**Testing, Inspection and Quality Control**: Testing of sand, recent developments e.g. mulling index, moldability index, compactability; deformability; Review of X-ray and gamma ray radiography, magnetic particle, die penetrant and ultrasonic inspection, use of statistical quality control in foundry.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors / Books / Publisher	Year of Publication/ Reprint
1.	Flinn R.A., "Fundamentals of Metal Casting", Addison Wesley Inc., Reading.	1963
2.	Heine R.W, Loper C.R. and Rosenthal P.C., "Principles of Metal Casting", Tata McGraw-Hill.	1997
3.	Niebel B.W., and Draper A.B., "Modern Manufacturing Process Engineering", McGraw Hill.	1990
4.	"Metals Handbook-Metal Casting", ASM.	1985
5	Beeley, Peter R. , "Foundry Technology", Butterworth-Heinemann.	2001
6	Jain, P. L., "Principles of Foundry Technology", Tata Mc. Graw-Hill.	1999

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPARTMENT: Mechanical & Industrial Engineering

1. **Subject Code:** MIN-588 **Course Title:** Non-Traditional Machining Processes
2. **Contact Hours:** L: 3 ; T: 1 ; P: 0 ;
3. **Examination Duration (Hrs.): Theory** 3 **Practical** - -
4. **Relative Weightage:** CWS 2 5 PRS - - MTE 2 5 ETE 5 0 PRE - -
5. **Credits:** 0 4 **6. Semester:** Both
7. **Pre – requisite:** NIL **8. Subject Area: DEC/DHC**
9. **Objectives of Course:** This course covers the details of various non-traditional/unconventional or advanced machining processes (AMPs).
10. **Details of Course:**

S. No.	Particulars	Contact Hours
1	**Introduction:** Types of advanced manufacturing processes; Evolution, need, and classification of advanced machining processes (AMPs).	02
2	**Mechanical Type AMPs:** USM, Rotary Ultra Sonic Machining (RUM), AJM, WJM, AWJM processes - Process principle and mechanism of material removal; Process Parameters; Process Capabilities; Applications; Operational characteristics; Limitations.	08
3	**Advanced Fine Finishing Process:** Abrasive Flow Machining (AFM), Magnetic Abrasive Finishing (MAF), Magneto Rheological Abrasive Finishing (MRAF) - Process principle; Process equipment; Process Parameters; Process Capabilities; Applications; Limitations.	06
4	**Chemical Type AMPs:** Process principle and details of Chemical Machining (CHM), Photo-Chemical Machining (PCM), and Bio-Chemical Machining (BCM) processes.	04
5	**Electro Chemical Type AMPs:** ECM - Process principle; Mechanism of material removal; Process Parameters; Process Capabilities; Applications	06
6	**Thermal Type AMPs:** EDM, Wire Electro Discharge Machining (WEDM), LBM, EBM, IBM, PAM processes – Process principle and mechanism of material removal; Process parameters and characteristics; Surface finish and accuracy, Process Capabilities; Applications; Limitations.	08
7	**Derived and Hybrid AMPs:** Electro Stream Drilling (ESD), Shaped Tube Electro Machining (STEM), Electro Chemical Honing (ECH), Electro Chemical Deburring (ECDE), Electro Chemical Discharge Machining (ECDM) - Process Parameters; Process Capabilities; Applications; Limitations, Introduction to form machining.	08
	Total	**42**

11. **Suggested Books:**

S.	Name of Books / Authors / Publisher	Year of

No.		Publication
1.	Pandey P. C., Shan H. S. "Modern Machining Processes", , Tata McGraw-Hill Publishing Co. Ltd, New Delhi (ISBN 0-07-096553-6)	1977
2.	Ghosh A., Mallik A. K., "Manufacturing Science", Affiliated East-West Press Ltd, New Delhi	1985
3.	Benedict G. F., "Nontraditional Manufacturing Processes", Marcel Dekker, Inc. New York (ISBN 0-8247-7352-7)	1987
4.	McGeough J. A.,"Advanced Method of Machining", Chapman and Hall, New York (ISBN 8842-0412-31170-5)	1988
5.	Mishra P. K., "Nonconventional Machining", Narosa Publishing House, New Delhi (ISBN 81-7319-138-7)	1997
6.	Jain V. K.,"Advanced Machining Processes", Allied Publishers, New Delhi (ISBN 81-7764-294-4)	2002
7.	“Machining Data Handbook: Vol. 2”, Machinability Data Center, (3rd edition), Metcut Research Associates Inc., Ohio	1980

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Mechanical and Industrial Engineering**

1. Subject Code: **MIN-593** Course Title: **Non Conventional Welding Processes**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs): **Theory: 3 Practical: 0**
4. Relative Weightage: **CWS 25 MTE 25 ETE 50 PRS 0 PRE 0**
5. Credits: **4** 6. Semester : **Both** 7. Subject Area: **DEC/DHC**
8. Pre-requisite: **nil**
9. Objectives: The aim of the course is to provide theoretical and practical details of various non-conventional welding/joining processes and techniques including high energy density welding processes.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Resistance Welding: Principle of contact resistance; calculation of current, time and voltage for spot welding, choice of electrode material; electrode shapes; shunt current; shop tests for soundness of spot welds, seam, projection, butt and flash welding; selection of welding and other process details; stud welding; power sources for resistance welding**.**	10
2.	High Power Density Welding Processes: Electron Beam (EB) welding in different degrees of vacuum, applications; Laser welding; principle of operation; laser materials, applications.	4
3.	Solid State Welding Processes : Fundamental principles of various non- conventional pressure welding processes and their applications; friction, explosive, diffusion and ultrasonic welding; induction welding.	8
4.	Special Topics: Soldering; brazing and braze welding; welding of plastics.	5
5.	Cutting and Surfacing : Plasma and thermal cutting and surfacing operations; parameters; consumables; and equipment; arc and gas gouging.	8
6.	Safety Measures in Welding: Various safety measures for conventional and non-conventional welding processes. Gas cylinder colour codes; storage and transportation of gases; protection from fire and explosions. Protection against electric shocks and short circuiting; chemistry and mechanism of formation of fumes; effect of fumes; radiations and noise on welder's health; eye flash, skin burn, heat exhaustion and other diseases; protective devices such as exhaust hoods, booths, shields, goggles, screens, clothing and ear covers; safety during welding in confined spaces.	7
	Total	**42**

11. Suggested Books**:**

S. No.	Name of Authors/ Books/ Publisher	Year of Publication
1.	“Welding Handbook”, Vol. 2 & 3, 9 th Edition, American Welding Society.	**2003**
2.	“Metals Handbook”, Vol. 6, American Society of Metals.	**1993**
3.	“Procedure Handbook of Arc Welding”, Lincoln Electric Co., USA.	**2004**
4.	Tylecote R.F., “The Solid phase welding of Metals”, Edward Arnold Pub. Ltd.	**1968**
5.	Richard Little L., “Welding and Welding Technology”, McGraw Hill.	**1976**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical and Industrial Engineering**

1. Subject Code: **MIN-594** Course Title: **Safety Aspect of Welded Structures**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.) : **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 6. Semester: Both 7. Subject Area: **DEC/DHC**

8. Pre – requisite: Nil

9. Objectives of Course: Objective of this course is to provide knowledge of safety of welded structure primarily in reference to various consequences of stress and strain state, loading conditions and susceptible mode of fracture. The course is also intended to cover different methods of safety analysis of welded structure using fracture mechanics concepts.

10. Details of Course:

S. NO.	Contents	Contact Hours
1.	**Basis of Safety Concept**: Definition of safety and definition of safety concept; Basic mechanism of failure of components; Brittle and ductile fracture; Collapse fatigue fracture mechanism and representations at sub-microscopic and macroscopic levels through Mohr's Circle; Specific problems of safety related to weldments; Definition and safety relevance of weld imperfections.	8
2.	**Conventional Methods for Safety Analysis**: Concepts of strength and toughness of engineering materials; Determination and consequences of stress and strain state; Material - stress and strain state embitterment, their reasons and consequences; Effects of notches, stress state in notched component, safety analysis and assessment of notched components using notch theory; Semi quantitative Fracture Analysis Diagrams (Pellim's FAD); limitations of conventional methods.	8
3.	**Fracture Mechanics:** Concepts of stress-strain state of cracked components; Introduction and basic principles of fracture mechanics; Linear Elastic Fracture Mechanics (LEFM); Stress intensity factor; Determination of fracture toughness.	9
4.	**Methods for Safety Analysis:** ASTME:399 method; Limitations of LEFM; Modified LEFM (ASTME 1820); General yielding criterion; Plastic Limit Load Calculations (PLLC); Principles of Two Criteria Approach (TCA); Failure assessment diagram (CEGB Report R-6); Mechanism of cyclic crack growth; Paris law; Modifications of Paris law; Effects of temperature and environment; Elastic plastic fracture mechanics (EPFM); Stable crack growth; COD concept (CTOD BS: 5762); R-curve technique; Instability diagram.	9
5.	**Application of Safety Concepts to Welded Structures:** Material imperfections and stress states in weldments; Quality - degradation in welded structures; CODE	8

	requirements; Case studies as examples of failures; Design and service requirements for engineering structures fabricated by welding i.e. welded structures.	
	Total	**42**

11. Suggested Books:

S.No.	Name of Books/ Authors/ Publisher	Year of Publication
1.	Anderson T. L., “Fracture Mechanics: Fundamentals and Applications”, 3rd Edition, Taylor & Francis Group.	**2000**
2.	Farahmand Bahram.,”Fracture Mechanics of Metals, Composites, Welds and Bolted Joints”, Hardcover, Kluwer Academic Publishers .	**2000**
3.	Broek D., “Elementary Engineering Fracture Mechanics”, Martinus Nijhoff.	**1982**
4.	Latzko D.G.H, “Post Yield Fracture Mechanics”, 2nd Edition, Elsevier Applied Science Publication.	**1984**
5.	Maddox S.J., “Fatigue of Welded Structures”, 2nd Edition, Woodhead Publishing.	**1991**
6.	Gurney T.R.,“Fatigue of Welded Structures”, Cambridge University Press.	**1979**
7.	Chell G.G.,“Development of fracture Mechanics”, Elsevier Applied Science Publication.	**1979**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-595** Course Title: **Failure Analysis of Welding Joints**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weightage**: CWS25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits**: 4** 6. Semester**: Both** 7.Subject Area**: DEC/DHC**

8. Pre-requisite**:** **Nil**

9. Objective: To pr ovide basic know ledge fundamental caus es of failure and general procedure of failure analysis.

10. Details of Course:

S. No.	**Contents**	**Contact Hours**
1.	**Fundamental So urces o f Failure**: Deficiencies in design, m aterial and processing errors, improper service condition, residual stresses	**8**
2.	**Tools f or failure an alysis:** Fault tr ee di agram, Failure mode a nd effective analysis, Weibull distribution, Pareto diagram	**6**
3.	**General P ractice in F ailure A nalysis**: O bjective, c ollection of background data, selection o f s amples; S election, c leaning a nd preservation of f ractured s urface, identification of m ode of f ailure, approach f or failure a nalysis, a scertaining c auses of f ailure, r eporting practice.	**6**
4.	**Examination of Fractured Components**: Preliminary examination of fractured surface, equipment used for preliminary ex amination, preservation of failure re cords, Identification of Mode of Failure: Classification, specific characteristics, distinction between different t ype of fractures, factors a ffecting mode of f racture and defects.	**6**
5.	**Analysis of t he C auses of F ailure**: Chemical analysis,	**10**

	optical microscopic examination, use of scanning electron microscope, micro probe analyser and X-ray diffraction etc. Correlation of weldment failure of different materials developed using various welding processes including repair welding	
6.	**Application of Fracture Mechanics in Failure Analysis**: Physical meaning of K_{Ic}, J_{IC} and CTOD with reference to fracture control, fracture analysis in the light of fatigue crack growth rate behaviour of material, residual life assessment . Case studies of failure in different components such as pressure vessel and nuclear reactor.	**6**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Becker, W. T. and Shipley, R. J. "Metals Handbook, Failure Analysis and Prevention", Volume 11, ASM International.	2002
2.	Hutchings, F. R. and Unterweiser, Paul M., "Failure Analysis, The British Engineering Technical Report", ASM International.	1981
3.	Robert H. and Bhadeshia H. H.K.D.H. "Steels: Microstructure and Properties", 3rd Edition, Butterworth-Heinemann.	1995
4.	"Metals Handbook, Fractography", Volume 12, ASM International.	1992
5.	Das A. K., "Metallurgy of Failure Analysis", Special Indian Edition, Tata McGraw- Hill.	1997
6	Besterfield, D C and Besterfield C (1999), Total Quality Management, Pearson Education Asia,	2002
7	Andrew K. S. and Albert H. C. Tsang, "Maintenance, replacement, and Reliability", Taylor & Francis.	2006
8	Dhillon B.S., "Engineering Maintenance: a Modern Approach". 1st Edition, CRC.	2002

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Mechanical and Industrial Engineering**

1. Subject Code: **MIN-596** Course Title: **Solid State Joining Processes**
2. Contact Hours: **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs): **Theory: 3** **Practical: 0**
4. Relative Weightage: **CWS 25 PRS 0 MTE 25 ETE 50 PRE 0**
5. Credits: **4** 6. Semester : **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objectives: The aim of the course is to provide theoretical and practical details of solid state welding/joining processes and their significance in manufacturing.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Joining defined; Fundamental forces involved in joining; Mechanical fastening and integral attachment: using mechanical forces; Adhesive bonding: using chemical forces; Welding: using physical forces; Overview of fusion and solid state welds; Fundamental principles of solid state welding processes; Classification of solid state/non-fusion welding processes.	8
2.	Adhesive bonding as a joining process; General description of adhesive bonding; Cementing and mortaring as an adhesive joining process; The functions of adhesives; Mechanisms of adhesion; Failure in adhesive-bonded joints; Adhesive joint designs; Design criteria and analysis of adhesive joints.	8
3.	Friction welding process; application of friction welding process; friction welding process parameters; radial and orbital friction welding; direct drive and inertia drive friction welding; study of friction welds; joint quality of friction welds.	8
4.	Overview of friction stir welding (FSW) process principles; welding tools used for FSW; Parameters' effects; Materials used with FSW;thermomechanical aspect of FSW; Plastic deformation in relation to material properties; Material flow and property relationships of the resultant FSW joint, friction stir processing (FSP), process parameters of FSP; Application of FSW and FSP processes.	10
5.	Diffusion joining processes: conventional diffusion, deformation diffusion, resistance diffusion & continuous seam diffusion welding; diffusion brazing; braze welding, combined forming and diffusion welding; solid-state deposition welding processes. Pressure non-fusion welding processes: cold welding processes, pressure gas welding process,	8

	forge welding process; Roll welding; Explosion welding process.	
	Total	**42**

11. Suggested Books:

S. No.	Name of Author (s)/ Book/ Publisher	Year of Publication
1.	Messler Robert W. Jr., "Joining of Materials and Structures"Elsevier Butterworth–Heinemann.	**2004**
2.	Messler Robert W. Jr., "Principles of welding"WILEY-VCHVerlag GmbH & Co. KGaA, Weinheim.	**2004**
3.	"Friction stir welding From basics to applications" Edited by Daniela Lohwasser and Zhan Chen,Woodhead Publishing India Pvt. Ltd.	**2010**
4.	"Welding Handbook", Vol. 2 & 3, 9thEdition, American Welding Society.	**2003**
5.	Richard Little L., "Welding and Welding Technology", McGraw Hill.	**1976**
6.	TylecoteR.F., "The Solid phase welding of Metals", Edward Arnold Pub. Ltd.	**1968**

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT/CENTER: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-597** Course Title: **Welding Procedure for Specific Applications**

2. Contact Hours : **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.) : **Theory** 3 **Practical** 0

4. Relative Weightage : **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 **6.** Semester: Both **7.** Subject Area: **DEC/DHC**

8. Pre-requisite: Nil

9. Objective: To introduce the students to the field problems of welding and provide details for solving them.

10. Details of Course:

S.No.	Contents	Contact Hours
1.	**Introduction and Economic Consideration:** Groove geometry and weld metal deposition rates for different welding processes; Welding cost estimation; Standard data for cost estimation; Comparative cost study for various welding procedures.	6
2.	**Welding of Offshore Constructions:** Requirement of offshore construction welding; Problems in underwater welding; Various underwater welding techniques.	6
3.	**Welding of Low Temperature Containment Plants:** Materials used for cryogenic applications; Problems of welding; Welding processes and procedures used for cryogenic materials.	6
4.	**Welding of Pressure Vessels:** Materials used for construction of pressure vessels; Processes and procedures for pressure vessels welding; Requirement of various codes.	6
5.	**Repairing of Castings:** Specific problems in repairing of castings of various materials; Welding methods used for repairing and reclamation.	6
6.	**Micro joining Techniques:** Various techniques used for joining of electronic circuitry and other micro joining applications.	6
7.	**Corrosion in Weldments**: Various types of corrosion; Factors affecting corrosion; Minimization of susceptibility to corrosion; Corrosion testingand stress corrosion cracking.	6
	Total	**42**

11. Suggested Books:

S.No.	Name of Books/ Authors/ Publisher	Year of

		Publication
1.	Peter Thomas, “Welding Process Technology”, Houldcroft Technology.	**1977**
2.	“Developments in Micro joining”, TWI, Abbington, Cambridge U.K	**1983**
3.	“Welding Hand Book” Vol. 3 and 4, 9th Edition., AWS	**2001**
4.	“Rules for Construction of Pressure Vessels”, ASME	**1977**
5.	Yahalom J. and Aladjan A., “Stress corrosion Cracking”, SN Publishers	**1980**
6.	Nixon, J.H.,“Underwater Repair Technology”, Gulf Professional Publishing	**2000**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical and Industrial Engineering**

1. Subject Code: **MIN-598** Course Title: **Weldability of Metals**

2. Contact Hours : **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs): **Theory: 3** **Practical: 0**

4. Relative Weightage: **CWS 25** **PRS 0** **MTE 25** **ETE 50** **PRE 0**

5. Credits: **4** 6.Semester: Both 7. Subject Area: D**EC/DHC**

8. Pre-requisite: Nil

9. Objective: The aim of this course is to provide the fundamental understanding on weldability of metals of commercial importance like steels, cast iron and Aluminum besides various problems encountered their remedies and precautions to be undertaken during the welding of the above mentioned metals.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Fundamentals : Weldability, definitions, factor affecting the weldability of steel Carbon equivalent, solidification of weld metal; heat affected zone (HAZ), factors affecting properties of HAZ, gas-metal, slag-metal and solid state reactions in welding and their influence on soundness of weld joint, common metal system and their weldability: work hardenable, precipitation hardenable and heat treatable alloys	4
2.	Weldability of Plain Carbon Steels: Various grade of plain-C steels, factors affecting Weldability, viz., Carbon content, section thickness, Mn/S ratio, phosphorus concentration, microstructure of weld and HAZ, cold cracking and lamellar, tearing gas porosity, mechanism, causes and prevention of defects in plain –C steel welds,	6
3.	Weldability of Stainless and Heat Resisting Steels: properties of stainless steels affecting weldability, common types of stainless steel austenitic, martensitic, ferritic and PH steel and their weldability, problems in welding of stainless steel and their remedy, weld decay, sigma phase formation, knife line cracking, stress corrosion cracking.	8
4.	Weldability of HSLA Steels: Common grades of high strength low alloy (HSLA) steels, effect of various alloying elements on weldability, factors affecting weld-metal and HAZ Properties, problems and defects encountered in welding, post weld heat treatment of HSLA steels	6

S. No.	Contents	Contact Hours
5.	Weldability of Cast Irons: Common grades of cast irons, carbon equivalent in cast irons, factors affecting weldability of cast irons, approaches for welding of cast irons common problems encountered during the welding of cast and their remedy.	6
6.	Weldability of Aluminium Alloys: Physical metallurgy of heat treatable and work hardenable aluminium alloys, properties of aluminium alloys and weldability, solidification cracking, hydrogen induced porosity, partial melting zone and liquation cracking, HAZ softening, precautions in the welding of age hardenable alloy.	6
7.	Weldability of Copper Alloys: Common copper alloys, properties of copper alloys and weldability, effect of various alloying element of weldability, problem in welding of heat treatable and none-heat treatable copper alloys and their remedy.	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Books/ Authors/ Publisher	Year of Publication
1.	Lancaster J F., “Metallurgy of Welding”, Allen & Unwin Co.	**2000**
2.	Castro R. and Cadenet J. J. de., “ Welding Metallurgy of Stainless and heat-resisting steels”, Cambridge Uni. Press.	**1975**
3.	“Welding, Brazing and soldering”, Vol. 6, ASM International, ASM, Ohio.	**1993**
4.	Kou S., Welding metallurgy, 2nd edition, Wiley Publications	**2003**
5.	Hrivnák, I., “Theory of Weldability of Metals and Alloys”, Elsevier Science	**1991**
6.	Gene Mathers, “Welding of Aluminium and alloys”, Wood Head Pub. UK.	**2002**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN – 599** Course Title: **Surface Engineering**
2. Contact Hours : **L: 3** **T: 1** **P: 0**
3. Examination Duration (Hrs.) : **Theory: 3** **Practical: 0**
4. Relative Weightage : **CWS 25** **PRS -** **MTE 25** **ETE 50** **PRE 0**
5. Credits: **4** 6. Semester: Both 7. Subject Area: **DEC/DHC**

8. Pre – requisite: **Nil**

9. Objective: The course will highlight the different surface degradation phenomena, importance of the surface engineering techniques, their benefits and limitations. Selective characterisation techniques for quality assurance of engineered surfaces will be introduced.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Concept and Importance, classification of surface modification techniques, advantages and their limitations.	3
2	**Surface Degradation**: Causes, types and consequences of surface degradation, Forms of wear – adhesive, abrasive, surface fatigue, corrosive, fretting and erosive wear, Classical governing laws related to wear, techniques to evaluate the wear damage.	10
3	**Materials for Surface Engineering**: Materials characteristics, their importance in surface engineering, wear resistant materials, selection of materials for engineering the surfaces for specific applications, New coating concepts including multi-layer structures, functionally gradient materials (FGMs), intermetallic barrier coatings and thermal barrier coating.	9
4	**Coating based Surface Modification Techniques**: Principles and application of weld surfacing: SMAW, SAW, GMAW, Thermal spraying – flame spraying, electric arc spraying, plasma spraying, detonation gun spraying and high velocity oxy fuel spraying Electro deposition and electro less coatings.	8

5	**Diffusion based Surface Modification Techniques**: Ion implantation, chemical vapour deposition (CVD) and physical vapour deposition (PVD), carburizing, nitriding, plasma nitriding, cyaniding.	4
6	**Irradiation based and Laser Assisted Surface Engineering (LASE) Techniques**: Laser cladding, alloying, glazing, laser and induction hardening, heat treatment of steel and remelting by laser / TIG. Microwave glazing.	4
7	**Characterisation and Quality Assurance of Engineered Surfaces**: Importance, Different characterisation techniques – physical, mechanical and functional characterisations, surface finish, microhardness, strength and tribological characterisations.	4
	Total	**42**

11. Suggested Books:

S.No	Name of Author (s)/ Book/ Publisher	Year of Publication
1	Burakowski T. and Wierzchoń T., "Surface Engineering of Metals: Principles, Equipment, Technologies", CRC Press, Boca Raton, Florida.	**1999**
2	Burnell-Gray J.S. and Datta P.K. (eds.), "Surface Engineering Casebook", Woodhead Publishing Limited, Cambridge, England.	**1996**
3	Grainger, S. and Blunt J. (eds.), " Engineering coatings - design and application", Abington Publishing, Cambridge, England.	**1998**
4	Rickerby D. S. and Matthews A. (eds), "Advanced Surface Coatings: a Handbook of Surface Engineering", Blackie, London.	**1991**
5	Holmberg K. and Matthews A., "Coatings Tribology: Properties, Techniques and Applications in Surface Engineering", Elsevier Science B.V., Amsterdam.	**1994**

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPARTMENT: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-601** Course Title: **Additive Manufacturing**
2. Contact Hours: L: **3** T:0 P: **2**

3. Examination Duration (Hrs.) : Theory 3 Practical 0

4. Relative Weightage :CWS 15 PRS 25 MTE 20 ETE 40 PRE 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre–requisite: **CAD**

9. Objectives of Course: The aim of this subject is to establish a broad concept of the effective and creative applications of additive manufacturing technologies in different stages of time based new product development.

10. Details of Course:

	Topics	
1	Classification of additive manufacturing (AM) processes. AM based rapid prototyping (RP) Systems like Stereo-lithography, Fused Deposition Modeling (FDM), Selective Laser Sintering (SLS), Laminated Object Manufacturing (LOM), 3-D Printing, LENS etc.	10
2	Role of additive manufacturing and rapid prototyping in product design and development. Solid modeling techniques for additive manufacturing with comparison, advantages and disadvantages.	12
3	Process planning for rapid prototyping, STL file generation Defects in STL files and repairing algorithms, Slicing and various slicing procedures.	08
4	Accuracy issues in additive manufacturing, Properties of metallic and non-metallic additive manufactured surfaces, Stress induced in additive manufacturing (AM) processes. Surface roughness problem in rapid prototyping, Part deposition orientation and issues like accuracy, surface finish, build time, support structure, cost etc.,	10
5	Rapid tooling techniques such as laminated metallic tooling, direct metal laser sintering, vacuum casting etc.	02
		42

Suggested reading

S.No	Name of Book / Authors / Publisher	Year
1	**Chua, C .K., L eong, K .F.**, R apid P rototyping: P rinciples a nd Applications in Manufacturing, John Wiley and Sons Inc.	2000
2	**Pham, D .T., D emov, S .S.,** Rapid M anufacturing: T he T echnologies and A pplications of R apid P rototyping a nd R apid T ooling, S pringer-Verlag London Limited.	2001
3	**Hopkinson, N.**, **Hague, R .J.M.** and D ickens, **P .M.**, Rapid Manufacturing a nd Industrial R evolution f or t he D igital A ge, J ohn Wiley and Sons Ltd, Chichester**.**	2005
4	**Gebhardt, A.,** Rapid Prototyping, Hanser Gardner Publications, Inc., Cincinnati	2003
5	**Noorani, R.,** Rapid Prototyping: Principles and Applications, John Wiley & Sons, Inc., New Jersey.	2006
6	**Gibson, I.,** Software Solutions for Rapid Prototyping, Professional Engineering Publication Ltd	2002
7	**Patri, K. V.,** and **Weiyin, Ma,** Rapid Prototyping - Laser-based and Other Technologies, Kluwer Academic Publishers, U.S.A.	2003
8	**Mortenson, M.E.,** Geometric Modelling, John Wiley and Sons, Inc.	1997
9	**Saxena, A., Sahay, B.,** Computer Aided Engineering Design, Anamaya Publishers, New Delhi.	2005
10	**Zeid, I.,** Mastering CAD/CAM, Tata McCraw Hill.	2006

Practical work

Assignments on va rious a spects of g eometric m odeling, f abrication of pr ototype, programming assignments and project work.

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT. /CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-603** Course Title: **Finite Element Method for Thermal Engineering**
2. Contact Hours : **L: 3 T: 1 P: 0**
3. Examination Duration (Hrs.) : **Theory** 3 **Practical** 0
4. Relative Weight: CWS 25 PRS 0 MTE 25 ETE 50 0 E
5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**
8. Pre-requisite: **Nil**
9. Objective: To introduce the recent developments in field of finite element analysis for a better engineering design.
10. Details of Course:

S. No.	Contents	Contact Hours
1	**Basic Concepts of Finite Element Methods**: Introduction, variational methods, collocation method, subdomain method, Galerkin's method, least squares method.	4
2	**Finite Element in 1-D**: Basis steps of finite element analysis, linear element, notation, weighted functions, weighted residual integral, boundary condtions, global matrix, Galerkin's formulation, Applications to fin problem, fluid flow problems.	8
3	**Finite Element in 2-D**: Single variable problems in 2-D, types of elements, triangular and rectangular elements, iso-parametric concept, higher order elements, numerical integration and computer implementation, higher order shape functions, boundary conditions, Galerkin's formulation, applications to conduction and convection heat transfer problems, plane stress and plane strain problems.	10
4	**Time dependent field problems**: Galerkin's method, consistent and lumped formulations, finite difference solution in time, numerical oscillations, example problem from heat transfer and flow problems, computer implementation	6
5	**Flow problems**: Governing equations for continuity, momentum and energy conservations, velocity-pressure formulation, velocity-vorticity formulation, finite element implementation for the solution of Navier-Stokes equations, Eulerian velocity correction method, application to two-dimensional problem, pressure boundary condition, computer	8

	implementation	
6	**Non-linear problems:** Non-linear elasticity, non-linear thermo-physical properties, implementation of Galerkin's method for non-linear heat conduction equation, application of Newton-Raphson method and other methods for non-linear heat transfer and flow problems.	6
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books /Publisher	Year of Publication/Reprint
1	Segerlind, L. J., "Applied Finite Element Analysis", 2nd Ed., John Wiley and Sons.	1984
2	Reddy, J.N., "An Introduction to Finite Element Methods", 3rd Ed., Tata McGraw-Hill.	2005
3	Rao, S.S., "The Finite Element Method in Engineering", 4th Ed., Elsevier Science.	2005
4	Zienkiewicz, O. C., Taylor, C., and Nithiarasu, P., "Finite Element Method for Fluid Dynamics", 6th Ed., Butterworth-Heinemann.	2005
5	Bathe, K. J., "Finite Element Procedures in Engineering Analysis", Prentice Hall.	1982

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical & Industrial Engineering**

1. Subject Code: **MIN-604** Course Title: **Fire Dynamics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 6. Semester**: Autumn/Spring** 7. Subject Area**: DEC/DHC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce students to the fundamental concepts of fire dynamics a base-level understanding of the principals of fire dynamics, compartment fire and smoke movement.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Fuels and combustion processes; physical chemistry of combustion in fires; summary of the heat transfer equations of conduction, conection and radiation	3
2	**Premixed Flames:** Limits of flammability; structure of premixed flame; heat loss and measurement of burning velocity; variation of burning velocity with composition, temperature, pressure, suppressant and turbulence.	6
3	**Diffusion Flames and Fire Plumes:** Laminar and turbulent jet flames; flames from natural fire: buoyant plume, fire plume, upward flow; interaction of fire plume with compartment boundaries; effect of wind on fire plume	7
4	**Steady Burning of Liquids and Solids:** Burning of liquids: pool fire, burning of liquid droplets; burning of solids: synthetic polymers, wood, dusts and powders	4
5	**Frictionless Compressible Flow:** Governing equations, full potential equation, flow through constant area ducts with heat transfer, Rayleigh lines.	6

6	**Ignition and Spread of Flames:** Ignition of liquids and solids; Flame spread over liquids and solids;.	**5**
7	**Pre-flashover and Post-flashover Compartment Fire:** Growth of flash-over: necessary conditions; ventilation requirements; factors affecting time to flashover and fire growth; fully developed fire behavior; temperature in fully developed fire; fire resistance and fire severity.	**6**
8	**Production and Movement of Smoke:** Production and measurement of smoke particles**;** test for smoke production potential; smoke movement; smoke control systems	**5**
	Total	**42**

11. Suggested Books:

S. No.	Author(s) / Title / Publisher	Year of Publication/ Reprint
1.	Drysdale, D. “Introduction to Fire Dynamics”, John Wiley	**2011**
2.	Karlsson, B., Quintiere, J., “Enclosure Fire Dynamics” , James; CRC Press	**2000**
3	Quintiere, J.G.,., “Fundamentals of Fire Phenomena”, John Wiley	**2006**
4	Gorbet, G.E., and Pharr, J.L, Fire Dynamics; Pearson Education	**2010**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Mechanical and Industrial Engineering**

1. Subject Code: **MIN-605** Course Title: **Friction and Wear**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory : 03** **Practical : 0**.

4. Relative Weight**:** **CWS :** 25 **PRS :** 0 **MTE :** 25 **ETE :** 50 **PRE :** 0

5. Credits**: 4** 6. Semester**: Autumn/Spring** 7. Subject Area**: PEC**

8. Pre-requisite**:** **Nil**

9. Objective: To impart knowledge on concepts of friction and wear of engineering materials.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Introduction: Concept of a surface and surface topography of engineering surfaces; Interaction between contacting surfaces, concept of elastic and plastic deformation, Hertz's contact theory; Concept of surface forces – electrostatic forces, capillary forces and van der Waal forces.	**4**
2.	Friction: Concept and laws of friction; Theories of friction, rolling friction, sliding friction, Coulomb model, junction growth, asperity deformation, stresses in friction; Temperature in friction.	**5**
3.	Friction and Engineering Materials: Friction of metallic materials, ceramics, polymers and lamellar solids.	**7**
4.	Assessment and Control of Friction: Assessment of co-efficient of friction, measurement of friction force and contact temperature, assessment of surface forces, tribometer and atomic force microscope (AFM); Lubricants in reducing friction..	**4**
5.	Wear: Concept of wear of engineering surfaces; Types of wear; Sliding wear, dry and lubricated wear of surfaces, chemical wear.	**5**
6.	Wear Mechanisms: Abrasion; Adhesion; Erosion; Fatigue; Corrosion; Other forms of wear.	**7**
7.	Wear Characteristics of Engineering Materials: Wear of metallic	**6**

	materials, ceramics, composites and polymers.	
8.	Wear estimation and Control: ASTM standards for estimation of wear of engineering surfaces; Modification of functional surfaces for minimization of wear, selection of materials and techniques.	**4**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Books / Authors/ Publishers**	**Year of Publication/ Reprint**
1.	Rabinowicz, E., "Friction and Wear of Materials", John Wiley and Sons, Inc., New York.	1965
2.	Hutchings, I.M., "Tribology: Friction and Wear of Engineering Materials", Edward Arnold, London.	1992
3.	Rigney, D.A.(ed.), "Fundamentals of Friction and Wear of Materials", American Society for Metals, Ohio, USA.	1981
4.	Zum Gahr, K. H., "Microstructure and Wear of Materials", Elsevier, Amsterdam.	1987
5.	Burnell-Gray, J. S. and Datta, P.K. (eds.), "Surface Engineering Casebook", Woodhead Publishing Limited, Cambridge, England.	1996
6.	Dowson, D., "History of Tribology", Longman, London.	1978
7.	Bowden, F. P. and Tabor, D., "The Friction and Lubrication of Solids", Part I & II, Clarendon Press, Oxford.	1964
8.	Takadoum, J., "Materials and Surface Engineering in Tribology", John Wiley and Sons, Inc., London.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-606** Course Title: **Numerical Methods in Manufacturing**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weight: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 6. Semester: **Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: To expose the students to in various numerical methods and modeling tools to model and simulate manufacturing and materials processing operations.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Numerical Methods:** Introduction, Linear equations, Non-linear equations, Functional approximation, Numerical differentiation, Numerical integration, Ordinary differential equations, Partial differential equations, Finite difference method, Finite element method, Finite volume method, Orthogonal collocation, Boundary integral method, Optimization	8
2.	**Science Base of Mathematical Model Development:** Introduction, Fluid flow phenomenon, Heat transfer, Diffusion and mass transfer, Multiphase flow	8
3.	**Modeling of Casting & Solidification Process:** Fundamentals of casting and solidification process, Heat flow in solidification, Solidification of mushy zones, Finite element simulation of solidification problems, Modeling and formulation of casting problems, case studies, Macro-modeling of solidification; Numerical approximation methods, Discretization of governing equations, Solution of discretized equations, Application of macro-modeling of solidification	10

4.	**Modeling of Metal Forming Processes:** Introduction, Plasciticity fundamentals: von Mises yield criterion, Tresca yield criterion, Flow rule, Generalised stress & generalised strain increment, Plastic anisotropy, Anisotropic yield criterion, Plastic instability, Process modeling: Uniform energy method, slab method, slip-line field method, upper bound method, Visioplasticity method, Finite element method, Application of finite element method, Eulerian rigid-plastic FEM formulation for plane strain rolling, Governing equations	**10**
5.	**Modeling of Welding Processes:** Weld pool heat & fluid flow, Modeling of fluid dynamics & coupled phenomenon in arch weld pools, finite element analysis of welding residual stress & distribution	**6**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Books / Authors**	**Year of Publication**
1.	Ilegbusi, Olusegun J., Iguchi, M., Wanhsiedler, W., “Mathematical and Physical Modelling of Materials Processing Operations”, Chapman & Hall/ CRC Press	**2000**
2.	Stefanescu, D. M., “Science and Engineering of Casting Solidification”, Kluwer Academic/ Plenum Publishers,	**2002**
3.	Lal, G. K., Dixit, P. M., Reddy, N. Venkata., "Modelling Techniques for Metal Forming Processes", Narosa Publishimg House, 2011	**2011**
4.	Gupta Santosh K, Numerical Methods for Engineers, New Age International (P) Limited Publishers, 2009	

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-607** Course Title: **Processing of Non-Metals**

2. Contact Hours: **L: 3** **T: 0** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**: CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 4 6. Semester**: Spring** 7.Subject Area**: PEC**

8. Pre-requisite**:** **Nil**

9. Objective: The main objective of the course is to impart an understanding of the manufacturing science and engineering of non-metals. The course deals with the study of the basic nature of different non-metals and the manufacturing processes.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Classification of engineering materials and processing techniques, structure and properties of non-metals	**3**
2.	**Processing of Glass**: Glass structure and properties, glass melting and forming, glass annealing	**3**
3.	**Processing of ceramics:** Ceramic powder preparation, synthesis of ceramic powders, fabrication of ceramic products from powders: pressing, casting, vapour phase techniques, sintering, finishing, machining. ceramic coatings	**7**
4.	**Processing of Plastics:** thermoplastics and thermosets, Processing of Plastics: Extrusion. Injection moulding. Thermoforming. Compression moulding. Transfer moulding. General behavior of polymer melts, Machining of plastics	**8**
5.	**Processing methods of polymeric matrix composites**: Classification of composite materials, properties of composites hand lay-up, autoclaving, filament winding, pultrusion, compression molding, pre-pegging, sheet molding compounds etc., process capability and application areas of various techniques	**10**
6.	**Ceramic matrix composites:** mechanical properties of ceramic	**6**

	matrix composites, different processing techniques for ceramic matrix composites, process capability and applications of various techniques	
7.	**Secondary processing of composite materials:** Need of secondary operations, different type of secondary operations, machining and drilling of non-metals, machining induced damage, different methods of reducing the damage on account of secondary processing	**5**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Kalpakjian, S.,"Manufacturing Processes for Engineering Materials," 3rd Ed., Addison – Wesley	**1997**
2.	Strong,A.B., " Plastics: Materials and Processing," Pearson Prentice Hall	**2006**
3.	Mathews, F.L., and Rawlings,R.D., " Composite Materials: Engineering and Science," Woodhead Publishing	**1999**
4.	"Handbook of Composites"ed. By S.T. Peters, 2nd Ed., Chapman Hall	**1998**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering**

1. Subject Code: **MIN-608** Course Title: **Product and Process Optimization**

2. Contact Hours: **L: 3 T: 1 P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 6. Semester: **Autumn/Spring** 7. Subject Area: **PEC**

8. Pre-requisite: **Nil**

9. Objective: This course will introduce to the students, the basic concepts, techniques and applications of engineering optimization in a comprehensive manner.

10. Details of Course:

S. No.	Contents	Contact Hrs
1.	**Introduction to Design Optimization:** The design process; basic terminology and notations.	2
2.	**Optimum Design Problem Formulation:** The problem formulation process; and illustration with examples.	3
3.	**Graphical Optimization:** Graphical solution process; problems with – bounded (single or multiple) and unbounded solutions.	3
4.	**Optimum Design Concepts:** Local and global optima; necessary and sufficient optimality conditions for unconstrained and constrained multivariate functions.	6
5.	**Linear Programming Methods for Optimum Design:** Basic concepts; simplex method; two-phase simplex method; post-optimality analysis.	4
6.	**Numerical methods for Unconstrained and Constrained Optimum Design:** Gradient-based and direct search methods; Sequential linear and quadratic programming.	6
7.	**Multi-objective Optimization:** Fundamental shift from single-objective optimization; Pareto-set and Pareto-optimal Front.	4
8.	**Evolutionary Techniques for Optimization:** Genetic algorithms; Differential Evolution Algorithms; Ant colony Optimization; and Particle Swarm Optimization.	6
9.	**Advanced topics on Optimum Design:** Meta models for design optimization; design of experiments; discrete design with orthogonal arrays; robust design approach; reliability-based design optimization.	4
10.	**Practical applications of optimization:** Illustration on engineering problems with single and multiple objectives.	4
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	S. S. Rao; Engineering Optimization; 4th Edition, John Wiley & Sons.	**2009**
2.	K. Deb; Optimization for Engineering Design; Prentice Hall of India.	**2005**
3.	K. Deb; Multi-objective Optimization using Evolutionary Algorithms; John Wiley & Sons.	**2003**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Physics**

1. Subject Code: **PHN-001** Course Title: **Physics Department**
2. Contact Hours: **L: 3** **T: 0** **P: 2**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weightage**:** **CWS: 15** **PRS: 25** **MTE: 20** **ETE: 40** **PRE: 0**
5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: BSC**
8. Pre-requisite**: None**
9. Objective: **To familiarize students with the basic principles of mechanics**
10. Details of Course:

S.No.	Contents	Contact Hours
1	**STATICS OF PARTICLES.** Vectorial representation of forces and moments- Vector Operation-Concepts of Particles and Rigid bodies – Composition of concurrent forces in plane free body Diagram – Equilibrium of Rigid bodies in Two and three dimensions-Moment of a force about a point and about an axis-Couple moment-Reduction of a force system to a force and a couple	8
2	**PROPERTIES OF SURFACES, MOMENTS AND PRODUCTS OF INERTIA** Definition Moment of Inertia for areas-Parallel axis theorem –Perpendicular axis theorem-Moment of inertia for composite area-product of inertia form an area-mass moment of inertia	6
4	**FRICTION** Laws of coulomb friction- Coefficient of Friction-Dry Friction-sliding Friction-Ladder friction-Belt friction – Rolling Resistance.	4
5	**KINEMATICS OF PARTICLES** Principle of virtual work for a particle and rigid body-condition for equilibrium for a conservative system, stability-particle dynamics in rectangular coordinate, cylindrical coordinate and in terms of path variables-General motion of system of particles-	8
6	**WORK ENERGY METHODS, IMPULSE AND MOMENTUM** Work Energy Method-Conservation of Energy-Impulse and Momentum Relation-Impulsive Force-Impact force-Conservation of momentum – Moment of Momentum Equation.	8
7	**RIGID BODY MOTION;** Translation and rotation of rigid bodies- Derivative of a vector fixed in moving reference-General relationship between time derivative of a vector for different references-Moment of momentum equation-kinetic energy of rigid body-work and energy relations-Euler's equation of motion-Three dimensional motion about a fixed point	8
	TOTAL	**42**

List of experiments:

1. Study of magnetic field of a pair of coils in Helmholtz arrangement
2. Determination of e/m
3. Determination of first excitation potential of a gas by Frank-Hertz experiment
4. Determination of Stefan's constant
5. Determination of Planck's constant by radiation
6. To study and verify Malus' law
7. Study of Polarization of light using quarter wave plate
8. Determination of Brewster's angle at glass-air interface
9. Determination of with of a slit by single-slit diffraction pattern
10. Four probe method of finding resistivity of semiconductor
11. Quinck's Method for determining mass susceptibility
12. Wavelength of Na light by Newton's ring method

11. Suggested Books:

S.No.	Title/Authors/Publishers	Year of Publication
1.	Shames I .H. a nd Rao G.K., "Engineering Mechanics-Statics an d Dynamics" ,4 Edition, Pearson Education	2006
2.	Beer F.P and Johnson E.R., "Vector Mechanics for Engineers- Statics and Dynamics",9 Edition, Tata McGraw-Hill Publishing Company	2010
3.	Pytel A. and Kiusalaas J., " Engineering Mechanics: Statics" 3rd Edition, Cengage Learing	2010
4.	Pytel A. and Kiusalaas J., " Engineering Mechanics: Dynamics"3rd Edition Cengage Learing	2010
5.	Hibberler R .C a nd G upta A ., E ngineering M echanics,", 12 th Edition, Pearson Education	2012
6.	Meriam J .L. and Kraige L.G., "Engineering Mechanics: S tatics", 6 th Edition, John Willey and Son,s	2012
7.	Meriam J.L., and Kraige L.G., "Engineering M echanics: D ynamics", 6th Edition , John Willey and Son's	2012

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE : **Department of Physics**

1. Subject Code: **PHN-008** Course Title: **Electromagnetic Theory**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory : 3** **Practical : 0**

4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE : 25** **ETE: 50** **PRE: 0**

5. Credits: **4** 6. Semester: **Spring** 7. Subject Area: **BSC**

8. Pre-requisite: **None**

9. Objective: To impart basic concepts of electromagnetism and their applications in engineering.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Vector Algebra:** Cartesian, Cylindrical and Spherical coordinate Systems, Constant coordinate surfaces, Del operator, Gradient, Divergence of a Vector and Divergence Theorem, Curl of a vector and Stokes theorem, Gradient, Divergence, Curl and Laplacian in the three coordinate Systems, Laplacian of a scalar, Scalar & Vector Fields, Classification of Vector fields.	9
2	**Electrostatics:** Coulomb's law, electric field intensity due to continuous charge distribution, Gauss's law & its applications, electric potential, the line integral, electric dipole and flux lines, energy density in an electrostatic field, electrostatic discharge. Current and current density, metallic conductors, conductor properties and boundary conditions, polarization in dielectrics, nature of Dielectric materials and related boundary conditions, capacitance.Electrostatic boundary-value problems, Laplace's and Poisson's equations, Uniqueness theorem, General procedure for solving Laplace's and Poisson's equation.	11
3	**Magnetostatics:** Biot-Savart's law, Ampere's circuital law, Applications of Ampere's law, Magnetic flux and magnetic flux density, Scalar and vector magnetic potentials.Magnetic dipole, Force due to Magnetic field on a differential current element, force between two differential current elements, Force and torque on a closed circuit, The nature of magnetic materials, Magnetization and permeability, Magnetic boundary conditions, Inductors, inductances, Magnetic energy, Magnetic circuits, Potential energy and force on magnetic materials, magnetic levitation.	11

4	**Time varying electric and magnetic fields and electromagnetic waves:** Faraday's law, transformer, EMF, DC motors, displacement current, Maxwell's equations for time varying fields, electromagnetic wave equation in free space, plane waves in free space, polarization, Poynting vector and power associated with electromagnetic waves, plane waves in lossless, homogeneous, and isotropic dielectric, reflection and transmission of plane waves at dielectric interface, normal and oblique incidence, plane waves in good conductors, skin depth. Microwaves and their applications in telecommunication, radar, and heating.	**11**
	Total	**42**

11. Suggested Books:

S.No.	**Name of Authors / Books / Publishers**	**Year of Publication/ Reprint**
1.	William H Hayt, Jr., and John A. "Engineering Electromagnetics", Buck, Tata McGraw Hill Publishing Company Ltd, New Delhi, 7^{th} Ed.	**2005**
2.	Matthew N.O. Sadiku,"Elements of Engineering Electromagnetics", Oxford University Press, 3^{rd} Ed.	**2003**
3.	Nannapaneni Narayan Rao, "Elements of Engineering Electromagnetics", Prentice Hall of India, New Delhi, 4^{th} Ed.	**2000**
4.	D.J. Griffiths, "Introduction to Electrodynamics", Prentice Hall, 3^{rd} Ed.	**2000**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT/CENTRE: **DEPARTMENT OF CIVIL ENGINEERING**

1. Subject code: **CEN-105** Course Title: **Introduction to Environmental Studies**
2. Contact Hours: **L: 3 T: 0 P: 0**
3. Examination Duration (Hrs): **Theory:** 3 **Practical:** 0
4. Relative Weightage: **CWS:** 15 **PRS:** 0 **MTE:** 35 **ETE:** 50 **PRE:** 00
5. Credits: **3** 6. Semester: **Autumn** 7. Subject Area: **GSC**
8. Pre-requisite: **Nil**
9. Objective: To introduce fundamentals of environmental pollution and its control.
10. Details of Course:

S. No.	Contents	Contact Hours
1.	Overview: Environment and Natural Processes; Development (Resource Utilization & Waste Generation); Environmental issues; Concept of Sustainable Development; Issues affecting future development (population, urbanization, health, water scarcity, energy, climate change, toxic chemicals, finite resources etc.); Environmental units	6
2.	Air –Water interaction: (Liquid phase-gas phase equilibrium) Henry's Law Constant with units, Dimensionless Henry's Law Constant	3
3.	Water –Soil Interaction: Carbonate System (Alkalinity and buffering capacity); Major ions in water; Natural Organic Matter (NOMs); Water quality parameters; Physical processes (Mass Balance): Spatio-temporal variation in quality of river water, lake water, ground water; Water quality standards	9
4.	Wetlands, water treatment and wastewater treatment .	6
5.	Air resources: Atmosphere; Air pollutants; Emissions and control of air pollutants; Atmospheric meteorology and dispersion; Transport of air (global, regional, local); Air/ atmospheric stability; Plume shape; Gaussian modeling; Air quality standards	9
6.	Land pollution and solid waste management	3
7.	Ecosystem: Structure and function; Energy flow in ecosystem; Material flow in ecosystem; Biodiversity and ecosystem health; Bio-amplification and bio-magnification	3
8.	Hazardous Waste: Definition; Classification; Storage and management; Site remediation; Environmental Risk: assessment, and management	3
Total		**42**

11. Suggested Books:

S. No.	Name of Books / Authors/ Publishers	Year of Publication/ Reprint
1.	Davis M. L. and Cornwell D. A., “Introduction to Environmental Engineering”, McGraw Hill, New York 4/e	2008
2.	Masters G. M., Joseph K. and Nagendran R. “Introduction to Environmental Engineering and Science”, Pearson Education, New Delhi. 2/e	2007
3.	Peavy H. S., Rowe D.R. and Tchobanoglous G., “Environmental Engineering”, McGraw Hill, New York	1986
4.	Mines R. O. and Lackey L. W. ““Introduction to Environmental Engineering”, Prentice Hall, New Yark	2009
5.	Miheicic J. R. and Zimmerman J. B. “ Environmental Engineering: Fundamentals, Sustainability, Design” John Wiley and Sons, Inc.	2010

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Humanities & Social Sciences**

1. Subject Code: **HS-001A** Course Title: **Communication Skills (Basic)**

2. Contact Hours: **L: 1** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory** **2** **Practical** **0**

4. Relative Weight**:** **CWS** **25** **PRS** **00** **MTE** **25** **ETE** **50** **PRE** **0**

5. Credits**:** **2** 6. Semester**: Autumn/Spring** 7. Subject Area**: HSS**

8. Pre-requisite**: NIL**

9. Objective:
The course intends to build the required communication skills of the students having limited communicative abilities, so that they may communicate effectively in real-life situations

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Understanding the Basics of Communication Skills: Listening, Speaking, Reading & Writing, Scope and Importance	**01**
2.	Grammar & Composition: Time and Tense, Agreement, Active-Passive, Narration, Use of Determiners, Prepositions & Phrasal Verbs	**05**
3.	Vocabulary Building & Writing: Word-formation, Synonyms, Antonyms, Homonyms, One-word Substitutes, Idioms and Phrases, Collocations, Abbreviations of Scientific and Technical Words	**02**
4.	Introduction to Sounds (Vowels & Consonants) Organs of Speech, Place and Manner of Articulation, Stress & Intonation, Listening Comprehension (Practical Sessions in Language Laboratory)	**02**

5.	Speaking, Countering Stage-fright and Related Barriers to Communication.	**02**
6.	Reading and Comprehension: Two lessons to be identified by the department.	**02**
	Total	**14**

List of Practicals:

1. Ice-breaking Exercises
2. Assignments on Time and Tense, Agreement, Active-Passive
3. Laboratory Session on Narration, Use of Determiners, Prepositions & Phrasal Verbs, Revisionary Exercises & Quiz
4. Laboratory Session on Synonyms, Antonyms, Homonyms
5. Assignments and Practice Sheets on One-word Substitutes, Idioms and Phrases, Collocations, Abbreviations of Scientific and Technical Words
6. Laboratory Session on Practice of sounds, Intonation and Stress, Listening Comprehension
7. Individual presentation, debates, Extempore & Turncoats
8. Exercises in Composition and Comprehension

11. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Murphy, Raymond. *Intermediate English Grammar*, New Delhi, Cambridge University Press.	**2009**
2.	Quirk, Randolph & Sidney Greenbaum. *A University Grammar of English*, New Delhi, Pearson.	**2009**
3.	McCarthy, Michael & Felicity O' Dell. *English Vocabulary in Use*, New Delhi, Cambridge University Press	**2010**
4.	Jones, Daniel. *The Pronunciation of English*, New Delhi, Universal Book Stall.	**2010**
5.	Birchfield, Susan M. *Fowler's Modern English Usage*, New Delhi, OUP.	**2004**
6.	Llyod, Susan M. *Roget's Thesaurus of English Words and Phrases*. New Delhi: Penguin.	**2010**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Humanities & Social Sciences**

1. Subject Code: **HS-001B** Course Title: **Communication Skills (Advanced)**

2. Contact Hours: **L: 1** **T: 0** **P: 2**

3. Examination Duration (Hrs.): **Theory** 2 **Practical** 0

4. Relative Weight: **CWS** 25 **PRS** 00 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 2 6. Semester: **Autumn/Spring** 7. Subject Area: **HSS**

8. Pre-requisite: **NIL**

9. Objective: The course intends to train the learners in using both verbal and non-verbal communication effectively.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	Advanced Communication Skills: Scope, Relevance, & Importance	**01**
2.	Soft Skills: Interpersonal Communication; Verbal & Non-verbal, Persuasion, Negotiation, Neuro-Linguistic Programming	**03**
3.	Communication and Media (Social and Popular), The Social and Political Context of Communication, Recent Developments and Current Debates in Media	**04**
4.	Cross-cultural and Global Issues in Communication: Race, Ethnicity, Gender & Diaspora	**03**
5.	Rhetoric and Public Communication, Audience Awareness, Emotionality	**03**
	Total	**14**

List of Experiments:

1. Discussion on the Process of Communication in Personal and Professional Life
2. Group Discussion, Case Studies and Role-Play
3. Assignments on E-mail Etiquette, Social Networking, Blog Writing, Discussions on Current Issues
4. Non-Verbal Communication in Cross-Cultural Situations, Case Studies, Group Discussions and Readings on Topics Related to Race, Ethnicity , Gender and Diaspora
5. Individual Presentations (Audience Awareness, Delivery and Content of Presentation)

11. Suggested Books:

S. No.	**Name of Authors / Books / Publishers**	**Year of Publication/ Reprint**
1.	Rentz, Kathryn, Marie E. Flatley & Paula Lentz. *Lesikar's Business Communication CONNECTING IH A DIGITAL WORLD*, McGraw-Hill, Irwin	**2012**
2.	Bovee, Courtland L & John V. Thill. *Business Communication Today*. New Delhi, Pearson Education	**2010**
3.	McMurrey, David A. & Joanne Buckley. *Handbook for Technical Writing*, New Delhi, Cengage Learning.	**2009**
4.	Jones, Daniel. *The Pronunciation of English*, New Delhi, Universal Book Stall.	**2010**
5.	Allan & Barbara Pease. *The Definitive Book of Body Language*, New York, Bantam	**2004**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Humanities and Social Sciences**

1. Subject Code: **HSN-002** Course Title: **Ethics and Self-awareness**

2. Contact Hours: **L: 01** **T: 0 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** **2** **Practical** **0**

4.Relative Weight**:** **CWS:25** **PRS:0** **MTE:25** **ETE:50** **PRE:0**

5. Credit **02** 6. Semester**: Autumn** 7. Subject Area**: HSSC**

8. Pre-requisite**: NIL**

9. Objective: To introduce the concepts pertaining to ethical and moral reasoning and action and to develop self - awareness.

10. Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction**: Definition of Ethics; Approaches to Ethics: Psychological, Philosophical, Social.	**1**
2	**Psycho-social theories of moral development**: View of Kohlberg; Morality and Ideology, Culture and Morality, Morality in everyday context.	**3**
3	**Ethical Concerns**: Work Ethics and Work Values, Business Ethics, Human values in organizations.	**3**
4	**Self-Awareness**: Self Concept: Johari Window, Self and Culture, Self Knowledge, Self-Esteem; Perceived Self-control, Self-serving bias, Self-presentation, Self-growth: Transactional Analysis and Life Scripts.	**4**
5.	**Self Development**: Character strengths and virtues, Emotional intelligence, Social intelligence, Positive cognitive states and processes (Self-efficacy, Empathy, Gratitude, Compassion, and Forgiveness).	**3**
	Total	**14**

11. Suggested Books:

S.No.	Name of Authors / Books / Publishers	Year of Publication
1.	Hall, Calvin S., Lindzey, Dardner., & Cambell, John B.,“Theories of Personality”,Hamilton Printing Company.	1998
2.	Car Alan, “Positive Psychology: The Science of Happiness and Human Strengths”, Brunner-Routledge.	2004
3.	Leary M.R., “The Curse of Self: Self-awareness, Egotism and the Quality of Human Life”, Oxford University Press.	2004
4.	Louis P. P., “The Moral Life: An Introductory Reader in Ethics and Literature”, Oxford University Press.	2007
5.	Corey, G., Schneider Corey, M., & Callanan, P., “Issues and Ethics in the Helping Professions”, Brooks/Cole.	2011
6.	Snyder, C.R., Lopez, Shane, J., & Pedrotti, J.T., “Positive Psychology” Sage, 2nd edition.	2011

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPARTMENT: **Department of Metallurgical and Materials Engineering**

1. Subject Code: **MTN-106** Course Title: **Materials Science**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs): **Theory: 3** **Practical**: **0**

4. Relative Weightage: **CWS: 25** **PRS: 0** **MTE: 25** **ETE: 50** **PRE: 0**

5. Credits: **4** 6. Semester: **Both** 7. Subject Area: **ESC**

8. Pre-requisite: **Nil**

9. Objective: To familiarize the students with fundamentals of materials science.

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	**Introduction to crystallography** Bonding in Solids: Ionic, Amorphous and Crystalline, Single crystal and Polycrystalline material, Polymorphism, Lattice, Unit cell, Bravais lattice, Types of crystals, Linear and Planer densities, Voids in crystalline structures, Ceramic crystal structures, Crystal defects (Point, Line ,Surface and Volume defects)	10
2	**Principles of alloy formation** Solid solution, Hume-Rothery rules, Binary phase diagrams: Gibbs phase rule, lever rule, cooling curves, Invariant reactions, Types of Binary phase diagrams (Isomorphous, Eutectic, Partial-Eutectic systems), Iron-Iron carbide phase diagram	7
3	**Plastic deformation** Elastic and Plastic deformation and Strain hardening with respect to Stress-Strain Curve, Plastic deformation by Slip: Slip system, Critical resolved shear stress, Frank-Read source Work hardening and dynamic recovery, Strengthening Mechanisms, Recovery, Recrystallization and Grain growth, Cold and hot working	5
4	**Mechanical Properties** Hardness Test (Brinell, Vickers, Rockwell and Microhardness Tests) Tensile Test (Engineering stress-strain curve: Y.S, U.T.S, work hardening, ductility, resilience and toughness, True stress-strain curve, Ductile and brittle fracture), Impact Test (Charpy and Izod specimens, Ductile – brittle transition, effect of carbon on ductile-brittle transition in plain carbon steels) Fatigue Test (Fatigue testing apparatus, S-N Curve for ferrous and non-ferrous, Fatigue	10

	fracture (transgranular fracture), Methods of improving fatigue life, Creep Test: Creep curve, Creep fracture, Material consideration for high temperature use.	
5	**Heat Treatment** Purpose of Heat treatments, Equilibrium and Non-equilibrium cooling, Nucleation, Grain growth and Kinetics , TTT and CCT diagrams Common heat treatments like Annealing, Normalizing, Hardening and Tempering, Hardenability: Jominy end-quench test, Hardenability curves, Martempering and Austempering, Surface hardening (carburizing, Nitriding, Flame and Induction hardening).	**6**
6	**Ceramic, Composite and Polymeric Materials** Ceramics: Types of ceramics, Fabrication and Processing of Ceramics: (i) Glass forming processes (ii) Particulate forming processes (iii) Cementation, Composites : Advantages of composites, Constituents of composites, Applications of composites ,Classification of composites: Based on matrix and reinforcement, Polymers: Hydrocabon and Polymer molecules, Molecular shape and structure, Molecular configuration, Thermoplastic and Thermosetting polymers	**4**
	Total	**42**

11. Suggested Books:

S.No.	**Name of Authors / Books / Publishers**	**Year of Publication/ Reprint**
1.	Callister W.D., “Materials Science and Engineering” Wiley India (P) Ltd. ISBN:978-81-265-21-43-2	2010
2.	Raghavan V.,”Materials Science and Engineering- A first Course,” 5th edition, ISBN:978-81-203-2455-8	2011
3.	Askeland D.R., “The Science and Engineering of Materials, 5th edition, ISBN: 978-81-315-0321-8	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-201** Course Title: **Kinematics of Machines**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0

5. Credits: 4 6. Semester**: Autumn** 7. Subject Area**: DCC**

8. Pre-requisite: **Nil**

9. Objective: To provide basic concepts of kinematic analysis of machines and machine members.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Objective of kinematic analysis of mechanism, classification of links, pairs, Basic terminology and kinematic symbols, kinematic chains, plane motion; constraints and degrees of freedom, mechanism and machines, inversion of mechanisms along with their practical applications.	**7**
2.	**Motion Analysis of Mechanisms:** Kinematic quantities and their relationships, absolute and relative motions, and their vector representation, instantaneous centers of motion, Kennedy Arnold's theorem; relative velocity method, method of instantaneous centers, resolution and orthogonal velocity methods; Acceleration analysis, Significance of Coriolis component of acceleration in mechanisms and its determination, mathematical analysis of slider crank mechanism, special graphical methods	**10**
3.	**Motion synthesis:** Introduction to synthesis of mechanisms, Graphical methods of Synthesis, Chebyshev spacing, two position synthesis, application to four bar mechanism, analytical synthesis using complex algebra, Freudensteins method.	**4**

4.	**Applied Linkages**: Radial engines and master crank, straight line motion and indicator mechanisms, steering mechanism, quick return mechanism, intermittent motion generating mechanisms, Geneva mechanism, analog computing mechanisms, various types of ingenious mechanism and their functioning.	**5**
5.	**Cams;** Classification of different types of cams, types of motion curves and their analytical expressions, graphical construction of cam profiles for different types of follower, pressure angle and cams with specified contours.	**5**
6.	**Gears**: Classification and Basic terminology, Fundamental law of gearing, geometric and kinematic considerations for various tooth profiles, the cycloidal and involute profiles , standards in tooth forms, spur gears and other types of gears; Gear trains, Simple, compound and epicyclic gear trains and their applications.	**7**
7.	**Flexible connectors**: Advantages and disadvantages of belt drives, Kinematic analysis of flat belt and V- Belt drives.	**4**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Martin, G .H., "Kinematics and Dynamics of Machines", 3rd Ed., McGraw-Hill	**1982**
2.	Ghosh, A, and Mallik, A.K., "Theory of Mechanisms and Machines", 2nd Ed., Affiliated East-West Press Pvt.Ltd.	**2003**
3.	Bevan, T ., "Theory of Machines", 3rd Ed., CBS Publishers and Distributors	**2003**
4.	Vicker, J.J., Shigley, J.E. and Penock, G.R., "Theory of Machines and Mechanisms", 3rd Ed., Oxford University Press	**2003**
5.	Hannah, J., and Stephens, R.C., "Mechanics of Machines : Elementary Theory and Examples", 4th Ed., Viva Books	**2004**
6	Norton, R.L., Kinematics and Dynamics of Machinery", Mc Graw Hill	**2009**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-291** Course Title: **Engineering Analysis and Design**
2. Contact Hours: **L: 3** **T: 1** **P: 2/2**
3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0
4. Relative Weightage**:** **CWS** 15 **PRS** 15 30 40 0
5. Credits**:** 4 6. Semester**: Spring** 7.Subject Area**: DCC**
8. Pre-requisite**:** None
9. Objective: This course aims to describe the role of analysis in engineering design and enhance critical thinking and design skills
10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Design, Mechanical Engineering Design, Different Phases of the Design Process	**4**
2.	**Engineering Analysis**: role of analysis, the design spiral, Computer Aided engineering analysis: visualization, analysis and redesign, Statistical Considerations, safety and reliability	**10**
3	**Reverse engineering:** Introduction, applications	**4**
4	**Learning from Failure**: Various failure case studies, Failure of machine components	**8**
5.	**Engineering Design**: projects for design of machine elements	**8**
6	Aesthetics in Engineering Design, written and oral presentation, posters	6
7	Engineering Ethics, team work.	2
	Total	42

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1	J. L . Y owell, and D. W .Carlson,, E ds., Introductory E ngineering Design: A Projects-Based Approach, Third Edition	2011
2.	A. H. Burr and J. B. Cheatham, Mechanical Analysis and Design, 2 nd Ed., Prentice Hall,	1997
3.	J. R . D ixon, D esign Engineering: Inventiveness, A nalysis and Decision Making, TMH, New Delhi,	1980.
4	Budynas−Nisbett , Shigley's Mechanical Engineering Design, Eighth Edition	2006
5	Mike W. Martin, Roland Schinzinger, Ethics in Engineering, McGraw-Hill 4 edition	2004

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-301** Course Title: **Dynamics of Machines**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0

5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **DCC**

8. Pre-requisite: **MI-201**

9. Objective: To introduce the students to various concepts related to dynamic analysis of machines.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Force Analysis of Mechanisms:** Review of basic principles of statics, Concept of free body and its equilibrium, Transmission of forces in machine elements, static force analysis, friction effects, forces on gear teeth; D'Alembert's principle, dynamic force analysis of mechanisms, force analysis of cam and follower mechanism, equivalent dynamical systems, dynamic analysis of reciprocating engines, practical examples from actual machines.	**10**
2.	**Flywheels and Governors:** Turning moment diagram, Fluctuation of energy and speed, coefficient of fluctuation of speed, use of crank effort diagram, calculation of flywheel size; Advantages of governors, Analysis of different types of governors, effect of sleeve friction, characteristic of governors, controlling forces curves, sensitivity, hunting phenomena in governors, stability, governor effort and power.	**6**
3.	**Balancing:** Balancing of rotating masses in single plane and in different parallel planes, balancing of slider crank mechanisms, balancing of in-line, V- and locomotive engines, principles of balancing machine.	**4**

4.	**Friction Devices:** Advantages and disadvantages of belt drives system, belt drive system, friction in pivots and collars, power screws, plate and cone clutches, band and block brakes.	**6**
5.	**Gyroscope:** Motion of rigid body in 3 - dimensions, Angular momentum, Gyroscopic action, equation for regular precession and gyroscopic torque, applications of gyroscope	**2**
6.	**Mechanical Vibration:** Basic terminology related to vibrations; Conservative systems; Free vibrations of systems without and with damping; Equilibrium and energy methods for determining natural frequency of vibratory system; Rayleigh's method, Free vibrations of system with viscous damping, over damped, critically and under damped systems, logarithmic decrement; Forced vibrations of systems with viscous damping, equivalent viscous damping; Impressed forces due to unbalanced masses and excitation of supports, vibration isolation, transmissibility, whirling of shaft; Introduction to multi degree of freedom system vibrations: Discrete and continuous systems.	**14**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Vicker, J.J., Shigley, J.E., and Pennock, G.R., "Theory of Machines and Mechanisms", 3rd Ed., Oxford University Press	**2003**
2.	Rao, J. S. "Theory of Machines", New Age pub	**2007**
3.	Norton, R.L., Kinematics and Dynamics of Machinery", Mc Graw Hill	**2009**
4.	Grover, G.K., "Mechanical Vibrations", 7th Ed., Nem Chand & Bros.	**2003**
5.	Thomson, W.T., "Theory of Vibration with Applications", 3rd Ed., CBS Publishers and Distributors	**2003**
6.	Vinogradov, O., "Fundamentals of Kinematics and Dynamics of Machines and Mechanisms", CRC Press	**2000**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-211** Course Title: **Theory of Machines**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0

5. Credits: 4 6. Semester: **Autumn** 7. Subject Area: **DCC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the basic concepts of kinematics and dynamics of machines.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction**: Objectives of kinematic analysis of mechanism, Plane motion, kinematic concept of links, kinematic chains, basic terminology and definitions, inversions of mechanisms along with their applications.	4
2.	**Motion and Force Analysis:** Absolute and relative motions, kinematic and dynamic quantities and their relationships, vector diagrams; Instantaneous center of motion, velocity and acceleration polygons, concept of Coriolis component of acceleration; concepts of free body and its equilibrium, review of basic principles of statics, static force analysis, friction effects, dynamic force analysis, equivalent dynamical systems.	15
3.	**Power Transmission using Gears and Belts:** Classification and basic terminology, Fundamental law of gearing, involute tooth profile and its kinematic considerations, spur gears, standards in tooth forms; Gear trains: Simple, compound and epicyclic gear trains; Kinematic design of pulleys, flat and V-belts, transmission, efficiency of power transmission.	10
4.	**Clutches and Brakes**: Friction between pivot and collars, plate and	4

	cone clutches, analysis of band and block brakes.	
5.	**Balancing:** Balancing of rotating masses in one and different parallel planes	**4**
6.	**Mechanical Vibrations:** Basic terminology related to vibrations, free and forced vibrations without and with damping	**5**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1	Martin, G.H., "Kinematics and Dynamics of Machines", 2nd Ed., McGraw-Hill	**1982**
2	Norton, R.L., Kinematics and Dynamics of Machinery", Mc Graw Hill	**2009**
3	Massie, H.H., and Reinholtz, C.F., "Mechanisms and Dynamics of Machinery, 4th Ed., John Wiley & Sons	**1987**
4	Vicker, J.J., Shigley, J.E., and Pennock, G.R., :Theory of Machines and Mechanisms:, 3rd Ed., Oxford University Press	**2003**
5	Hannah, J., and Stephens,R.C.,"Mechanics of Machines : Elementary Theory and Examples",4th Ed., Viva Books	**2004**
6.	Vinogradov, O ., "Fundamentals of K inematics and Dynamics of Machines and Mechanisms", CRC Press	**2000**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-212** Course Title: **Machine Design**

2. Contact Hours: **L: 2** **T: 0** **P: 4**

3. Examination Duration (Hrs.): **Theory** 4 **Practical** 0

4. Relative Weightage**:** **CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0

5. Credits**:** 4 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**: MIN-108; CEN-102; MI-211**

9. Objective: The student is exposed to basic principles of mechanical design and their applications to the common mechanical elements along with fundamental concepts of Machine drawing practice.

10. Details of Course:

S. No.	**Contents**	**Contact Hours**
	Machine Design	
1.	**General:** Introduction to design procedure, design requirements, review of force analysis concepts. Factor of safety concepts, concept and mitigation of stress concentration, motor selection.	**16**
2.	**Dynamic Loading:** Cyclic loading, endurance limit, fatigue failure criteria.	**6**
3.	**Component Design:** Rivets, welds and threaded fasteners, knuckle and cotter joints, design and force analysis of spur gears, design of shafts and shaft couplings.	**20**
	Total	**42**
Machine Drawing Practice		**2 x 21**
	Detachable Fasteners: Specifications of screw threads and threaded fasteners, foundation bolts. **Permanent fastenings:** Rivets and riveted Joints, types of welds and welded joints, and representation of welds on drawings. **Assembly Drawings:** Review of sheet preparation: Boundary lines, zones, title block. Revision panel; Parts List, Numbering of	

	components and associated detail drawings. Assembly drawing practices.	

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Shingley, J.E., Mischke, C.R., "Mechanical Engineering Design (in S.I. Units)", 6th Ed., Tata McGraw Hill,	**2006**
2.	Juvinall, R.C., Marshek, K.M., "Fundamentals of Machine Component Design", 4th Ed., John Wiley	**2006**
3.	Mahadevan, K., and B., Reddy, "Design Data Hand Book", CBS Publishers	**2003**
4.	Sidheswar, N., "Machine Drawing", McGraw-Hill	**2004**
5.	Giesecke, F.E., Mitchell, A., Spencer, H.C., Hill, I.L., Dygdon, J.T., Novak, J.E., and Lockhart, S.D., "Technical Drawing", 13th Ed., Prentice Hall	**2008**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MI-354** Course Title: **Automatic Controls**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage: **CWS** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

5. Credits: **4** 6. Semester**: Both** 7. Subject Area**: DEC/DHC**

8. Pre-requisite**:** **Nil**

9. Objective: To introduce the basic principles of control theory and its applications along with the methods of stability analysis and synthesis of industrial control systems.

10. Details of Course:

S. No.	Particulars	Contact Hours
1.	**Introduction**: Introduction to automatic control systems, open loop and closed loop systems, servomechanism, design principles of control systems.	3
2.	**Mathematical Model of Physical System:** Transfer functions, linearization of non-linear functions, linearization of operating curve, block diagrams and block diagram algebra, modeling in frequency and time domain, translation and rotational mechanical components, electrical components, series and parallel combinations, compactors for rotational and linear motions, integrating devices, hydraulic servomotor, temperature and speed control systems.	9
3.	**Transient Response Analysis:** First and second order systems response to step, pulse, ramp and sinusoidal inputs, higher order systems, Routh's Criteria.	2
4.	**Error Analysis and Introduction to system Optimization**: Steady state errors, Static error coefficient, dynamic error coefficients, error criteria, introduction to system optimization.	2
5.	**Control Action:** Proportional control, integral control, derivative control, combination of control actions and their effect on system	8

	performance, two position control, industrial control systems using various control actions.	
6.	**Control System Analysis**: Stability of control systems, root locus techniques, root locus plots of simple transfer functions, stability analysis and transient response from root locus; frequency response analysis, logarithmic plots, stability and relative stability analysis on Bode plots, experimental determination of transfer function.	**10**
7.	**Design and Compensation techniques:** Introduction of preliminary design consideration, lead and lag compensation, compensation, lag-lead compensation, summary of control system compensation methods, practical examples.	**4**
8.	**Control System Analysis Using State Variable Method**: State variable representation, conversion of state variable model to transfer function, conversion of transfer function to canonical state of variable models, solution to state equations, concept of controllability and observability, signal flow graph, equivalence between transfer function and state variable representations.	**4**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Books / Authors**	**Year of Publication**
1.	Katsuhiko, O., "Modern Control Engineering", 3rd Ed., Prentice Hall	**1996**
2.	Raven, F.H., "Automatic control Theory", 5th Ed., McGraw Hill	**1995**
3.	Kuo, B.C., " Automatic Control System", 5th Ed., Prentice Hall of India	**1995**
4	Nise, N.S., "Control Systems Engineering" 5th Ed., Willey	**2008**
5.	Chen, C.T., " Linear System Theory & Design", 3rd Ed., Oxford University Press	**1999**
6.	Gopal, M., " Control System: Principles and Design", 2nd Ed., Tata McGraw Hill	**1997**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-322** Course Title: **Principles of Lubrication Technology**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** **3** **Practical** **0**

4. Relative Weightage**:** **CWS** **25** **PRS** **0** **MTE** **25** **ETE** **50** **PRE** **0**

5. Credits**:** **4** 6. Semester**: Both** 7. Subject Area**: DEC/DHC**

8. Pre-requisite**:** **Nil**

9. Objective: To develop the understanding of tribological phenomena and fluid-film lubrication.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Brief history of tribology, Tribological Considerations in the design of machine elements, role of wear, friction and lubrication, geometrical properties of surfaces, method of studying surface; Contact of smooth surfaces, contact of rough surfaces; Role of friction, laws of static friction, cause of friction; Bowen & Tabor's theory of friction, laws of rolling friction, friction of metal and nonmetals, friction measurement; Wear definition, types of wear, wear mechanism, a brief introduction of wear test equipments, wear in plastics.	**10**
2.	**Industrial Lubricants and their Additives**: Functions of lubricants; Types of lubricants and their industrial uses; Solid lubricants and their functions, liquid mineral lubricants, synthetic liquid lubricants, greases, properties of liquid and grease lubricants; Viscosity, Newtonian and non-Newtonian lubricants, Electrorheological, Magnetorheological and micropolar lubricants, temperature and pressure dependence of viscosity, other properties of lubricants; Lubricant additives, general properties and selection for machines and	**10**

	processes; Oil reclamation and preventive maintenance for lubricants.	
3.	**Fluid-Film Lubrication:** Equations of continuity and motion; Generalized Reynold equation with incompressible and compressible lubricants; lubrication regimes, Stribeck curve; Hydrodynamic lubrication; Tower's experiment, finite journal bearings, solution of finite bearing using Galerkin method, finite difference and FEM, significance of flow restrictors in compensated bearings.	**12**
4.	**Bearing Design and selection of Bearings:** Comparative performance of various modes of lubrication, and bearing selection; Design of slider bearings and hydrostatic journal bearing, fixed type hydrodynamic and hydrostatic journal bearings, materials for sliding bearings; Bearing types, selection of rolling elements bearing, bearing life, dynamic load rating, bearing selection.	**6**
5.	**Some case studies related to tribological failures in machines**	**4**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1	Balling, J., "Introduction to Tribology", Wykeham	**1976**
2	Rowe, W.B., "Hydrostatic and Hybrid Bearing Design", 2nd Ed., Butterworth-Heinemann.	**1983**
3	Khonsari, M.M., and Booser, E.R., "Applied Tribology: Bearing Design and Lubrication", 2nd Ed., John Wiley and Sons	**2001**
4	Gross, W., Matsch, L., Castelli, V., Eshel, A., Vohr, J., and Wildman, M., "Fluid Film Lubrication", John Wiley and Sons	**1980**
5	Hamrock, B.J., Jacobson, B.O., and steven, R.S., "Fundamentals of Fluid Film Lubrication", 2nd Ed., Marcel Dekker	**2004**
6	Mang, T., and Dresel, W., "Lubricants and Lubrication", 2nd Ed., John Wiley and Sons	**2007**
7	Cameron A., "The Principles of Lubrication", Longmans Green and Co. Ltd., London,	**1966**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-411** Course Title: **Maintenance Techniques for Rotating Components**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 6. Semester: **Both** 7. Subject Area: **DEC/DHC**

8. Pre-requisite: **Nil**

9. Objective: Provide a comprehensive understanding of the various types of rotating equipment and focus on maximizing the efficiency, reliability, and longevity of rotating equipment by providing an understanding of the characteristics, selection criteria, common problems and repair techniques, preventive and predictive maintenance.

10. Details of Course

S. No.	Contents	Contact Hours
1.	**Introduction** to theory and practice of maintenance, operating policy and effective maintenance, operating practices to reduce maintenance work, reports from maintenance, operating characteristics of rotating equipments and the diagnostic techniques and inspections required for critical components of rotating equipment	8
2.	**Maintenance policies and strategies:** Breakdown, preventive, predictive and proactive maintenance, components of effective preventive maintenance, predictive maintenance, economics of preventive maintenance	6
3.	**Maintenance of rotating equipment:** Bearings - Plain bearings, rolling element bearings, gear drives and speed reducers, rotating shafts and flywheel, pumps – centrifugal and positive displacement, turbines – steam and gas	14
4.	**Advanced Maintenance:** Condition monitoring and its types, techniques of condition monitoring – analysis of vibrations, temperature and lubricating oil	10
5.	Testability and prognostics, Case studies.	4
	Total	**42**

11. Suggested Books

S.	Name of Authors/ Books	Year of

No.		Publication
1.	Lindley R. Higgins, R. Keith Mobley, Maintenance Engineering Handbook, McGraw Hill, 7th Edition	2008
2.	Lorenzo Fedele, Methodologies and Techniques for Advanced Maintenance, Springer	2011
3.	Philip Kiameh, Power Plant Equipment Operation and Maintenance Guide, McGraw-Hill, 1st Edition	2012
4.	Collacott, R.A., " Mechanical Fault Diagnosis and Condition Monitoring", Chapman & Hall	1977
5.	Davies, "Handbook of Condition Monitoring- Techniques and Methodology", Springer	2006

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-412** Course Title: **Vehicle Dynamics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 25 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 6. Semester**: Both** 7. Subject Area**: DEC/DHC**

8. Pre-requisite: **Nil**

9. Objective: To provide fundamental engineering principles underlying the control, stability, handling and cornering behavior of road vehicles.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Vehicle Dynamics**: Various kinds of vehicles; motions; mathematical modelling methods; methods of investigations.	**4**
2.	**Mechanics of Pneumatic Tyre**: Tyre construction; physics of tyre traction on dry and wet surfaces; tyre forces and moments; SAE recommended practice; rolling resistance of tyres; ride properties of tyres.	**10**
3.	**Performance Characteristics**: Equation of motion and maximum tractive effort; aerodynamic forces and moments; vehicle transmission characteristics; prediction of vehicle performance; braking performance; antilock braking systems.	**8**
4.	**Handling and Stability Characteristics**: Steering geometry; steady state handling characteristics; steady state response to steering input; transient response characteristics; directional stability.	**8**
5.	**Vehicle Ride Characteristics**: Human response to vibration; vehicle ride models; road surface profile as a random function; frequency	**7**

	response function; evaluation of vehicle vertical vibration in relation to ride comfort criterion.	
6.	**Experimental Testing:** Instruments for vehicle measurements; recording and evaluation methods; test methods and measurement procedures for vehicle dynamics; interpretation of test results.	**5**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Wong, J.Y., "Theory of Ground Vehicles", John Wiley.	**2008**
2.	Gillespie, T.D., "Fundamental of Vehicle Dynamics", S.A.E.	**1992**
3.	Rao V. Dukkipati, "Road Vehicle Dynamics", SAE International	**2008**
4.	Hans True, "The Dynamics of Vehicles on Roads and on Tracks", 1st Ed., Taylor and Francis,	**2003**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-323** Course Title: **Design of Pressure Vessels and Piping**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 4 6. Semester**: Both** 7. Subject Area**: DEC/DHC**

8. Pre-requisite**:** **CEN-102**

9. Objective: The course introduces design aspects for pressure vessels and pipings.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Industrial pressure vessels and piping systems. Type of failures of pressure vessels and piping systems. Safety of an Industrial plant.	4
2.	**Design Aspects of Pressure Vessel and Piping:** General theory of membrane stresses, stresses in cylinders and spheres subjected to internal and external pressure. Dilation of pressure vessels, auto-frettage and shrink fit stresses, mono-block and wire-wound cylinders, thermal stresses and their significance. Design of bottoms and roofs and cylindrical vessels, discontinuity stresses in vessels, deformation and stresses in flanges.	12
3.	**Fracture Mechanics Concepts and Design Application.**	4
4.	**Construction Features of Pressure Vessels:** Construction features of pressure vessels, localized stresses and their significance, welded joints, bolted joints, theory of reinforced openings.	6
5.	**Relevant National and International Design Codes and Their Limitations.**	2

6.	**Importance of Stress and Flexibility Analysis of Piping System:** Analysis of stresses due to static and dynamic loads, thermal stresses; Flexibility analysis for single and multi-plane configuration, Expansion joints and anchorages.	**8**
7.	**Design Features of Piping System:** Pipe fittings, elbows and flange design, wall thickness determination, branched connections. Piping network analysis.	**4**
8.	**Selection of Pipe Materials and Economical Considerations in Piping Design.**	**2**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Books / Authors**	**Year of Publication**
1.	Harvey, "Pressure Vessel Design", Van Nostrand	**1963**
2.	Gascoyne, "Analysis of Pipe Structures for Flexibility", Pitman	**1959**
3.	Barsom, J.M., Rolfe, S.T., "Fracture and Fatigue Control in Structures", 3rd Ed., Butterworth Hcinemann	**1999**
4.	Joshi, M.V., "Process Equipment Design", Macmillan India Ltd.	**1985**
5.	Smith, P. "The Fundamentals of Piping Design (Process Piping Design) (v. 1) **,** Gulf Publishing Company.	**2007**
6.	Smith, P. & Botermans, R., "Advanced Piping Design", Gulf Publishing Company.	**2008**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-415** Course Title: **Piping Technology**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 4 6. Semester**: Both** 7.Subject Area**: DEC/DHC**

8. Pre-requisite**: CEN-102**

9. Objective: The course deals with the various aspects concerning the piping technology.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Design/Analysis of Piping System:** Industrial, sub-sea & underground piping systems. Design and stress analysis of piping system. Pipe fittings, elbows and flange design, stresses in elbows and flanges. Failure theories, National and International codes. Branched connections. Piping network analysis. Design calculation of wall thickness and working pressure. Use of FEM and software tools. Pipeline sizing, Design criterion; least annual cost criterion, velocity criterion, Pressure drop criterion,	**18**
2.	**Vibration Problem in Piping System; Experimental Tests on Piping System/Components:** Vibration analysis of piping system, Determination of natural frequency, damping and mode shape. Design of experiments for piping system. Estimation of leakage of piping connections/joints.	**8**
3.	**Pipeline Machinery, Operation & Control:** Description of various components, methods for control strategies. Field metering and	**6**

	regulating facilities, pressure surges, Anti-surge control, Coriolis mass flow measuring techniques, Pigging, examples of pigging operation. Linear and nonlinear pipelines. Pipeline installation and maintenance equipments. Structural supports of piping system.	
4.	**Joining Techniques and Quality Control of Pipelines:** Welding techniques/processes, welding procedures and equipments, Various techniques for inspection and testing, weld defects, Underwater welding in Offshore constructions, GMA welding, SMA welding, Shrouded metal arc welding, Dry under water welding, Visual and NDT techniques for inspection and tools for quality control of pipelines. Maintenance techniques. Cleaning of pipe internal surface.	**4**
5.	**Prevention of Corrosion in Pipelines:** Corrosion process, Various types of corrosion in pipelines, Techniques for the prevention of corrosion, Anti-corrosive protective coatings, Cathodic protection of pipelines, Internal inspection and Corrosion monitoring. Recommended piping materials.	**4**
6.	**Well Head Installation & Water Injection:** Introduction, definition, water injections, water sources, treatment for sea water injection, equipments, material for constructions, design specifications, sources of injected water, filters, de-oxygenation, Water injection pumps.	**4**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Harvey,“Pressure Vessel Design”, Van Nostrand	**1963**
2.	Gascoyne,“Analysis of Pipe Structures for Flexibility”, Pitman	**1959**
3.	Joshi, M.V.,“Process Equipment Design”, Macmillan India Ltd.	**2009**
4.	Sahu, G.K., “Handbook of Piping Design”, New Age International Publishers.	**2008**
5.	Bausbacher, E. &Hunt, R.“Process Plant Layout and Piping Design”, Prentice Hall, ISBN: 0131386298.	**1993**
6.	Smith, P. & Botermans, R., “Advanced Piping Design”, Gulf Publishing Company.	**2008**
7.	Smith, P. “The Fundamentals of Piping Design (Process Piping Design), Gulf Publishing Company.	**2007**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-320** Course Title: **Automobile Engineering**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 6. Semester**: Both** 7. Subject Area**: DEC/DHC**

8. Pre-requisite**: Nil**

9. Objective: To introduce functional details and requirements of various components in automobiles.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Power Unit:** Engine classification, engine performance characteristics, description of power unit, fuel supply system, hybrid vehicles, engine lubrication.	**8**
2.	**Transmission:** Transmission requirement, standard transmission system, fluid transmission system, automatic transmission, performance requirements and gear ratios, tractive resistance.	**7**
3.	**Steering:** Different types of steering systems, performance requirements, power steering.	**4**
4.	**Vehicle Dynamics:** Stability analysis of vehicle, stability on curved path.	**3**
5.	**Braking Systems:** General braking requirements, weight transfer during braking, mechanical brakes, hydraulic brakes, vacuum brakes, power brakes.	**4**
6.	**Chassis and Suspension:** Loads on the frame, general consideration of strength and stiffness, engine mounting, various suspension systems including active suspension, shock absorbers.	**4**
7.	**Pneumatic Tyres:** Tyre-pavement interaction forces and moments,	**2**

	SAE terminology, tyre wear.	
8.	**Electrical System:** Ignition system, conventional and electronic, lighting, auxiliary electrical equipment, wiring diagrams.	**4**
9.	**Maintenance:** Preventive maintenance, trouble shooting, tuning and adjustment of power unit.	**3**
10.	**Air Pollution:** Pollution due to vehicle emission, exhaust emission control systems, effect of design and operating conditions.	**3**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors /Books	Year of Publication
1.	Crouse, W.A., and Anglin, D.L., "Automotive Mechanics",10th Ed., McGraw-Hill	**2007**
2.	Stockel, M.W., and Stockel, M.T., "Auto Mechanics Fundamentals", 5th Ed., The Good Heart – Willcon Company	**1982**
3.	John B. Heywood, Internal combustion engine fundamentals, McGraw-Hill	**1988**
4.	Heitner, J., "Automotive Mechanics", 2nd Ed., East-West Press	**1999**
5.	Heisler, H., "Advanced Vehicle Technology", 2nd Ed., Butterworth-Hienemann	**2002**
6.	Limpert, R., "Brake Design and Safety", 2nd Ed., SAE International	**1999**
7.	Reimpell, J., Stoll, H., and Betzler, J.W., "The Automotive Chassis", 2nd Ed., SAE International	**2001**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-410** Course Title: **Product and Process Optimization**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 6. Semester: **Both** 7. Subject Area: **DEC/DHC**

8. Pre-requisite: **Nil**

9. Objective: This course will introduce to the students, the basic concepts, techniques and applications of engineering optimization in a comprehensive manner.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Design Optimization:** The design process; basic terminology and notations.	2
2.	**Optimum Design Problem Formulation:** The problem formulation process; and illustration with examples.	3
3.	**Graphical Optimization:** Graphical solution process; problems with – bounded (single or multiple) and unbounded solutions.	3
4.	**Optimum Design Concepts:** Local and global optima; necessary and sufficient optimality conditions for unconstrained and constrained multivariate functions.	6
5.	**Linear Programming Methods for Optimum Design:** Basic concepts; simplex method; two-phase simplex method; post-optimality analysis.	4
6.	**Numerical methods for Unconstrained and Constrained Optimum Design:** Gradient-based and direct search methods; Sequential linear and quadratic programming.	6
7.	**Multi-objective Optimization:** Fundamental shift from single-objective optimization; Pareto-set and Pareto-optimal Front.	4

8.	**Evolutionary Techniques for Optimization:** Genetic a lgorithms; Differential Evolution Algorithms; Ant colony Optimization; and Particle Swarm Optimization.	**6**
9.	**Advanced topics on Optimum Design:** Meta m odels f or de sign optimization; de sign of e xperiments; di screte de sign with orthogonal arrays; robust design approach; reliability-based design optimization.	**4**
10.	**Practical applications of optimization:** Illustration on engineering problems with single and multiple objectives.	**4**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	S. S. Rao; Engineering Optimization; 4th Edition, John Wiley & Sons.	**2009**
2.	K. Deb; Optimization for Engineering Design; Prentice Hall of India.	**2005**
3.	K. Deb; Multi-objective Optimization using Evolutionary Algorithms; John Wiley & Sons.	**2003**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-324** Course Title: **FEM Applications in Mechanical Engineering**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 4 6. Semester**: Both** 7. Subject Area**: DEC/DHC**

8. Pre-requisite**: CEN-102, MIN- 205**

9. Objective: This course expounds on the basic principles of the finite element method and its application to solve a few representative mechanical engineering problems related to solid mechanics, heat-transfer, and fluid mechanics.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Underlying principles of the finite element analysis; application examples and versatility; basic steps in FEA.	**02**
2.	**Mathematical Preliminaries:** Principle of virtual work; Ritz method; weighted residual; collocation and Galerkin methods; classification of partial differential equations and the corresponding mechanical engineering applications; Poisson's, Laplace's, diffusion and wave equation; review of governing equations in solid and fluid mechanics.	**07**
3.	**One Dimensional Problems:** discretization, concept of shape functions, natural coordinates; element equations; assembly; boundary conditions; solution of assembled matrix equations; applications to solid mechanics, heat and fluid mechanics problems.	**08**
4.	**Trusses**: Plane truss, local and global coordinate systems; stress calculations; temperature effect on truss members; solution of practical problems.	**04**
5.	**Beams**: Euler-Bernoulli beam element	**04**

6.	**Two Dimensional Problems:** Plane stress and plane strain formulation; triangular and rectangular elements; isoperimetric formulation; axisymmetric problems; computer implementation; steady-state heat conduction	**08**
7.	**Finite Element Analysis of Time-dependent Problems:** Discretization of equation of motion; mass and stiffness matrices; eigenvalue problem; mode-shapes and natural frequencies; time-integration methods.	**05**
8.	**Computer Implementation of Finite Element Analyses:** Introduction to commercial packages and their capabilities; demonstration of the modeling and solution process for representative cases.	**04**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Cook, R.D., Malkus, D.S., and Plesha, M.E., "Concepts and Applications of Finite Element Analysis", 3^{nd} Ed., John Wiley & Sons.	**1989**
2.	Bathe, K.J., "Finite Element Procedures", 2^{nd} Ed., Prentice Hall.	**1996**
3.	Seshu, P., "Textbook of Finite Element Analysis", 1^{st} Ed., Prentice Hall of India Pvt. Ltd.	**2003**
4.	Reddy, J.N., "An Introduction to the Finite Element Analysis", 3^{rd} Ed., McGraw-Hill Education (ISE Editions).	**2005**
5.	Zienkiewicz, O.C., and Taylor, R.L., "The Finite Element Method for Solid and Structural Mechanics", 6^{th} Ed., Elsevier Ltd.	**2006**
6.	Logan, D.L., "A First Course in the Finite Element Method", 4^{th} Ed., Thomson Canada Ltd.	**2007**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-413** Course Title: **MEMS**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 6. Semester: **Both** 7. Subject Area: **DEC/DHC**

8. Pre-requisite: **CEN-102**

9. Objective: This course introduces the science of MicroElectroMechanical Systems, actuation and sensing mechanisms at the microscale, and conveys ideas related to the mechanical analysis of MEMS and basics of the microfabrication techniques.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Introduction to MEMS; historical perspective; application examples; course motivation.	02
2.	**Preliminaries of Continuum Mechanics:** Continuum hypothesis; governing equations of elasticity; thermo-elasticity; review of fluid dynamics principles; Navier-Stokes equation; Euler equation; fundamentals of electromagnetism; Maxwell's equations; electrostatics; magnetostatics; dimensional analysis and scaling laws of forces at the microscale; different actuation and sensing techniques used at the microscale.	07
3.	**MEMS Sensors and Actuators:** Pressure sensors; accelerometers; gyroscopes; RF MEMS devices; MEMS resonators; switches; digital micro mirror devices: principle of operation and mathematical modeling.	10
4.	**Mechanical Analysis of Electrostatically Actuated MEMS Devices:** Static analysis; spring constant for beams; electrostatic actuation; parallel-plates model; torsional plate actuator; comb drive actuator; shape of a deformed beam under electrostatic actuation; moderately large deflection analysis of fixed-fixed beams; dynamic	15

	analysis; mechanisms of energy dissipation; air damping fundamentals; squeeze film damping; Reynold's equation; dynamics response of beam-type actuators under electrostatic loading.	
5.	**Introduction to Microfabrication Techniques:** Basic process tools; oxidation; sputter deposition; chemical-vapor deposition; lithography; etching; advanced process tools: anodic bonding; silicon direct bonding; SU-8 photosensitive epoxy; Nonlithographic fabrication processes: laser machining, electrodischarge machining.	**08**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Pelesko, J.A., and Bernstein D.H., "Modeling MEMS and NEMS", 1st Ed., Chapman and Hall CRC	**2002**
2.	Beeby, S., Ensell, G., Kraft, M., and White N., "MEMS Mechanical Sensors", 1st Ed., Artech House, Inc.	**2004**
3.	Bao, M., "Analysis and Design Principles of MEMS Devices", 1st Ed., Elsevier B.V.	**2005**
4.	Mohamed Gad-el-Hak (Editor), "The MEMS Handbook", 2nd Ed., Taylor and Francis.	**2006**
5.	Adams, T.M., and Layton, R.A., "Introductory MEMS: Fabrication and Applications", Springer New York.	**2010**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-417** Course Title: **Energy and Variational Principles in Engineering Mechanics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**: CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 4 6. Semester**: Both** 7. Subject Area**: DEC/DHC**

8. Pre-requisite**: MAN-001, PHN-001, CEN-102**

9. Objective: This course introduces the elements of energy methods and variational calculus together with their application to solve mechanical engineering problems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Motivation and Mathematical Preliminaries:** Role of energy methods; historical perspective; review of vectors and vector calculus; basic equations in solid mechanics; index notation; conservation of linear and angular momentum; stress tensor; kinematics of deformation; strain tensor; constitutive laws.	08
2.	**Introduction to the Calculus of Variations:** The variational operator; concept of a functional; extremum principles; functionals of one independent variable; functionals of two independent variables.	07
3.	**Basic Notions of Energy Methods:** Virtual work; total potential energy and complementary potential energy; stability criteria; Castigliano's Theorem I; Castigliano's Theorem II; Betti and Maxwell reciprocity theorems.	06
4.	**Energy Methods for the Static Analysis of Deformable Solids:** Analysis of deformable members such as longitudinal bars, Euler-Bernoulli beams, membranes and plates under static loading conditions using variational principles; separation of natural and	11

	essential boundary conditions; introduction to Ritz, weighted residual, and Galerkin methods; Introduction to the finite element method.	
5.	**Energy Methods in Structural Dynamics:** Hamiltonian and Lagrangian dynamics; principle of least action; Euler-Lagrange equation; conservative and non-conservative systems; dynamics of non-deformable bodies; stability criterion; dynamics of deformable bodies: longitudinal vibration of rod, transverse vibration of strings and Euler-Bernoulli beams.	**10**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Langhaar, H.L., "Energy Methods in Applied Mechanics", 1st Ed., John Wiley and Sons, Inc.	**1962**
2.	Shames, I.H., and Dym, C.L., "Energy and Finite Element Methods in Structural Mechanics", 1th Ed., New Age International Publishers	**1991**
3.	Reddy, J.N., "Energy Principles and Variational Methods in Applied Mechanics", 1st Ed., John Wiley and Sons, Inc.	**2002**
4.	Berdichevsky, V.L., "Variational Principles of Continuum Mechanics-I: Fundamentals", 1st Ed., Springer	**2009**
5.	Berdichevsky, V.L., "Variational Principles of Continuum Mechanics-II: Applications", 1st Ed., Springer	**2009**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-321** Course Title: **Vibrations and Noise**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 6. Semester: **Both** 7. Subject Area: **DEC/DHC**

8. Pre-requisite: **Nil**

9. Objective: To introduce the basic concept of theory of vibrations and noise control in mechanical systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Simple Harmonic motion, Fourier analysis, Conservative systems.	**2**
2.	**Systems Having Single Degree of Freedom:** Free vibrations of systems without damping, equilibrium and energy methods for determining natural frequency; Rayleigh's method; Equivalent systems, systems with compound springs, shaft of different diameters; Free vibrations of system with viscous damping, over damped, critically and under damped systems, logarithmic decrement; Coulomb and structural damping; Forced vibrations of systems with viscous damping, equivalent viscous damping, power consumption in vibrating system, impressed forces due to unbalanced masses and excitation of supports, vibration isolation, transmissibility, commercial isolators; Vibration isolation using ER fluids.	**12**
3.	**Vibration Measuring Instruments:** Principle of frequency, displacement, velocity and acceleration measuring instruments, distortion effect.	**2**

4.	**Systems with two Degrees of Freedom:** Free undamped vibrations, static and dynamic coupling, principal modes of vibration, undamped dynamic vibration absorber, centrifugal pendulum absorber.	**4**
5.	**Multi-Degree of Freedom Systems:** Influence coefficients, eigen values and eigen vectors, matrix iteration; Dunkerley and Rayleigh's method.	**4**
6.	**Whirling of Shafts:** Whirling of light flexible vertical/horizontal shaft with an unbalanced disc at the centre of its length with and without damping.	**2**
7.	**Continuous Systems:** Vibration of strings, free longitudinal vibrations of prismatic bars, torsional vibrations of circular shafts, lateral vibrations of uniform beams.	**4**
8.	**Noise Control in Mechanical System:** Review of Fundamentals: Noise and vibration measurement units, levels, decibels, spectra. Objective/Subjective noise measurement-scales; Addition and subtraction of decibles; Frequency analysis bandwidths; Relationships for the measurement of free field sound propagation; The directional characteristics of sound sources; Sound power models. Industrial Noise and Vibration Control: Basic sources of industrial noise and vibration, basic industrial noise and vibration control methods; The economic factor; Sound transmission from one room to another acoustic enclosures, acoustic barriers, sound absorbing materials; Vibration control procedures; Fault detection from noise and vibration signals.	**12**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Grover, G. K., "Mechanical Vibrations", 3^{rd} Ed., Nem Chand	**2003**
2.	Rao, J. S. and Gupta, K., "Theory and Practice of Mechanical Vibration", 2^{nd} Ed., New Age International Publishers	**1999**
3.	Smith, J., and Whaley, W., "Vibration of Mechanical and Structural Systems with Microcomputer Applications", 2^{nd} Ed., Harper and Row	**1994**
4.	Thomason, W.T., "Theory of Vibrations with Applications", 5^{th} Ed., Prentice Hall	**1997**
5.	Timoshenko, "Vibration Problems in Engineering", 2nd Reprint Ed.,Wolfenden Press,	**2007**
6.	Norton, M.P., and Karcazub, D.G., "Fundamentals of Noise and Vibration Analysis for Engineers", 2^{nd} Ed., Cambridge University Press	**2003**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-416** Course Title: **Nonlinear Dynamics**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits: 4 6. Semester: **Both** 7. Subject Area: **DEC/DHC**

8. Pre-requisite: **Nil**

9. Objective: To introduce t he ba sic c oncept of t heory of vibrations and noi se c ontrol i n mechanical systems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Concepts in dynamical systems:** phase s pace, f ixed poi nts, stability, Poincaré map etc.	**4**
2.	**Basic theorems in system dynamics**: P oincaré-Lyapounov, Hartmann-Grobmann, Center Manifold, Review of KAM Theorem	**7**
3.	**Perturbation theory**: s ecular t erms, resonance i n perturbation theory, Gronwall lemma, error estimation in approximation methods	**7**
4.	**Applications in ODE's**: Duffing oscillator, forced oscillations, limit cycles; Lorentz equations	**7**
5.	**Applications in PDE's**: nonl inear di ffusion; a mplitude e quations; nonlinear wave equations - Burgers, KdV & NLS equations and their wave solutions, solitons, compactons	**7**
6.	**Chaos**: The logistic equations and the route to Chaos	**4**
7.	**Fractals**: Fundamental concepts in Fractals and Chaos	**4**
8.	**Nonlinear wave equations**	**2**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Nayfeh, A., Perturbation Methods, Wiley.	**1978**
2.	Wiggins, S., Introduction to Applied Nonlinear Dynamical Systems and Chaos, Springer-Verlag, NY, 1992.	**1992**
3.	Lichtenberg, A. J. & Lieberman, M. A., Regular and Chaotic Dynamics, Springer-Verlag, NY.	**1992**
4.	Hao Bai-Lin, Chaos, World Scientific, Singapore.	**1984**
5.	Kahn, P. B. & Zarmi Y., Nonlinear Dynamics – Exploration Through Normal Forms, Wiley, NY.	**1998**

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN–359** Course Title: **Fundamentals of Sound and Vibration**
2. Contact Hours: **L: 3** **T: 0** **P : 0**
3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0
4. Relative Weightage: **CWS** 25 **PRS** 0 **MTE** 25 **ETE** 50 **PRE** 0
5. Credits: 3 6. Semester: **Autumn** 7. Subject Area: **GSEC**
8. Pre–requisite: **Nil**
9. Objective of Course: The objective of the course is to teach the fundamentals of sound and vibration to the future engineers and develop ability to apply these principles to real life problems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Fundamental concepts:** Fundamentals of applied mechanics, sound and vibration fields, longitudinal waves in gases and liquids, diffraction, models in room acoustics, geometrical acoustics, waves in solid media, frequency analysis of sound, levels and decibel, filters, band pass, octave and third octave filters, summation of sound fields, interference and frequency components, summary of important formulas.	**3**
2.	**Influence of Sound and Vibration**: Ear and hearing, ear's function, measures of hearing, measures of noise, speech and masking, influence of noise on man, hearing injuries, hearing protection, sound quality, effects of shock and vibration, machinery and vehicle vibration, effects on man, international standards, regulations and recommendations on machine, vehicles, work environment, buildings and on external noise, summary of important formulas.	**3**
3.	**Signal Analysis and Measurements Techniques:** Mathematical fundamentals, fourier methods in sound and vibration, measurement	**3**

	systems, summary of important formulas.	
4.	**Wave Equation in Fluids:** Wave equation in a source free medium, general and harmonic solutions for free one dimensional wave propagation, sound intensity, energy and energy density, general and harmonic solutions for free spherical wave propagation, sound intensity, summary of important formulas.	**4**
5.	**Fundamentals of Vibrations:** Mechanical power, linear systems of one, two and multi-degree of freedom systems, damping, frequency response, mechanical-electrical circuits.	**7**
6.	**Reflection, Transmission and Standing Waves:** Reflection and transmission of plane waves, eigen-frequencies and eigen modes in enclosed spaces (rooms), summary of important formulas.	**3**
7.	**Wave Equation in Solids:** Introduction, wave propagation in infinite and semi-infinite media, quasi-longitudinal waves in beams, bending waves in beams and plates, summary of important formulas.	**4**
8.	**Room Acoustics:** Energy methods, room acoustics, acoustic absorbers, sound transmission through walls, summary of important formulas.	**3**
9.	**Sound Generation Mechanisms:** Monopoles, dipoles, quadra poles, influence of boundaries, live source, sound radiation from vibrating structures, point excited plates, flow generated noise, summary of important formulas.	**3**
10.	**Vibration Isolation:** Types, general comments, measures and prediction of vibration isolation, prediction models, rigid and flexible foundations, general expression, case studies.	**6**
11.	**Sound in Ducts:** Principals for sound reduction, insertion and transmission loss, sound propagation in ducts, introduction to silencers, helmholtz resonator, case studies.	**3**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Abom, M., "Sound and Vibration", KTH, Stockholm	**2006**
2.	Rao, J .S., and Gupta, K ., "Theory and Practice of Mechanical Vibrations", New Age International (Pvt) Ltd	**1999**
3.	Fahy, F.J,. and Walker, J.G., "Fundamentals of Noise and Vibration", E and FN, Spon	**1998**
4.	Kinsler, L.E., Frey, A.R., Coppens, A.B., and Sanders, J.V., "Fundamentals of Acoustics", John Wiley	**1982**
5	Grover, G.K., "Mechanical Vibrations", Nem Chand & Bros.	**2003**

INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-302** Course Title: **Machine Design**
2. Contact Hours : L: **4** T: **0** P: **4**
3. Examination Duration (Hrs.) : Theory **4** Practical **0**
4. Relative Weightage: CWS **15** PRS **15** MTE **30** ETE **40** PRE **0**
5. Credits: **6** 6. Semester: Spring 7. Subject Area: DCC

8. Pre–requisite: **MIN-206, MIN-301**

9. Objectives of Course: The student is exposed to basic principles of mechanical design and applications of these principles to the common mechanical elements used in general machinery.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**General:** Introduction to design procedure; design requirements; review of force analysis concepts; materials selection for design. Types of failures; theories of failures and their applications; factor of safety concepts, statistical considerations in design; Motor selection and matching of machinery. Causes of stress concentration; stress concentration factors; mitigation of stress concentration.	14
2.	**Dynamic loading:** Cyclic loading, endurance limit, effects of type of loading, size and surface finish; notch sensitivity; reliability considerations; Goodman and Soderberg diagrams; cumulative fatigue damage.	05
3.	**Design of Machine Elements:** Design of keys, threaded fasteners and power screws, belt and chain drives;; coil springs. Design of welded joints Design of spur, helical and worm gears; design of shafts; analysis of forces and bearing reactions; selection of rolling elements bearings. Design of clutches & brakes.	31
4.	**Principles of Machinery Construction:** Support and retainment of rotating assemblies, speed and motion changing devices, casting and weldment design, machine frame and housing design,	06
	Self-Study Design of keys and couplings; riveted and welded joints; design of bevel gears;	

	corrosion and wear considerations in design	
	Total	**56**

Suggested Books:

S. No.	Name of Books / Authors	Year of publication
1.	Mechanical Engg. Design, Shigley and Mitchke, McGraw Hill	**2003**
2.	Machine Design, Robert L. Norton, Pearson Education Asia	**2001**
3.	Fundamentals of Machine component design, Juvinall and Marshek, John Wiley	**2002**
4.	Design Data Hand book, Mahadevan and Balaveera Reddy, CBS Publishers	**2003**
5.	Machine Design. Paul H. Black & O. E. Adams. McGraw Hill	**1981**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-204** Course Title: **Machine Drawing**

2. Contact Hours: **L: 2** **T: 0** **P: 4**

3. Examination Duration (Hrs.): **Theory** 4 **Practical** 0

4. Relative Weightage**:** **CWS** 0 **PRS** 25 **MTE** 25 **ETE** 50 **PRE** 0

5. Credits**:** 4 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**: MIN-108**

9. Objective: This course aims at making the students well versed with the drawing practices for common machine elements, assembly drawings and blue-print reading.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Detachable Fasteners:** Screw threads, approximate and conventional representations; Specifications; Threaded fasteners; Types, forms, standard, and specifications; Drawing of temporary connections; Foundation bolts; Locking Devices; Classification, principles of operation, standard types and their proportions. Shaft Couplings; Common types, standard proportions for some couplings.	**4**
2.	**Permanent Fastenings:** Rivets; Standard forms and proportions, Riveted Joints, Common types of joints, terminology, proportions and representation; Welds; Types of welds and welded joints, edge preparation, specifications, and representation of welds on drawings.	**4**
3.	**Assembly Drawings:** Review of sheet preparation, boundary lines, zones, title block, revision panel, Parts List; Numbering of components and associated detail drawings; Assembly drawings of various machine sub-assemblies and assemblies from detail drawings, sketched and actual machine components.	**6**

4.	**Components Drawing:** Limits, Fits, and Tolerances o f Size and Form; Types and Grade, Use of Tolerance tables and specification of tolerances, Form and Cumulative T olerances; T olerance Dimensioning; General T olerances; S urface qua lity s ymbols, terminology and r epresentation on dr awings, correlation of tolerances and surface quality with manufacturing techniques.	**6**
5	Introduction t o A UTOCAD, us e of A UTOCAD f or a ssembly and component drawings	4
6	Introduction t o S olid modeling s oftware, us e of s olid m odeling software f or assembly a nd c omponent d rawings, generation of different views from solid models.	4
	Total	**28**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	French, T .E., V ierck, C .J., F oster, R .J., “ Engineering D rawing and Graphic Technology”, 14th Ed., McGraw Hill Science/Engg./Math,	**1993**
2.	Giesecke, F .E., M itchel, A ., S pencer, H.C., H ill, I.L., D ygdon, J .T., Novak, J .E., a nd Lockhart, S .D., “ Technical D rawing”, 13 th Ed., Prentice Hall	**2008**
3.	Sidheswar, N., “Machine Drawing”, McGraw Hill	**2004**
4.	Goutam Pohit, G outam G hosh, M achine D rawing w ith A utoCAD, Pearson	**2007**
5.	SolidWorks 2012: A Tutorial Approach, Prof. Sham Tickoo, CADCIM Technologies	**1988**
6	SP 46: 1988 Engineering Drawing Practice for Schools and Colleges, Bureau of Indian standards	**2012**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mechanical & Industrial Engineering Department**

1. Subject Code: **MIN-206** Course Title: **Mechanics of Materials**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**: CWS** 15 **PRS** 15 **MTE** 30 **ETE** 40 **PRE** 0

5. Credits**:** 4 6. Semester**: Spring** 7. Subject Area**: DCC**

8. Pre-requisite**: CEN-102**

9. Objective: To introduce the methods and tools of mechanics of material for the analysis for various types of engineering problems.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Three Dimensional State of Stress and Strain:** Stress and strain tensor, stress and strain transformations, principal stress and strain, Octahedral planes and stresses.	**6**
2.	**Elastic Strain Energy and Energy Methods:** Elastic strain energy due to normal and shear stress, strain energy of a three dimensional principal stress system, dilatational and distortional strain energy, strain energy due to axial, bending and torsional loads; Strain energy and complimentary energy theorems, Castigliano's theorems, theorem of virtual work, theorem of least work, reciprocal theorems, application of energy methods for determining slope and deflection in beams and twists in shafts, unit load method.	**13**
3.	**Theories of Elastic Failure:** Modes of failure, the necessity and significance of a failure theory, statement of various theories of failure and their application, graphical representation, comparison and limitations of various failure theories, safety factors.	**3**

4.	**Curved Beams:** Beams of large initial curvature, location of neutral axis, di stribution of s tresses a cross s ections h aving rectangular, circular and trapezoidal shapes.	**4**
5.	**Statically Indeterminate Beams:** Conditions of s tatical indeterminacy, d egree o f i ndeterminacy, analysis of bui lt-in be ams using i ntegration, s uperposition a nd a rea-moment m ethods, application of energy methods.	**6**
6.	**Unsymmetrical Bending:** Symmetrical a nd nonsymmetrical be am cross-sections a nd t heir properties, p roduct and second m oment o f area, principal s econd moments of ar ea, Mohr's ci rcle of s econd moments of a rea, be nding of s ymmetrical be am w ith s kew l oad, bending o f be ams ha ving uns ymmetrical c ross-section, l ocation of neutral ax is, shear cent er and i ts l ocation determination for thi n-walled open-sections.	**5**
7.	**Axi-symmetrical Problems:** Stresses and di splacements i n thick cylindrical shells subjected to internal and external pressure, press fits and laminated construction, thick spherical shells. Stresses in rotating cylinders a nd t hin r otating di sc, di sc ha ving uniform s trength i n rotation.	**5**
	Total	**42**

11. Suggested Books:

S. No.	**Name of Books / Authors**	**Year of Publication**
1.	Boresi, A.P., and Schmidt, R.J., "Advanced Mechanics of Materials", 6^{th} Ed., John Wiley & Sons	**2002**
2.	Hearn, E.J., "Mechanics of Materials", 3^{rd} Ed., Pergamon	**2003**
3.	Timoshenko, S.P., and Gere, J.M., "Mechanics of Materials", 2^{nd} Ed., CBS Publishers	**2002**
4.	Srinath, L.S., "Advanced Mechanics of Solids", 3^{rd} Ed., Tata McGraw Hill	**2009**
5.	Ugural, A.C., " Advanced S trength and A pplied E lasticity", 5^{th} Ed., Pearson Education Inc.	**2012**

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Mathematics Department**

1. Subject Code: **MAN-001** Course Title: **Mathematics I**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory** 3 **Practical** 0

4. Relative Weightage**:** **CWS** 25 **PRS** 00 25 50 0

5. Credits**:** 4 6. Semester**: Autumn** 7. Subject Area**: BSC**

8. Pre-requisite**:** **None**

9. Objective: **To provide essential knowledge of basic tools of Differential Calculus, Integral Calculus , Vector Calculus and Matrix Algebra for degree students.**

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Matrix Algebra:** Elementary operations and their use in getting the Rank, Inverse of a matrix and solution of linear simultaneous equations. Orthogonal, Symmetric, Skew-symmetric, Hermitian, Skew-Hermitian, Normal & Unitary matrices and their elementary properties. Eigen-values and Eigenvectors of a matrix, Cayley-Hamilton theorem, Diagonalization of a matrix.	**8**
2.	**Differential Calculus:** Limit, Continuity and differentiability of functions of two variables, Euler's theorem for homogeneous equations, Tangent plane and normal. Change of variables, chain rule, Jacobians, Taylor's Theorem for two variables, Error approximations. Extrema of functions of two or more variables, Lagrange's method of undetermined multipliers	**12**
3.	**Integral Calculus:** Review of curve tracing and quadric surfaces, Double and Triple integrals, Change of order of integration. Change of variables. Gamma and Beta functions. Dirichlet's integral. Applications of Multiple integrals such as surface area, volumes, centre of gravity and moment of inertia..	**12**
4.	**Vector Calculus:** Differentiation of vectors, gradient, divergence, curl and their physical meaning. Identities involving gradient, divergence and curl. Line and surface integrals. Green's, Gauss and Stroke's theorem and their applications.	**10**
	Total	**42**

11. Suggested Books:

S. No.	Name of Authors/ Books/Publishers	Year of Publication/Reprint
1.	E. Kreyszig, Advanced Engineering Mathematics, 9th edition, John Wiley and Sons, Inc., U.K.	2011
2.	R.K. Jain and S.R.K. Iyenger, Advanced Engineering Mathematics, 2nd Edition, Narosa Publishing House.	2005
3.	M.D. Weir, J. Hass, F.R. Giordano, Thomas' Calculus, 11th Edition, Pearson Education.	2008

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NAME OF DEPTT./CENTRE: **Department of Physics**

1. Subject Code: **PHN-001** Course Title: **Mechanics**
2. Contact Hours: **L: 3** **T: 0** **P: 2**
3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**
4. Relative Weightage**:** **CWS: 15** **PRS: 25** **MTE: 20** **ETE: 40** **PRE: 0**
5. Credits**: 4** 6. Semester**: Autumn** 7. Subject Area**: BSC**
8. Pre-requisite**: None**
9. Objective: **To familiarize students with the basic principles of mechanics**
10. Details of Course:

S.No.	Contents	Contact Hours
1	**STATICS OF PARTICLES.** Vectorial representation of forces and moments- Vector Operation-Concepts of Particles and Rigid bodies – Composition of concurrent forces in plane free body Diagram – Equilibrium of Rigid bodies in Two and three dimensions-Moment of a force about a point and about an axis-Couple moment-Reduction of a force system to a force and a couple	8
2	**PROPERTIES OF SURFACES, MOMENTS AND PRODUCTS OF INERTIA** Definition Moment of Inertia for areas-Parallel axis theorem –Perpendicular axis theorem-Moment of inertia for composite area-product of inertia form an area-mass moment of inertia	6
4	**FRICTION** Laws of coulomb friction- Coefficient of Friction-Dry Friction-sliding Friction-Ladder friction-Belt friction – Rolling Resistance.	4
5	**KINEMATICS OF PARTICLES** Principle of virtual work for a particle and rigid body-condition for equilibrium for a conservative system, stability-particle dynamics in rectangular coordinate, cylindrical coordinate and in terms of path variables-General motion of system of particles-	8
6	**WORK ENERGY METHODS, IMPULSE AND MOMENTUM** Work Energy Method-Conservation of Energy-Impulse and Momentum Relation-Impulsive Force-Impact force-Conservation of momentum – Moment of Momentum Equation.	8
7	**RIGID BODY MOTION;** Translation and rotation of rigid bodies- Derivative of a vector fixed in moving reference-General relationship between time derivative of a vector for different references-Moment of momentum equation-kinetic energy of rigid body-work and energy relations-Euler's equation of motion-Three dimensional motion about a fixed point	8
	TOTAL	**42**

List of experiments:

1. Study of magnetic field of a pair of coils in Helmholtz arrangement
2. Determination of e/m
3. Determination of first excitation potential of a gas by Frank-Hertz experiment
4. Determination of Stefan's constant
5. Determination of Planck's constant by radiation
6. To study and verify Malus' law
7. Study of Polarization of light using quarter wave plate
8. Determination of Brewster's angle at glass-air interface
9. Determination of with of a slit by single-slit diffraction pattern
10. Four probe method of finding resistivity of semiconductor
11. Quinck's Method for determining mass susceptibility
12. Wavelength of Na light by Newton's ring method

11. Suggested Books:

S.No.	Title/Authors/Publishers	Year of Publication
1.	Shames I .H. a nd Rao G .K., "Engineering M echanics-Statics a nd Dynamics" ,4 Edition, Pearson Education	2006
2.	Beer F.P and Johnson E.R., "Vector Mechanics for Engineers- Statics and Dynamics",9 Edition, Tata McGraw-Hill Publishing Company	2010
3.	Pytel A. and Kiusalaas J., " Engineering Mechanics: Statics" 3rd Edition, Cengage Learing	2010
4.	Pytel A. and Kiusalaas J., " Engineering Mechanics: Dynamics"3rd Edition Cengage Learing	2010
5.	Hibberler R .C a nd G upta A ., E ngineering M echanics,", 12 th Edition, Pearson Education	2012
6.	Meriam J.L . and Kraige L.G., " Engineering M echanics: S tatics", 6th Edition, John Willey and Son,s	2012
7.	Meriam J.L., a nd K raige L .G., " Engineering M echanics: D ynamics", 6 th Edition , John Willey and Son's	2012