COURSE STRUCTURE & CURRICULUM
FOR
BACHELOR OF TECHNOLOGY
IN
PRODUCTION AND INDUSTRIAL ENGINEERING
(HOUNOURS IN FOUNDRY FORGE)

(Applicable from the academic session 2022-2023)

National Institute of Advanced Manufacturing Technology
(Formerly National Institute of Foundry and Forge Technology)
Hatia, Ranchi 834003, Jharkhand, India

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Bachelor of Technology in Production and Industrial Engineering

(Effective from academic session 2022-23)

First Year First Semester						
Sl No.	**Subject Code**	**Subject Name**	**Total No. of contact hours**			**Credits**
			L	T	P	
Theory						
1	BSC101	Mathematics I	3	0	0	3
2	BSC102	Physics I	3	0	0	3
3	ESC101	Basic Electrical Engineering	3	0	0	3
4	ESC102	Engineering Mechanics	3	0	0	3
5	ESC103	Engineering Graphics and Computer Aided Engineering Graphics	1	0	4	3
6	HSC101	Professional Communication	1	1	0	2
		Total Theory	14	1	4	17
Practical						
1	BSC111	Physics I Laboratory	0	0	2	1
2	ESC111	Basic Electrical Engineering Laboratory	0	0	2	1
3	ESC112	Engineering Mechanics Lab	0	0	2	1
4	NCC101	Extra Academic Activities (EAA)	0	0	2	0
		Total Practical	0	0	6	3
		Total of First Semester	14	1	10	20

Second Semester						
Sl No.	**Subject Code**	**Subject Name**	**Total No. of contact hours**			**Credits**
			L	T	P	
Theory						
1	BSC201	Mathematics II	3	0	0	3
2	BSC202	Physics II	3	0	0	3
3	BSC203	Engineering Chemistry	3	0	0	3
4	ESC201	Computer Programming and Data Structure	3	0	0	3
5	ESC202	Basic Electronics Engineering	3	0	0	3
		Total Theory	15	0	0	15
Practical						
1	BSC211	Physics II Laboratory	0	0	2	1
2	BSC222	Engineering Chemistry Laboratory	0	0	2	1
3	ESC211	Computer Programming Laboratory	0	0	2	1

4	ESC203	Workshop Practices	1	0	4	3
5	NCC201	Extra Academic Activities (EAA)	0	0	2	0
		Total Practical	1	0	10	6
		Total of Second Semester	14	1	10	21

Third Semester						
Sl No.	**Subject Code**	**Subject Name**	**Total No. of contact hours**			**Credits**
			L	T	P	
Theory						
1	BSC301	Mathematics III	3	0	0	3
2	PCC301	Strength of Material	3	0	0	3
3	PCC302	Engineering Thermodynamics	3	0	0	3
4	PCC303	Fluid Mechanics and Machinery	3	0	0	3
5	PCC304	Introduction to Materials Engineering	3	0	0	3
6	PCC305	Metrology and Inspection	3	0	0	3
		Total Theory	18	0	0	18
Practical						
1	PCC311	Strength of Material Lab	0	0	2	1
2	PCC312	Fluid Mechanics and Machinery Lab	0	0	2	1
3	PCC313	Materials Characterization Lab	0	0	2	1
4	PCC314	Machine Drawing	0	0	2	1
5		Mini Project	0	0	2	1
6	NCC301	Extra Academic Activities (EAA)	0	0	2	0
		Total Practical	0	0	10	5
		Total of Third Semester	18	0	10	23

Fourth Semester						
Sl No.	**Subject Code**	**Subject Name**	**Total No. of contact hours**			**Credits**
			L	T	P	
Theory						
1	PCC401	Kinetics of Machine	3	0	0	3
2	PCC402	Applied Thermodynamics	3	0	0	3
3	PCC403	Manufacturing Engineering-I	3	0	0	3
4	PCC404	Industrial Engineering	3	0	0	3
5	PCC405	Production Planning & Control	3	0	0	3
6	PEC411-415	Professional Elective Course # I	3	0	0	3
7	HEC416	Technology of Ferrous Casting	3	0	0	3
		Total Theory	21	0	0	21
Practical						

1	PCC417	Metrology and Inspection Lab	0	0	2	1
2	PCC418	Manufacturing Engineering -I Lab	0	0	2	1
3	PCC419	Industrial Engineering Lab	0	0	2	1
4	HEC420	Technology of Ferrous Casting Lab	0	0	2	1
5		Mini Project	0	0	2	1
		Total Practical	0	0	10	5
		Total of Fourth Semester	21	0	10	26

Fifth Semester						
Sl No.	**Subject Code**	**Subject Name**	**Total No. of contact hours**			**Credits**
			L	T	P	
Theory						
1	PCC501	Manufacturing Engineering –II	3	0	0	3
2	PCC502	Dynamics of Machine	3	0	0	3
3	PCC503	Heat and Mass Transfer	3	0	0	3
4	PCC504	Operations Research	3	0	0	3
5	PCC505	Ergonomics and Work Design	3	0	0	3
6	PEC511-515	Professional Elective Course # II	3	0	0	3
7	HEC516	Technology of Ferrous Forging	3	0	0	3
		Total Theory	21	0	0	21
Practical						
1	PCC517	Manufacturing Engineering –II Lab	0	0	2	1
2	PCC518	Kinetics and Dynamics of Machine Lab	0	0	2	1
3	PCC519	Thermal and Heat Transfer Laboratory	0	0	2	1
4	HEC520	Technology of Ferrous Forging Lab	0	0	2	1
5	SI591	IVth Industrial Internship	0	0	2	1
		Total Practical	0	0	10	5
		Total of Fifth Semester	21	0	10	26

Sixth Semester						
Sl No.	**Subject Code**	**Subject Name**	**Total No. of contact hours**			**Credits**
			L	T	P	
Theory						
1	PCC601	Machine Design	3	0	0	3
2	PCC602	Production and Operations Management	3	0	0	3
3	PCC603	Product Design & Value Eng.	3	0	0	3
4	PEC611-615	Professional Elective Course # III	3	0	0	3

5	PEC616-619	Professional Elective Course # IV	3	0	0	3
6	OEC617-620	Open Elective # I	3	0	0	3
7	HEC621	Technology of Non-Ferrous Casting	3	0	0	3
		Total Theory	21	0	0	21
Practical						
1	PCC623	Machine Design Lab	0	0	2	1
2	PEC624-628	Professional Elective Course # III Lab	0	0	2	1
3	HEC627	Technology of Non-Ferrous Casting Lab	0	0	2	1
		Total Practical	0	0	10	3
		Total of Sixth Semester	21	0	10	24

Seventh Semester						
Sl No.	**Subject Code**	**Subject Name**	**Total No. of contact hours**			**Credits**
			L	T	P	
Theory						
1	PEC711-714	Professional Elective Course # V	3	0	0	3
2	OEC714-717	Open Elective # II	3	0	0	3
3	OEC718-721	Open Elective # III	3	0	0	3
4	OEC722-725	Open Elective # IV	3	0	0	3
5	HEC726	Technology of Non-Ferrous Forging	3	0	0	3
6	HEC727	Foundry Tooling and Methoding	3	0	0	3
7	HEC728	Forging Die Design and Product Realization	3	0	0	3
		Total Theory	21	0	0	21
Practical						
1	PEC729-731	Professional Elective Course # V Lab	0	0	2	1
2	HEC734	Technology of Non-Ferrous Forging Lab	0	0	2	1
3	HEC735	Foundry Tooling and Methoding Lab	0	0	2	1
4	HEC736	Forging Die Design and Product Realization Lab	0	0	2	1
5	SI791	VIth Industrial Internship	0	0	2	1
6	PW 791	Minor Project Work	0	0	1	1
		Total Practical	0	0	10	6
		Total of Seventh Semester	21	0	10	27

Eight Semester

Sl No.	Subject Code	Subject Name	Total No. of contact hours			Credits
			L	T	P	
1	PW891	Major Project	0	0	20	10
2	SR892	Seminar	0	0	4	2
3	GV893	Grand Viva	0	0	0	1
		Total of Eight Semester	0	0	24	13

Total Credits: 180

Professional Elective Courses #

PEC411-415	Professional Elective Course # I	3	0	0	3
PEC411	Solidification of Metals and Alloys	3	0	0	3
PEC412	Rapid Manufacturing Process	3	0	0	3
PEC413	Technology of Melting and Casting	3	0	0	3
PEC414	Advanced Foundry Processes	3	0	0	3
PEC415	Measurement and Control in casting and forging process	3	0	0	3

PEC511-515	Professional Elective Course # II	3	0	0	3
PEC511	Plasticity and Deformation	3	0	0	3
PEC512	Severe Plastic Deformation	3	0	0	3
PEC513	Sheet Metal Forming	3	0	0	3
PEC514	Near Net Shape Processes	3	0	0	3
PEC515	Rolling, Extrusion and Other Hot Working Process	3	0	0	3

PEC611-615	Professional Elective Course # III	3	0	2	4
PEC611	Simulation in Casting and Forging	3	0	2	4
PEC612	Smart Manufacturing	3	0	2	4
PEC613	Finite Element Methods	3	0	2	4
PEC614	Computational Fluid Dynamics	3	0	2	4
PEC615	Product and Process Optimization	3	0	2	4

PEC616-619	Professional Elective Course # IV	3	0	0	3
PEC616	Reverse Engineering and Remanufacturing	3	0	0	3
PEC617	Total Quality Management	3	0	0	3
PEC618	Supply Chain Management	3	0	0	3
PEC619	Engineering Economics	3	0	0	3

PEC711-714	Professional Elective Course # V	3	0	2	4
PEC711	Heat treatment of Casting and Forging	3	0	2	4
PEC712	Industrial Tribology	3	0	2	4
PEC713	Fuels, Furnaces and Refractories	3	0	2	4
PEC714	Fracture Mechanics	3	0	2	4

Open Electives #

OEC617-620	Open Elective # I	3	0	0	3
OEC617	Physical Metallurgy for casting and forging process	3	0	0	3
OEC618	Industrial Psychology	3	0	0	3
OEC619	Environmental Pollution Control in Industries	3	0	0	3
OEC620	Management Concepts and Techniques	3	0	0	3

OEC714-717	Open Elective # II	3	0	0	3
OEC714	Equipment and Tooling for Foundry and Forging	3	0	0	3
OEC715	Probability and Statistics for Engineers	3	0	0	3
OEC716	Design and Analysis of Experiments	3	0	0	3
OEC717	Computer Aided Manufacturing and Computer Integrated Manufacturing	3	0	0	3

OEC718-721	Open Elective # III	3	0	0	3
OEC718	Manufacturing Process Design	3	0	0	3
OEC719	Design for Manufacturing	3	0	0	3
OEC720	Artificial Intelligence and Data Analytics	3	0	0	3
OEC721	Cyber Physical System	3	0	0	3

OEC722-725	Open Elective # IV	3	0	0	3
OEC722	Future Materials Processing	3	0	0	3
OEC723	Foundry and Forge Shop Environmental Management	3	0	0	3
OEC724	Financial Management	3	0	0	3
OEC725	Robotics and Automation	3	0	0	3

Syllabus

Semester-I

Course Code : BSC101	**Category :** Basic Science Courses
Course Title : Mathematics – I	**Semester** : First
L-T-P : 3-0-0	**Credit:**3

1. Calculus (Integration) – 8L

Evolutes and involutes; Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions.

2. Calculus (Differentiation) – 6L

Rolle's Theorem, Mean value theorems, Taylor's and Maclaurin's theorems with remainders; Indeterminate forms and L'Hospital's rule; Maxima and minima.

3. Sequence and Series – 10L

Convergence of sequence and series, tests for convergence; Power series, Taylor's series, series for exponential, trigonometric and logarithm functions; Fourier series: Half range sine and cosine series, Parseval's theorem.

4. Multivariate Calculus – 10L

Limit, continuity and partial derivatives, Directional derivatives, Total derivative; Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers; Gradient, Curl and Divergence.

5. Matrices – 8L

Inverse and rank of a matrix, Rank-nullity theorem; System of linear equations; Symmetric, Skew-symmetric and Orthogonal matrices; Determinants; Eigenvalues and Eigenvectors; Diagonalization of matrices; Cayley-Hamilton Theorem, and Orthogonal transformation.

Learning Resources:

1. Reena Garg, Engineering Mathematics-I, Khanna Publishers.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.
3. Michael Greenberg, Advanced Engineering Mathematics, Pearson.
4. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers.
5. Kanti B. Dutta, Mathematical Methods of Science and Engineering, Cenage Learning.
6. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi.

Course Code : BSC102	**Category :** Basic Science Courses
Course Title : Physics-I	**Semester** : First
L-T-P : 3-0-2	**Credit:**4

Module 1: Harmonic Oscillation 6 Lectures

Simple harmonic motion, damped and forced simple harmonic oscillator with examples, damped harmonic oscillator – heavy, critical and light damping, Amplitude and energy decay in a damped harmonic oscillator. Forced oscillation and resonance condition.

Module 2: Wave optics 8 Lectures

Superposition of waves, Interference, thin film interference and Newton's ring, Diffraction of light, Diffraction due to single slit, double slits, Unpolarized& Polarized light, Polarization of

wave, Production of polarized wave: Brewster's law, Malus' law, Double refraction, Retardation plate, Analysis of polarization.

Module 3: Vector Calculus 6 Lectures

Scalar & Vector field, Gradient of scalar field, Divergence & Curl of Vector field, Gauss' Divergence theorem, Stokes' theorem.

Module 4: Electrostatics 7 Lectures

Laplace's and Poisson's equations for electrostatic potential, Uniqueness theorem. Electric polarization; Relation between **D**, **E** and **P** Electric displacement and boundary conditions; Dielectric sphere in uniform electric field.

Module 5: Magnetostatics 7 Lectures

Biot-Savart's law and applications, Three magnetic vector **B**, **H** and **M** andrelation between them; Boundary conditions on **B** and **H**. magnetic susceptibility, diamagnetic, paramagnetic and ferromagnetic materials. Hysteresis loop Hysteresis loss and its application.

Module 6: Maxwell's equations & EMW 8 Lectures

Continuity equation for current densities; Ampere's law and its modification, Differential and integral forms of Maxwell's equation, Maxwell's equation in vacuum and non-conducting medium; The wave equation; Plane electromagnetic waves in vacuum, transverse character, relation between electric and magnetic fields of an electromagnetic wave; Energy in an electromagnetic field and Poynting theorem.

Text Book:

● Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.

Reference books:

● Fundamentals of Physics Electricity and Magnetism, Halliday and Resnick, tenth edition (published 2013).
● Electricity, magnetism and light, W. Saslow, 1st edition
● Electromagnetic Theory, Singh and Prasad, I. K. International Publication, 1/e
● Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
● Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
● Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
● Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
● Optics, AjoyGhatak, 2008, Tata McGraw Hill
● Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, Tata McGraw-Hill.
● Engineering physics, Gaur and Gupta, DhanpatRai Publications
● Modern engineering physics, A. S. Vasudeva, S Chand & Company Ltd

COURSE OUTCOMES

Students to get familiarize with the knowledge of harmonic oscillation and wave optics.

To make student understand the basic of electrostatics and magneto statics in vacuum and in material medium.

Students to get familiarized with the vector calculus and Maxwell's equation leading to the application of EMW in vacuum and in media.**……**

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Course Code : BSC111	**Category :** Basic Science Courses
Course Title : Physics-I Laboratory	**Semester** : First
L-T-P : 0-0-2	**Credit:**1

Choice of 08-10 experiments from the following:

- Experiments on electromagnetic induction and electromagnetic breaking;
- Study of LCR circuits
- Magnetic field from Helmholtz coil
- Coupled oscillators
- Experiment on moment of inertia measurement
- Experiments with gyroscope
- Resonance phenomena in mechanical oscillators
- Frank-Hertz experiment
- Photoelectric effect experiment
- Diffraction (from ordinary light or laser pointers)
- interference experiment (from ordinary light or laser pointers)
- Minimum deviation, refractive index and dispersive power of material of a prism
- Study of variation of resistance due to heating effect
- Study of variation of magnetic field along the axis of current carrying coil.
- Use of Carey-Foster bridge
- Measurement of numerical aperture of optical fibre

Text Book:

- Text Book of Practical Physics, Dr. S. K. Ghosh, New Central Book Agency (P.) Ltd., 2000.

Reference books:

- Laboratory Manual in Applied Physics, Hannah Sathyaseelam, New Age International Pvt. Ltd.
- B.Sc. Practical Physics, C.L. Arora, S. Chand Publication.
- Practical optics, NattalyMenn, Elsevier Publication

LABROTARY OUTCOMES

Students to have hands on experience with experiments on the basic laws and principles of Physics in the field of Mechanics, Optics, Electricity, Magnetism, Modern Physics, etc.

Course Code : ESC101	**Category :** Engineering Science course
Course Title : Basic Electrical Engineering	**Semester** : First
L-T-P : 3-0-0	**Credit:**3

1. DC Circuits – 8L

Electrical circuit elements (R, L and C), voltage and current sources, Kirchoff current and voltage laws, analysis of simple circuits with dc excitation. Superposition, Thevenin and Norton Theorems. Time-domain analysis of first-order RL and RC circuits.

2. AC Circuits – 8L

Representation of sinusoidal waveforms, peak and rms values, phasor representation, real power, reactive power, apparent power, power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel), resonance. Three phase balanced circuits, voltage and current relations in star and delta connections.

3. Transformers – 6L

Magnetic materials, BH characteristics, ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency. Auto-transformer and three-phase transformer connections.

4. Electrical Machines – 8L

Generation of rotating magnetic fields, Construction and working of a three-phase induction motor, Significance of torque-slip characteristic. Loss components and efficiency, starting and speed control of induction motor. Single-phase induction motor. Construction, working, torque- speed characteristic and speed control of separately excited dc motor. Construction and working of synchronous generators.

5. Power Converters – 6L

DC-DC buck and boost converters, duty ratio control. Single-phase and three-phase voltage source inverters; sinusoidal modulation.

6. Electrical Installations – 6L

Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wires and Cables, Earthing. Types of Batteries, Important Characteristics for Batteries. Elementary calculations for energy consumption, power factor improvement and battery backup.

Learning Recourses:

1. RituSahdev, Basic Electrical Engineering, Khanna Book Publishing Co. (P) Ltd., Delhi.
2. D. P. Kothari and I. J. Nagrath, “Basic Electrical Engineering”, Tata McGraw Hill, 2010.
3. D. C. Kulshreshtha, “Basic Electrical Engineering”, McGraw Hill, 2009.
4. L. S. Bobrow, “Fundamentals of Electrical Engineering”, Oxford University Press, 2011.
5. E. Hughes, “Electrical and Electronics Technology”, Pearson, 2010.
6. V. D. Toro, “Electrical Engineering Fundamentals”, Prentice Hall India, 1989.

Course Code : ESC111	**Category :** Engineering Science course
Course Title : Basic Electrical Engineering Laboratory	**Semester** : First
L-T-P : 0-0-2	**Credit:**1

Choose 10 experiments from the following:

1. First activity: Introduction to basic safety precautions and mentioning of the do’s and Don’ts. Noting down list of experiments to be performed, and instruction for writing the

laboratory reports by the students. Group formation. Students are to be informed about the modalities of evaluation.

2. Introduction and uses of following instruments:

(a) Voltmeter

(b) Ammeter

(c) Multimeter

(d) Oscilloscope

Demonstration of real life resistors, capacitors with color code , inductors and autotransformer.

3. Demonstration of cut-out sections of machines: DC machine, Induction machine, Synchronous machine and single phase induction machine.

4. Calibration of ammeter and Wattmeter.

5. Determination of steady state and transient response of R-L, R-C and R-L-C circuit to a step change in voltage.

6. Determination of steady state response of R-L and R-C and R-L-C circuit and calculation of impedance and power factor.

7. Determination of resonance frequency and quality factor of series and parallel R-L-C circuit.

8. (a) Open circuit and short circuit test of a single-phase transformer

(b) Load test of the transformer and determination of efficiency and regulation

9. Demonstration of three phase transformer connections. Voltage and current relationship, phase shifts between the primary and secondary side.

10. Measurement of power in a three phase unbalanced circuit by two wattmeter method.

11. Determination of Torque –Speed characteristics of separately excited DC motor.

12. Determination of Torque speed characteristics and observation of direction reversal by change of phase sequence of connection of Induction motor.

13. Determination of operating characteristics of Synchronous generator.

14. Demonstration of operation of (a) DC-DC converter (b) DC-AC converter (c) DC-AC converter for speed control of an Induction motor

15. Demonstration of components of LT switchgear.

Course Code : ESC102	**Category :** Engineering Science Courses
Course Title : Engineering Mechanics	**Semester** : First
L-T-P : 3-0-0	**Credit:**3

Introduction to Engineering Mechanics covering, Force Systems – 4L

Basic concepts, Particle equilibrium in 2-D & 3-D; Rigid Body equilibrium; System of Forces, Coplanar Concurrent Forces, Components in Space – Resultant- Moment of Forces and its Application; Couples and Resultant of Force System, Equilibrium of System of Forces, Free body diagrams, Equations of Equilibrium of Coplanar Systems and Spatial Systems; Static Indeterminancy.

Friction – 5L

Friction covering, Types of friction, Limiting friction, Laws of Friction, Static and Dynamic Friction; Motion of Bodies, wedge friction, screw jack & differential screw jack

Truss and Frame – 5L

Basic Structural Analysis covering, Equilibrium in three dimensions; Method of Sections; Method of Joints; How to determine if a member is in tension or compression; Simple Trusses; Zero force members; Beams & types of beams; Frames & Machines.

Centroid and Centre of Gravity covering – 5L

Centroid of simple figures from first principle, centroid of composite sections; Centre of Gravity and its implications; Area moment of inertia- Definition, Moment of inertia of plane sections from first principles, Theorems of moment of inertia, Moment of inertia of standard sections and composite sections; Mass moment inertia of circular plate, Cylinder, Cone, Sphere, Hook.

Virtual Work and Energy Method – 5L

Virtual displacements, principle of virtual work for particle and ideal system of rigid bodies, degrees of freedom. Active force diagram, systems with friction, mechanical efficiency. Conservative forces and potential energy (elastic and gravitational), energy equation for equilibrium. Applications of energy method for equilibrium. Stability of equilibrium.

Review of particle dynamics – 6L

Rectilinear motion; Plane curvilinear motion (rectangular, path, and polar coordinates). 3-D curvilinear motion; Relative and constrained motion; Newton's 2nd law (rectangular, path, and polar coordinates). Work-kinetic energy, power, potential energy.Impulse-momentum (linear, angular); Impact (Direct and oblique).

Introduction to Kinetics of Rigid Bodies covering – 6L

Basic terms, general principles in dynamics; Types of motion, Instantaneous centre of rotation in plane motion and simple problems; D'Alembert's principle and its applications in plane motion and connected bodies; Work energy principle and its application in plane motion of connected bodies; Kinetics of rigid body rotation.

Mechanical Vibrations covering – 5L

Basic terminology, free and forced vibrations, resonance and its effects; Degree of freedom; Derivation for frequency and amplitude of free vibrations without damping and single degree of freedom system, simple problems, types of pendulum, use of simple, compound and torsion pendulums.

Learning Recourses:

1. M.P. Poonia& D.S. Bedi, Engineering Mechanics, Khanna Publishing House, 2019
2. Irving H. Shames (2006), Engineering Mechanics, 4th Edition, Prentice Hall
3. R.S. Khurmi, Engineering Mechanics, S.Chand Publications, Delhi
4. F. P. Beer and E. R. Johnston (2011), Vector Mechanics for Engineers, Vol I - Statics, Vol II, – Dynamics, 9th Ed, Tata McGraw Hill
5. R. C. Hibbler (2006), Engineering Mechanics: Principles of Statics and Dynamics, Pearson Press.
6. Andy Ruina and Rudra Pratap (2011), Introduction to Statics and Dynamics, Oxford University Press
7. Shanes and Rao (2006), Engineering Mechanics, Pearson Education,
8. Hibler and Gupta (2010),Engineering Mechanics (Statics, Dynamics) by Pearson Education
9. Reddy Vijaykumar K. and K. Suresh Kumar(2010), Singer's Engineering Mechanics
10. Bansal R.K.(2010), A Text Book of Engineering Mechanics, Laxmi Publications

11. Tayal A.K. (2010), Engineering Mechanics, Umesh Publications

Course Code : 112	**Category :** Engineering Science Courses
Course Title : Engineering Mechanics Lab	**Semester** : First
L-T-P : 0-0-2	**Credit:**1

Course Code : ESC103	**Category :** Engineering Science course
Course Title : Engineering Graphics and Computer Aided Engineering Graphics	**Semester** : First
L-T-P : 1-0-4	**Credit:**3

Introduction to Engineering Drawing

Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering, Different types of lines and their use; Drawing standards and codes.

Lettering, Dimensioning, Scales

Plain scale, Diagonal scale and Vernier Scales.

Geometrical Construction and Curves

Construction of polygons, Conic sections including the Rectangular Hyperbola (General method only); Cycloid, Epicycloid, Hypocycloid, Involute, Archemedian Spiral.

Projection of Points, Lines, Surfaces

Principles of Orthographic Projections-Conventions - 1st and 3rd angle projection, Projections of Points and lines inclined to both planes; Projections of planes (Rectangle, pentagon, Hexagon etc.) inclined Planes- Auxiliary Planes.

Projection of Regular Solids

Regular solids inclined to both the Planes- Auxiliary Views; Draw simple annotation, dimensioning and scale (Cube, Pyramid, Prism, Cylinder, Cone).

Combination of Regular Solids, Floor Plans

Regular solids in mutual contact with each other like Spheres in contact with cones standing on their base. Floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc.

Isometric Projections

Principles of Isometric projection – Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids; Conversion of Isometric Views to Orthographic Views and Vice-versa, Conventions;

Sections and Sectional Views of Right Angular Solids

Prism, Cylinder, Pyramid, Cone – Auxiliary Views; Development of surfaces of Right Regular Solids - Prism, Pyramid, Cylinder and Cone; Draw the sectional orthographic views of geometrical solids, objects from industry and dwellings (foundation to slab only)

Overview of Computer Graphics, Customisation & Cad Drawing

Listing the computer technologies that impact on graphical communication, Demonstrating knowledge of the theory of CAD software [such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in

CAD, Select and erase objects.; Isometric Views of lines, Planes, Simple and compound Solids]; Set up of the drawing page and the printer, including scale settings, Setting up of units and drawing limits; ISO and ANSI standards for coordinate dimensioning and tolerancing; Orthographic constraints, Snap to objects manually and automatically; Producing drawings by using various coordinate input entry methods to draw straight lines, Applying various ways of drawing circles;

Annotations, Layering & Other Functions

Applying dimensions to objects, applying annotations to drawings; Setting up and use of Layers, layers to create drawings, Create, edit and use customized layers; Changing line lengths through modifying existing lines (extend/lengthen); Printing documents to paper using the print command; orthographic projection techniques; Drawing sectional views of composite right regular geometric solids and project the true shape of the sectioned surface; Drawing annotation, Computeraided design (CAD) software modeling of parts and assemblies. Parametric and non-parametric solid, surface, and wireframe models. Part editing and two-dimensional documentation of models. Planar projection theory, including sketching of perspective, isometric, multiview, auxiliary, and section views. Spatial visualization exercises. Dimensioning guidelines, tolerancing techniques; dimensioning and scale multi views of dwelling;

Demonstration of A Simple Team Design Project

Geometry and topology of engineered components: creation of engineering models and their presentation in standard 2D blueprint form and as 3D wire-frame and shaded solids; meshed topologies for engineering analysis and tool-path generation for component manufacture; geometric dimensioning and tolerancing; Use of solidmodeling software for creating associative models at the component and assembly levels; floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc. Applying colour coding according to building drawing practice; Drawing sectional elevation showing foundation to ceiling; Introduction to Building Information Modelling (BIM).

Learning Resources:

1. Pradeep Jain, Ankita Maheswari, A.P. Gautam, Engineering Graphics & Design, Khanna Publishing House
2. Bhatt N.D., Panchal V.M. & Ingle P.R., (2014), Engineering Drawing, Charotar Publishing House
3. Agrawal B. & Agrawal C. M. (2012), Engineering Graphics, TMH Publication
4. Shah, M.B. & Rana B.C. (2008), Engineering Drawing and Computer Graphics, Pearson Education
5. Narayana, K.L. & P Kannaiah (2008), Text book on Engineering Drawing, Scitech Publishers
6. Corresponding set of CAD Software Theory and User Manuals

Course Code : HSC101	**Category :** Humanities and Social Sciences courses
Course Title : Professional Communication	**Semester** : First
L-T-P : 1-1-0	**Credit:**2

1. Vocabulary Building

1.1 The concept of Word Formation: Compounding, Backformation, Clipping, Blending.
1.2 Root words from foreign languages and their use in English
1.3 Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives.
1.4 Synonyms, antonyms, and standard abbreviations: Acronyms

2. Basic Writing Skills

2.1 Sentence Structures & Types: Simple, Compound, Complex
2.2 Use of phrases and clauses in sentences: Transformation of sentences, active, passive, narration
2.3 Importance of proper punctuation
2.4 Creating coherence: Arranging paragraphs & Sentences in logical order
2.5 Creating Cohesion: Organizing principles of paragraphs in documents
2.6 Techniques for writing precisely

3. Identifying Common Errors in Writing

3.1 Subject-verb agreement
3.2 Noun-pronoun agreement
3.3 Misplaced modifiers
3.4 Articles
3.5 Prepositions
3.6 Redundancies
3.7 Clichés

4. Nature and Style of sensible Writing

4.1 Describing
4.2 Defining
4.3 Classifying
4.4 Providing examples or evidence
4.5 Writing introduction and conclusion

5. Writing Practices

5.1 Comprehension
5.2 Précis Writing and Essay Writing
5.3 Business Letter, Cover Letter & CV; E-mail

Learning Resources:

(i) Kulbushan Kumar, R S Salaria,Effective Communication Skills, Khanna Publishing House, Delhi.
(ii) Practical English Usage. Michael Swan. OUP. 1995.
(iii) Remedial English Grammar. F.T. Wood. Macmillan.2007
(iv) On Writing Well. William Zinsser. Harper Resource Book. 2001
(v) Study Writing. Liz Hamp-Lyons and Ben Heasly. Cambridge University Press. 2006.
(vi) Communication Skills. Sanjay Kumar and PushpLata. Oxford University Press. 2011.
(vii) Exercises in Spoken English. Parts. I-III. CIEFL, Hyderabad. Oxford University Press
(viii) Universal English Prof. Prasad Kataria Publications, 2019.
(ix) "Communication Skills for Professionals"-NiraKonar, Prentice Hall of India 2nd edition, New Delhi, 2011

(x) Gajendra Singh Chauhan, SmitaKashiramka and L. Thimmesha. Functional English. Cengage , 2019.

Course Code : NCC101	**Category :**
Course Title : Extra Academic Activities (EAA)	**Semester** : First
L-T-P : 0-0-2	**Credit:0**

Semester-II

Course Code : BSC201	**Category :** Basic Science Courses
Course Title : Mathematics – II	**Semester** : Second
L-T-P : 3-0-0	**Credit:**3

Multivariate Calculus (Integration) – 11L

Multiple Integration: Double integrals (Cartesian), change of order of integration in double integrals, change of variables (Cartesian to Polar), Applications: Areas and volumes, Center of mass and Gravity (constant and variable densities); Triple integrals (Cartesian), Orthogonal curvilinear coordinates, Simple applications involving cubes, sphere and rectangular parallelepipeds; Scalar line integrals, vector line integrals, scalar surface integrals, vector surface integrals, Theorems of Green, Gauss and Stokes.

First order ordinary differential equations – 5L

Exact, linear and Bernoulli's equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type.

Ordinary differential equations of higher orders – 9L

Second order linear differential equations with constant coefficients, Use of D- operators, Second order linear differential equations with variable coefficients, method of variation of parameters, Cauchy-Euler equation; Power series solutions; Legendre polynomials, Bessel functions of the first kind and their properties.

Complex Variable – Differentiation – 6L

Differentiation of complex functions, Cauchy-Riemann equations, Analytic functions, Harmonic functions, determination of harmonic conjugate, elementary analytic functions (exponential, trigonometric, logarithmic) and their properties; Conformal mappings, Mobius transformations and their properties

Complex Variable – Integration – 9L

Contour integrals, Cauchy-Goursat theorem (without proof), Cauchy integral formula (without proof), Liouville's theorem and Maximum-Modulus theorem (without proof); Taylor's series, Zeros of analytic functions, Singularities, Laurent's series; Residues, Cauchy residue theorem (without proof), Evaluation of definite integral involving sine and cosine, Evaluation of certain improper integrals using the Bromwich contour

Learning Resources:

1. Reena Garg, Chandrika Prasad, Advanced Engineering Mathematics, Khanna Publishers.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.
3. Michael Greenberg, Advanced Engineering Mathematics, Pearson.
4. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers.
5. Kanti B. Dutta, Mathematical Methods of Science and Engineering, Cenage Learning.
6. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi.
7. E. L. Ince, Ordinary Differential Equations, Dover Publications.

Course Code : BSC202	**Category :** Basic Science Courses
Course Title : Physics-II	**Semester** : Second
L-T-P : 3-0-0	**Credit:**3

Physics-II

Module 1: Basic Quantum Mechanics 08 Lectures

Inadequacy of Classical Mechanics, Introduction to quantum physics, black body radiation; explanation using the photon concept; photoelectric effect: Stopping Potential, Work Function, Einstein's photo electric equation, Compton Effect: Compton Shift.

Module 2:Wave particle duality and bound states 10 Lectures

de Broglie hypothesis, wave-particle □ duality, □ Bragg's □ Law, □ Davision □ and □ Germer's
experiment; Phase velocity, group velocity and relation between phase, group and particle velocity, uncertainty principle- mathematical Illustration, Determination of minimum energy of harmonic oscillator, Non existence of electron within a nucleus.

Wave □function □and □Born's □interpretation □of □the □wave □function, □Schrodinger □wave □equation:
time dependent and independent form, eigen value and eigen function, normalization of wave function, particle in a box- one and three dimensional box, Linear harmonic oscillator.

Module 3: Theory of relativity 08 Lectures

Frame of reference, inertial and non-inertial frames, postulates of special theory of relativity, Galilean Transformation, Michelson Morley experiment, Lorentz transformation, length contraction, time dilation, relativistic variation of mass, addition of velocity, mass-energy equivalence

Module 4: Fibre Optics 08 Lectures

Introduction of optical fibre as a dielectric wave guide: total internal reflection, numerical aperture and various fibre parameters, losses associated with optical fibres, step and graded index fibres, application of optical fibres.

Module 5: **Lasers** 0**8 Lectures**

Introduction to interaction of radiation with matter, Stimulated and spontaneous emission, Einstein's □coefficient, □principles □and □work inlags e□r: o pfopulation inversion, pumping,
various modes, threshold population inversion, three levels and four level laser, types of laser: Ruby laser and He- Ne laser; application of lasers.

Text book:

● Eisberg and Resnick, Introduction to Quantum PhysicsPublisher New York: Wiley. Collection

Reference Books:

● Introduction to Quantum mechanics, Nikhil Ranjan Roy, 2016, Vikash Publishing House Pvt. Ltd.
● Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
● Quantum Mechanics: Theory & Applications, A.K.Ghatak&S.Lokanathan, 2004, Macmillan
● Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
● Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
● Optics, Ajoy Ghatak, 2008, Tata McGraw Hill
● Introduction to Special theory of Relativity, Robert Resnick, John Wiley & Sons
● Concept of Modern Physics, Arthur Beiser,2002, McGraw-Hill
● Engineering Physics, Gaur and Gupta, DhanpatRai Publications
● Modern Engineering Physics, A. S. Vasudeva, S Chand & Company Ltd

COURSE OUTCOMES

Students to learn the basics of Quantum mechanics and its application to bound states.
To understand the wave particle duality.
To be able to understand Special theory of relativity and its consequences.
To get familiarize with fiber optics and laser, their basic concept and application in engineering**.**

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Course Code : BSC203	**Category :** Basic Science Courses
Course Title : Engineering Chemistry	**Semester** : Second
L-T-P : 3-0-0	**Credit:**3

Atomic and molecular structure - 10L

Schrodinger equation. Particle in box solutions and their applications for conjugated molecules. Molecular orbitals of diatomic molecules and plots of the multicentre orbitals.

Equations for atomic and molecular orbitals. Energy level diagrams of diatomics. Pi-molecular orbitals of butadiene and benzene and aromaticity. Crystal field theory and the energy level diagrams for transition metal ions and their magnetic properties. Band structure of solids and the role of doping on band structures.

Spectroscopic techniques and applications - 6L

Principles and Applications of Electronic spectroscopy and Nuclear magnetic resonance. Vibrational and rotational spectroscopy of diatomic molecules and its applications. Fluorescence and its applications in Medicine. Surface Characterisation Techniques (Scanning Electron Microscopy and Transmission Electron Microscopy)

Intermolecular forces – 4L

Ionic, dipolar and van Der Waals interactions. Measurement of non-covalent interaction, Hydrogen bond, Equations of state of real gases and critical phenomena.

Use of free energy in chemical equilibria – 8L

Thermodynamic functions: energy, entropy and free energy. Estimations of entropy and free energies. Free energy and emf. Cell potentials, the Nernst equation and applications. Acid base, oxidation reduction and solubility equilibria. Corrosion: Introduction, Causes, consequences, Mechanism, Laws of Dry Corrosion, Wet Corrosion , Factors Influencing Corrosion, Protective measures against corrosion. Use of free energy considerations in metallurgy through Ellingham diagrams.

Periodic properties and Stereochemistry – 8L

Effective nuclear charge, penetration of orbitals, variations of s, p, d and f orbital energies of atoms in the periodic table, electronic configurations, atomic and ionic sizes, ionization energies, electron affinity and electronegativity, polarizability, oxidation states, coordination numbers and geometries, hard soft acids and bases. Representations of 3 dimensional structures, structural isomers and stereoisomers, configurations and symmetry and chirality, enantiomers, diastereomers, optical activity, absolute configurations and conformational analysis.

Polymer – 6L

Classification of polymers, Mechanism of Polymerisation, structure-property relationship, conductive polymers.

Learning Resources:

1. University Chemistry, by B.H.Mahan Chemistry, Second Edition, By Prasanta Ratha and S. Chakroborty –Cengage pub
2. Engineering Chemistry by Jaya Shree Anireddy, Wiley publication
3. Text book of Engineering Chemistry , First Ed.2019, By Sashi Chawala, Dhanpat
4. Rai, publication Chemistry: Principles and Applications, by M.J.Sienko and R.A.Plane
5. Fundamentals of molecular Spectroscopy, by C.N.Banwell
6. Engg Chemistry(NPTEL Web Book),by B.L.Tembe, Kamaluddin and
7. M.S.Krishnan Physical Chemistry, by P.W.Atkins
8. Organic Chemistry: Structure and Function by K.P.C. Volhardt and N.E. Schore,
9. 5 th Edition http://bcs.whfreeman.com/volhardtschore5e/default.asp

Course Code : BSC211	**Category :** Basic Science Courses
Course Title : Physics-II Laboratory	**Semester** : Second
L-T-P : 0-0-2	**Credit:**3

Course Code : BSC222	**Category :** Basic Science Courses
Course Title : Engineering Chemistry Laboratory	**Semester** : Second
L-T-P : 0-0-2	**Credit:**1

Choice of 08-10 experiments from the following

1. Determination of surface tension and viscosity
2. Thin layer chromatography
3. Preparation of a metal complex
4. Determination of chloride content of water
5. Colligative properties using freezing point depression
6. Determination of the rate constant of a reaction
7. Determination of cell constant and conductance of solutions
8. Potentiometry - determination of redox potentials and emfs
9. Synthesis of a polymer/drug
10. Saponification/acid value of an oil
11. Chemical analysis of a salt
12. Lattice structures and packing of spheres
13. Redox-titration (Estimation of Iron using permanganometry)
14. Chemical oscillations- Iodine clock reaction
15. Determination of the partition coefficient of a substance between two immiscible liquids
16. Adsorption of acetic acid by charcoal
17. Use of the capillary viscometers to demonstrate the isoelectric point as the pH of Minimum viscosity for gelatin sols and/ or coagulation of the white part of egg.

Course Code : ESC201	**Category :** Engineering Science course
Course Title : Computer Programming	**Semester** : Second

and Data Structure	
L-T-P : 3-0-0	**Credit:**3

Introduction to Programming – 6L

Introduction to components of a computer system (disks, memory, processor, where a program is stored and executed, operating system, compilers etc.). Idea of Algorithm: steps to solve logical and numerical problems. Representation of Algorithm: Flowchart/Pseudo code with examples. From algorithms to programs; source code, variables (with data types) variables and memory locations, Syntax and Logical Errors in compilation, object and executable code.

Arithmetic expressions and precedence - 12L

Conditional Branching and Loops Writing and evaluation of conditionals and consequent branching, Iteration and loops

Arrays - 3L

Arrays (1-D, 2-D), Character arrays and Strings

Basic Algorithms, Searching, Basic Sorting Algorithms – 4L

(Bubble, Insertion and Selection), Finding roots of equations, notion of order of complexity through example programs (no formal definition required)

Function and Pointers – 6L

Functions (including using built in libraries), Parameter passing in functions, call by value, Passing arrays to functions: idea of call by reference Idea of pointers, Defining pointers, Use of Pointers in self-referential structures, notion of linked list (no implementation).

Recursion and Structure – 9L

Recursion, as a different way of solving problems. Example programs, such as Finding, Factorial, Fibonacci series, Ackerman function etc. Quick sort or Merge sort. Structures, Defining structures and Array of Structures

Learning Resources:

1. Byron Gottfried, Schaum's Outline of Programming with C, McGraw-Hill
2. E. Balaguruswamy, Programming in ANSI C, Tata McGraw-Hill
3. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language, Prentice Hall of India

Course Code : ESC211	**Category :** Engineering Science course
Course Title : Computer Programming Laboratory	**Semester** : Second
L-T-P : 0-0-2	**Credit: 1**

Lab1: Familiarization with programming environment
Lab 2: Simple computational problems using arithmetic expressions
Lab 3: Problems involving if-then-else structures
Lab 4: Iterative problems e.g., sum of series
Lab 5: 1D Array manipulation
Lab 6: Matrix problems, String operations
Lab 7: Simple functions

Lab 8 and 9: Programming for solving Numerical methods problems
Lab 10: Recursive functions
Lab 11: Pointers and structures
Lab 12: File operations

Course Code : ESC202	**Category :** Engineering Science course
Course Title : Basic Electronics Engineering	**Semester** : Second
L-T-P : 3-0-0	**Credit: 3**

Semiconductor Devices and Applications – 7L

Introduction to P-N junction Diode and V-I characteristics, Half wave and Full-wave rectifiers, capacitor filter. Zener diode and its characteristics, Zener diode as voltage regulator. Regulated power supply IC based on 78XX and 79XX series, Introduction to BJT, its input-output and transfer characteristics, BJT as a single stage CE amplifier, frequency response and bandwidth.

Operational amplifier and its applications – 6L

Introduction to operational amplifiers, Op-amp input modes and parameters, Op-amp in open loop configuration, op-amp with negative feedback, study of practical op-amp IC 741, inverting and non inverting amplifier applications: summing and difference amplifier, unity gain buffer, comparator, integrator anddifferentiator.

Timing Circuits and Oscillators – 6L

RC-timing circuits, IC 555 and its applications as tableand mono-stable multi-vibrators, positive feedback, Barkhausen's criteria for oscillation, R-Cphase shift and Wein bridge oscillator.

Digital Electronics Fundamentals – 7L

Difference between analog and digital signals, Boolean algebra, Basic and Universal Gates, Symbols, Truth tables, logic expressions, Logic simplification using K- map, Logic ICs, half and full adder/sub tractor, multiplexers, De-multiplexers, flip-flops, shift registers, counters, Block diagram ofmicroprocessor/microcontroller and their applications.

Electronic Communication Systems – 6L

The elements of communication system, IEEE frequency spectrum, Transmission media: wired and wireless, need of modulation, AM andFM modulation schemes, Mobile communication systems: cellular concept and block diagram of GSM system.

Learning Resources:

1. Floyd ," Electronic Devices" Pearson Education 9th edition, 2012.
2. R.P. Jain , "Modern Digital Electronics", Tata McGraw Hill, 3rd Edition, 2007.
3. S.Biswas, Basic Electronics, Khanna Publishing House, 2019
4. Frenzel, "Communication Electronics: Principles and Applications", Tata McGraw Hill, 3rd Edition, 2001
5. Shanti Ram Kal, Basic Electronics, PHI

Course Code : ESC203	**Category :** Engineering Science course
Course Title : Workshop Practices	**Semester** : Second
L-T-P : 1-0-4	**Credit: 3**

Detailed contents:

1. Manufacturing Methods- casting, forming, machining, joining, advanced manufacturing methods
2. CNC machining, Additive manufacturing
3. Fitting operations & power tools
4. Electrical &Electronics
5. Carpentry
6. Plastic moulding, glass cutting
7. Metal casting
8. Welding (arc welding & gas welding), brazing

Workshop Practice:

Machine shop

Typical jobs that may be made in this practice module:

To make a pin from a mild steel rod in a lathe.

To make rectangular and vee slot in a block of cast iron or mild steel in a shaping and / or millingmachine.

Fitting shop

Typical jobs that may be made in this practice module:

To make a Gauge from MS plate.

Carpentry

Typical jobs that may be made in this practice module:

To make wooden joints and/or a pattern or like.

Welding shop

Typical jobs that may be made in this practice module:

ARC WELDING: To join two thick (approx 6mm) MS plates by manual metal arcwelding.

GAS WELDING: To join two thin mild steel plates or sheets by gas welding.

Foundry shop

Typical jobs that may be made in this practice module:

One/ two green sand moulds to prepare, and a casting be demonstrated.

Smithy shop

Typical jobs that may be made in this practice module:

A simple job of making a square rod from a round bar orlike.

Plastic moulding & Glass cutting Shop

Typical jobs that may be made in this practice module:

For plastic moulding, making at least one simple plastic component should be made. For glass cutting, three rectangular glass pieces may be cut to make a kaleidoscope using a black colour diamond cutter, or similar other components may be made.

Learning Resources:

1. Hajra Choudhury S.K., Hajra Choudhury A.K. and Nirjhar Roy S.K., “Elements of Workshop Technology”, Vol. I 2008 and Vol. II 2010, Media promoters and publishers private limited,Mumbai.

2. Kalpakjian S. and Steven S. Schmid, “Manufacturing Engineering and Technology”, 4th edition, Pearson Education India Edition, 2002.

3. Gowri P. Hariharan and A. Suresh Babu,”Manufacturing Technology – I” Pearson Education, 2008.

4. Roy A. Lindberg, “Processes and Materials of Manufacture”, 4th edition, Prentice Hall India,1998.
5. Rao P.N., “Manufacturing Technology”, Vol. I and Vol. II, Tata McGrawHill House, 2017.

Course Code : NCC201	**Category :**
Course Title : Extra Academic Activities (EAA)	**Semester** : Second
L-T-P : 0-0-2	**Credit:0**

Semester-III

Course Code : BSC301	**Category :** Basic Science Courses
Course Title : Mathematics III	**Semester** : Third
L-T-P : 3-0-0	**Credit: 3**

Partial Differential Equation – 14L

Definition of Partial Differential Equations, First order partial differential equations, solutions of first order linear PDEs; Solution to homogenous and non-homogenous linear partial differential equations of second order by complimentary function and particular integral method. Second-order linear equations and their classification, Initial and boundary conditions, D'Alembert's solution of the wave equation; Duhamel's principle for one dimensional wave equation. Heat diffusion and vibration problems, Separation of variables method to simple problems in Cartesian coordinates. The Laplacian in plane, cylindrical and spherical polar coordinates, solutions with Bessel functions and Legendre functions. One dimensional diffusion equation and its solution by separation of variable.

Probability – 12L

Probability spaces, conditional probability, independence; Discrete random variables, Independent random variables, the multinomial distribution, Poisson approximation to the binomial distribution, infinite sequences of Bernoulli trials, sums of independent random variables; Expectation of Discrete Random Variables, Moments, Variance of a sum, Correlation coefficient, Chebyshev's Inequality. Continuous random varibales and their properties, distribution functions and densities, normal, exponential and gamma densities. Bivariate distributions and their properties, distribution of sums and quotients, conditional densities, Bayes' rule.

Statistics – 12L

Basic Statistics, Measures of Central tendency: Moments, skewness and Kurtosis - Probability distributions: Binomial, Poisson and Normal - evaluation of statistical parameters for these three distributions, Correlation and regression – Rank correlation. Curve fitting by the method of least squares- fitting of straight lines, second degree parabolas and more general curves. Test of significance: Large sample test for single proportion, difference of proportions, Tests for single mean, difference of means, and difference of standard deviations. Test for ratio of variances - Chi-square test for goodness of fit and independence of attributes.

Learning Resources:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. Chandrika Prasad & Reena Garg, Advanced Engineering Mathematics, Khanna Publishing House, 2019.
3. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2010.
4. P. G. Hoel, S. C. Port and C. J. Stone, Introduction to Probability Theory, Universal Book Stall, 2003 (Reprint).
5. S. Ross, A First Course in Probability, 6th Ed., Pearson Education India, 2002.
6. Ramana, Higher Engineering Mathematics, TMH
7. Sashtry, Advanced Engineering Mathematics, PHI

Course Code : PCC301	**Category :** Professional Core Courses
Course Title : Strength of Material	**Semester** : Third
L-T-P : 3-0-0	**Credit: 3**

Analysis of Stress & Strain – 10L

Uniaxial stress and strain: Stress, Strain, Hooke's Law, Stress-strain curves, Elastic Constants, Strain Energy, Statically Indeterminate problems, Thermal Effects, Impact Loading; Biaxial stress and strain: Stress at a Point, Variation of Stress, Stress Transformation, Analysis of Strain, Strain-displacement relations, Strain transformation, StrainMeasurements,Constitutiveequations,Principalstressesandstrain.

Bending & Shear Stresses – 6L

Introduction, Pure Bending, Normal stresses in beams, Combined Bending and Axial Stress, Composite Beams, Shear Stress, Shear Centre, Strain energy in bending

Torsion – 6L

Introduction, Torsion of Circular Shaft, Power Transmitted by a Shaft, Compound Shaft, Tapered Shaft, Strain Energy in Torsion, Combined Bending and Twisting, Torsion of Thin Walled Tubes, Open and Closed Coiled Springs

Thin & Thick Cylinders & Spheres – 6L

Introduction, Thin Walled Shells, Thick Shells, Compound Cylindrical Shell

Deflections of Beams – 5L

Introduction, Equation of Elastic Curve, Methods for Determining Deflections - Double Integration, Macaulay's Method, Moment-Area Method, Conjugate-beam method, Castigliano's Theorem

Columns and Theories of Failure – 7L

Introduction, Euler's Theory for Long Columns, Rankine-Gordon Formula, Empirical Formulae, Eccentrically Loaded Columns

Learning Resources:

1. Elements of Strength of Materials, S.P. Timoshenko and D.H. Young, East-West Press Pvt. Ltd. Publications.
2. Mechanics of Materials, Pytel and Kiusalaas, Cengage Learning Publications.
3. Mechanics of Materials, Gere and Timosheinko, CBS Publications.
4. Mechanics of Materials, E. P. Popov, Prentics Hall Publications.
5. Strength of Materials, G. H. Ryder, Macmillan India Limited.
6. Strength of Materials- Pytel and Singer, Harpercollins College division publications.

7. Strength of Materials, Crandal, Dahal and Lardener, Tata Mcgraw Hill Publications.
8. Mechanics of Materials- Riley, Struges and Morris, John Wiley & Sons.

Course Code : PCC311	**Category :** Professional Core Courses
Course Title : Strength of Material Lab	**Semester** : Third
L-T-P : 0-0-2	**Credit:**1

Experiment 1: Tension Test
Experiment 2: Compression Test
Experiment 3: Torsion Test
Experiment 4: Beam Bending
Experiment 5: Impact Tests
Experiment 6: Closed and Open coiled springs
Experiment 7: Shear Test
Experiment 8: Buckling of Struts
Experiment 9: Hardness Test (Brinell and Rockwell)
Experiment 10: Tensometer (Tension Test)

Course Code : PCC302	**Category :** Professional Core Courses
Course Title : Engineering Thermodynamics	**Semester** : Third
L-T-P : 3-0-0	**Credit: 3**

Introduction – 8L

Introduction to thermodynamic system, surrounding, state, process, properties, equilibrium, heat and work, Zeroth Law of Thermodynamics

Properties of Pure Simple Compressible Substance – 5L

PvT surface, Pv, Tv, TP diagrams. Equation of state for ideal and real gases. Virial equation of state, van der Waal equation, use of steam tables and Mollier diagram

First Law of Thermodynamics – 5L

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.

Second Law of Thermodynamics – 5L

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 increase of entropy. Calculation of entropy change.

Entropy and Exergy – 5L

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.

Gas-Vapour Mixtures and Air-conditioning – 8L

Properties of gas-vapour mixtures, adiabatic-saturation and wet-bulb temperatures, psychrometric chart, human comfort and air conditioning, various air conditioning processes.

Gas and Vapour Power Cycles: Otto, Diesel, Dual, Stirling, Joule-Brayton cycle. Thermal efficiency and mean effective pressure, Rankine cycle.

Refrigeration Cycles – 4L

Reverse Carnot cycle, vapour compression refrigeration cycle.

Learning Resources:

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", 4th 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

Course Code : PCC303	**Category :** Professional Core Courses
Course Title : Fluid Mechanics and Machinery	**Semester** : Third
L-T-P : 3-0-0	**Credit: 3**

Introduction to Fluid Mechanics – 8L

Statics and Kinematics Fluid and continuum, Physical properties of fluids, Types of fluid flows, Rheology of fluids.Manometers, pressure transducers, pressure on plane and curved surfaces, centre of pressure, fluid masses subjected to linear acceleration and uniform rotation about an axis.Kinematics of Fluid flow: steadiness, uniformity, rotational and irrotational flows, streamline, streakline, pathline, continuity equation, stream function and velocity potential, applications of potential flow.

Dynamics of Fluid Flow – 8L

Dynamics of Fluid Flow and Dimensional Analysis Euler's Equation of motion along a streamline and its integration, Bernoulli's equation and its applications, momentum equation and its application to pipe bends.Dimensional Analysis, Buckingham's Pi theorem, important dimensionless numbers and their physical significance, geometric, kinematic and dynamic similarity, model studies, Hydraulic similitude.

Laminar and Turbulent Flows – 10L

Equation of motion for laminar flow through pipes, Stokes law, transition from laminar to turbulent flow, types of turbulent flow, isotropic and homogenous turbulence, scale and intensity of turbulence, eddy viscosity, Prandtl's mixing length theory, velocity distribution in turbulent flow over smooth and rough surfaces, resistance to flow, minor losses, pipe in series and parallel, power transmission through a pipe, three reservoir problems and pipe network.

Hydrodynamic Boundary Layer – 8L

Introduction with a historical background, boundary layer, displacement and momentum thickness, boundary layer over a flat plate, Prandtl boundary layer equation, laminar boundary layer, application of momentum equation, turbulent boundary layer, laminar sub-

layer, separation and its control, drag and lift, drag on a sphere, 2D cylinder and airfoil, Magnus effect.

Measurement Techniques – 4L

Flow measurement by Pitot tube, orifice, Venturi, nozzle, and bend meter, rotameter, notches and weirs, hot-wire anemometer, LDV and PIV, Turbine flowmeter, Vortex shedding flowmeter, magnetic flowmeter, Doppler Ultrasonic flowmeter, Coriolisflowmeter etc.

Introduction to Hydraulic Machines – 4L

Introduction to Hydroelectric power station and its components, Classification of turbines and pumps, similarity laws and specific speed, efficiency, cavitation.

Learning Resources:

1. Fox, R.W., McDonald, A.T., Introduction to Fluid Mechanics, 7th edition, Wiley India.
2. Ojha, C.S.P., Berndtsson, R., Chandramouli, P.N., Fluid Mechanics and Machinery, Oxford University Press, New Delhi.
3. Majumdar, B., Fluid Mechanics with Laboratory Manual, PHI Learning, New Delhi.
4. Som, S.K. and Biswas G, Introduction of Fluid Mechanics & Fluid Machines, TMH, New Delhi.
5. Mohanty, A.K., Fluid Mechanics, PHI Learning, New Delhi.
6. Shames, I.H., Mechanics of Fluids, McGraw Hill, International Students Edition.
7. Agarwal, S.K., Fluid through Problems, New Age International Pvt. Ltd, New Delhi.
8. Lal, J., Hydraulic Machines, Metropolitan Book Co. Pvt. Ltd., Delhi.

Course Code : PCC312	**Category :** Professional Core Courses
Course Title : Fluid Mechanics and Machinery Lab	**Semester** : Third
L-T-P : 0-0-2	**Credit:1**

Experiment 1: To verify the momentum equation using the experimental set-up on diffusion of submerged air jet.

Experiment 2: To study the boundary layer velocity profile over a flat plate and to determine the boundary layer thickness.

Experiment 3: To study the transition from laminar to turbulent flow and to determine the lower critical Reynolds number.

Experiment 4: To study the variation of friction factor '*f* ' for turbulent flow in commercial pipes.

Experiment 5: To calibrate an orifice meter, venturimeter, and bend meter and study the variation of the co-efficient of discharge with the Reynolds number.

Experiment 6: To study the impact of jets in a flat plate.

Experiment 7: To study performance of a Pelton wheel/ Francis turbine/ Kaplan Turbine.

Experiment 8: To study performance of two Centrifugal pumps connected in series and parallel.

Experiment 9: To study performance of a Reciprocating pump.

Learning Resources:

1. Singh, S. Experiments in Fluid Mechanics, PHI Learning, New Delhi.

2. Prakash, M. N. S., Experiments in Hydraulics and Hydraulic Machines: Theory and Procedures, PHI Learning, New Delhi.
3. Majumdar, B., Fluid Mechanics with Laboratory Manual, PHI Learning, New Delhi.

Course Code : PCC304	**Category :** Professional Core Courses
Course Title : Introduction to Materials Engineering	**Semester** : Third
L-T-P : 3-0-0	**Credit: 3**

Introduction – 3L

Historical perspective of Materials Science, Structure and properties relationship of Engineering Materials, Classification of materials, Advanced Materials.

Structure of Solids and Characterization of Materials – 6L

Introduction to crystal structures and systems, Metallic structures, Ceramic crystal structures, Carbon nano-structures, Crystallographic directions and planes, Miller indices, Density computations, Crystallography, Diffraction methods, Electron microscopy, Metallography, Thermal characterization techniques.

Imperfections in Solids – 4L

Point defects, Dislocations, Interfacial Defects, Bulk defects.

Diffusion – 4L

Diffusion mechanisms, steady and non-steady state diffusion, Factors that influence diffusion, Law's of diffusion, Applications of Diffusion.

Mechanical Behaviour of Materials – 6L

Elastic and plastic properties, Creep, Fatigue, Fracture, Heat treatment of steels.

Phase Diagrams and Phase Transformations – 6L

Unary, Binary, Equilibrium phase diagrams, Eutectic, Eutectoid, Peritectic and peritectoidreactions**,** Transformation rate effects and TTT diagrams. Microstructure and property changes in iron-carbon system, Iron-Carbon (Fe-C or Fe-Fe3C) Diagram.

Ceramic Materials – 2L

Ceramic types, Properties, Processing Application, Advanced ceramics.

Composites – 2L

Introduction, Applications, Particle reinforced composites, Fiber reinforced composites, Structural composites.

Thermal, Electrical, Magnetic, Optical Properties – 5L

Heat capacity, Thermal expansion, Thermal conductivity, Thermal stresses, Electrical conduction, Semi conductivity, Super conductivity, Electrical conduction in ionic ceramics and in polymers, Dielectric behaviour, Ferroelectricity, Piezoelectricity, Diamagnetism and paramagnetism, Ferromagnetism, Antiferromagnetism and ferrimagnetism, Influence of temperature on magnetic behaviour, Domains and hysteresis, Optical properties of metals, Optical properties of non-metals, Application of optical phenomena.

Economic, Environmental and Social Issues of Material Usage – 2L

Economic considerations, Environmental and societal considerations, Recycling issues, Life cycle analysis and its use in design.

Learning Resources:

1. Materials Science and Engineering An Introduction by Callister W. D. Jr.
2. Material Science by Van Vlack.
3. Material Science by Raghavan V.
4. Material Science and Engineering by K. M. Gupta.
5.

Course Code : PCC313	**Category :** Professional Core Courses
Course Title : Materials Characterization Lab	**Semester** : Third
L-T-P : 0-0-2	**Credit: 1**

Experiment 1: Study of various dislocation models, drawing burgers circuit and finding Burgers vector.
Experiment 2: Study of various unit cells and crystals for,
a) Their geometry and symmetry,
b) Total number of atoms and their arrangement,
c) Effective number of atoms per unit cell,
d) Co-ordination number,
e) Atomic packing efficiency,
f) Determining density,
g) Concept of Miller indices and Inter-planer spacing.
Experiment 3: To study the effect of a surface treatment (Etching) on the strength of glass.
Experiment 4: Heat treatment processes (Annealing, Normalizing, Quenching) and comparison of hardness before & after heat treatment.
Experiment 5: To predict creep characteristic of materials by plotting strain vs. time curves for different loadings.
Experiment 6: Comparative study of microstructures of different given specimens (mild steel, grey C.I., brass, and copper).
Experiment 7: Specimen preparation for micro structural examination by cutting, grinding, polishing and etching of aluminium specimen.
Experiment 8: Fabrication of composite by hand-lay up technique.
Experiment 9: Mechanical testing ofcomposite made by hand-lay up technique in experiment no. 8.
Experiment 10: To study the fatigue behaviour of a given sample.

Course Code : PCC305	**Category :** Professional Core Courses
Course Title : Metrology and Inspection	**Semester** : Third
L-T-P : 3-0-0	**Credit: 3**

Introduction – 6L

Introduction to measurement and measuring instrument, generalized measuring system and functional elements, static and dynamic performance, characteristics of measurement devices, concept of error, sources of error, statistical analysis of errors.

Sensors and transducers – 5L

Sensors and transducers- types and their characteristics, measurement of pressure, direct acting and elastic pressure transducers, measurement of very low pressures. Strain

measurement- types of strain gauges and their working, strain gauge circuits, temperature strain rosettes.

Measurement of force and torque – 5L

Measurement of force and torque, temperature measurement by thermometers, bimetallic thermocouples, thermistors and pyrometers. Measurement of flow, vibration and noise measurement, seismic instruments. Data acquisition system.

Standards of liner measurement – 6L

Standards of liner measurement, line and end standards, system of limits and fits, linear and angular measurement devices and systems, limit gauges and their design.

Measurements of geometric forms – 6L

Measurements of geometric forms like straightness, flatness, roughness and circularity, optical projectors, tool , makers microscope, autocollimators, principle and use of interferometry, optical flat interferometers, laser interferometers. Comparators-types, working principles and magnification range, measurement of screw threads and gears.

Surface texture-quantitative evaluation – 6L

Surface texture-quantitative evaluation of surface roughness and its measurement, introduction to CMM, in-process gauging systems, inspection- in-process and final inspection, sampling and 100% inspection, sampling plans.

Learning Resources:

1. Beckwith Thomas G., Mechanical Measurement, Narosa Publishing House.
2. Doeblein, E.O., Measurement Systems: Application and Design, McGraw Hill.
3. Hume, K.J., Engineering Metrology, MacDonald and Co.
4. Gupta, I.C., Engineering Metrology, DhanpatRai& Sons.
5. Bewoor, A.K. and Kulkarni, V. A., Metrology & Measurement, Tata McGraw-Hill Education Pvt. Ltd.
6. Sawhney, A.K. and Mahajan, M., A textbook of measurement and metrology, DhanpatRai& Co.

Course Code : PCC314	**Category :** Professional Core Courses
Course Title : Machine Drawing	**Semester** : Third
L-T-P : 0-0-2	**Credit:**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.

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.

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 subassemblies and assemblies from detail drawings, sketched and actual machine components.

Components Drawing:

Limits, Fits, and Tolerances of Size and Form; Types and Grade, Use of Tolerance tables and specification of tolerances, Form and Cumulative Tolerances; Tolerance Dimensioning;General Tolerances; Surface quality symbols, terminology and representation on drawings, correlation of tolerances and surface quality with manufacturing techniques.

Introduction to AUTOCAD, use of AUTOCAD for assembly and component drawings

Introduction to Solid modeling software, use of solid modeling software for assembly and component drawings, generation of different views from solid models.

Learning Resources:

1. French, T.E., Vierck, C.J., Foster, R.J., "Engineering Drawing and Graphic Technology", 14th Ed., McGraw Hill Science/Engg./Math, 1993
2. Giesecke, F.E., Mitchel, A., Spencer, H.C., Hill, I.L., Dygdon, J.T., Novak, J.E., and Lockhart, S.D.,"Technical Drawing", 13th Ed., Prentice Hall, 2008
3. Sidheswar, N., "Machine Drawing", McGraw Hill, 2004
4. Goutam Pohit, Goutam Ghosh, Machine Drawing with AutoCAD, 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

Course Code :	**Category :**
Course Title : Mini Project	**Semester** : Third
L-T-P : 0-0-2	**Credit:1**

Course Code : NCC301	**Category :**
Course Title : Extra Academic Activities (EAA)	**Semester** : Third
L-T-P : 0-0-2	**Credit:0**

Semester-IV

Course Code : PCC401	**Category :** Professional Core Courses
Course Title : Kinetics of Machine	**Semester** : Fourth
L-T-P : 3-0-0	**Credit:**3

Introduction to mechanisms – 12L

Introduction to mechanisms, Applications of mechanisms, Kinematics of mechanisms, kinematic diagrams, Degree of freedom, Position and displacement analysis, graphical methods, Velocity analysis, relative motion, graphical method, instant center, Mechanical advantage, Acceleration analysis, graphical method.

Analytical methods in mechanism analysis - 10

Analytical methods in mechanism analysis, Computer oriented methods in kinematic analysis, Cam Design, Cam and follower types, Displacement diagrams, Cam profile synthesis, graphical and analytical methods, Design of plate cam, reciprocating flat faced follower – roller follower, Advanced cam profile techniques.

Gears –10L

Gears – Law of gearing, Involute spur gears, involutometry, Spur gear details, interference, backlash, Gear standardization, Internal gear, Cycloidal gear, Non-standard gears, Bevel, helical and worm gearing, Gear Trains – simple and compound gear trains, planetary gear trains, solution of planetary gear train problems, applications.

Kinematic synthesis – 10

Kinematic synthesis, Tasks of kinematic synthesis, type and dimensional synthesis, graphical synthesis for motion, path generation without and with prescribed timing, Function generation, overlay method, Analytical synthesis techniques, Complex number modelling, loop closure equation technique, Freudenstein's equation, Case studies in synthesis of mechanisms.

Learning Resources:

1. Uicker, J.J.Jr., Pennock, G.R., and Shigley, J.E., Theory of Machines and Mechanisms, 3rd ed., Oxford University Press, 2009.
2. Sandor, G.N., and Erdman, A.G., Advanced Mechanism Design: Analysis and Synthesis, Vol. I & II, Prentice-Hall of India, 1988.
3. Mabie, H.H., and Reinholtz, C.F., Mechanisms and Dynamics of Machinery, 4th ed., John Wiley & Sons, 1987.
4. Ghosh, A, and Mallik, A.K., Theory of Mechanisms and Machines, 3rd ed., Affiliated East-West Press, 1998.

5. Waldron, K.J., and Kinzel, G.L., Kinematics, Dynamics and Design of Machinery, John Wiley & Sons, 2004.
6. Norton, R.L., Design of Machinery, Tata McGraw-Hill, 2004.
7. Martin, G.T., Kinematics and Dynamics of Machines, McGraw-Hill, 1969.
8. Rattan, S.S., Theory of Machines, 3rd ed., Tata McGraw-Hill, 2009.
9. Nikravesh, P.E., Planar Multibody Dynamics, CRC Press, 2008.

Course Code : PCC402	**Category :** Professional Core Courses
Course Title : Applied Thermodynamics	**Semester** : Fourth
L-T-P : 3-0-0	**Credit:**3

Overview of Engine Operation – 6L

Overview and Basics of Engine Operation, Engine Geometry, Performance Parameters, Ideal Cycle Analysis, Combustion Stoichiometry, Fuel-air Cycle Model

Gas Exchange – 6L

Gas Exchange: 4-Stroke, Gas Exchange: 2-Stroke, Turbocharging, Mixture Preparation

Ignition System – 7L

Ignition System, Spark-ignition Engine Combustion, Knock, Diesel Combustion

Refrigeration – 7L

Refrigeration: Simple Vapour compression Systems, Pshychrometry, Air-conditioning Systems

Nozzles – 7L

Steam Flow through Nozzles: Types, Nozzle efficiency, energy equation, critical pressure.
Overview and Basics of Steam Turbines: Working principle, Types, Velocity diagrams

Steam Compressors – 7L

Overview and Basics of dynamic Compressors: Working principle, Types, Velocity diagrams
Steam Turbine Plants, Rankine cycle, Regenerative feed heating, Reheating

Learning Resources:

1. Internal Combustion Engine Fundamentals. New York: McGraw-Hill, 1988. ISBN: 9780070286375 by Heywood, John B
2. I.C.Engines by V. Ganeshan
3. Refrigeration and Airconditioning by C. P. Arora
4. Refrigeration and Airconditioning by Manohar Prasad
5. Turbines Compressors and Fans by S M Yahya
6. Thermodynamics and Heat Enginges, Vol. II by R. Yadav

Course Code : PCC403	**Category :** Professional Core Courses
Course Title : Manufacturing Science and Technology-I	**Semester** : Fourth

L-T-P : 3-0-0	**Credit:**3

Introduction – 2L

Classification of different manufacturing processes, application areas and limitations, selection of a manufacturing process.

Casting – 4L

Steps involved in casting, advantages, limitations and applications of casting process. Pattern types, allowances for pattern, pattern, materials color coding and storing of patterns.

Moulding methods – 4L

Moulding methods and processes-materials, equipment, moulding sand ingredients, essential requirements, sand preparation and control, testing, cores and core making.

Design considerations in casting, gating and Risering, directional solidification in castings. Sand castings-pressure die casting-permanent mould casting-centrifugal casting-precision investment casting, shell moulding, CO2 moulding, squeeze casting-electro slag casting. Fettling and finishing, defects in Castings.

Advanced Casting Processes – 4L

Metal mould casting, Continuous casting, Squeeze casting, Vacuum mould casting, Evaporative pattern casting, Ceramic shell casting (Introductory)

Massive Metal Forming Science and Technology – 14L

Need and Classification, Elastic and Plastic deformation-Yield and Flow; Rolling: Classification of Rolling, Process geometry and Analysis of Plate rolling for Rolling load and power calculations; Rolling mills and Roll pass design; Defects in Rolled Products; Forging: Classification of Forging, Process Geometry and Analysis of Strip and Disc forging for Forging Load and Power calculations; Defects in Forged Products; Drawing: Process Geometry and Analysis of Wire and Sheet Drawing for Load and Power calculations, Maximum Reduction Possible. Extrusion: Classification, Process Geometry and Analysis of Rod and Sheet Extrusion for Load and Power calculations, Maximum Reduction Possible; Defects in Extruded Product.

Welding– 8L

Types of welding-gas welding-arc welding-shielded metal arc welding, TAW, GMAW, SAW, ESW-Resistance welding (spot, seam, projection, percussion, flash types)-atomic hydrogen arc welding-thermit welding soldering, brazing and braze welding. Welding symbols-Positions of welding-joint and groove design-weld stress-calculations-design of weld size estimation of weld dilution, heat input, preheat, and post heat temperature-

computer applications in weld design, dissimilar metal. Gas welding equipments-welding power sources and characteristics safety aspects in welding-automation of welding, seam tracking, vision and arc sensing-welding robots. Defects in welding-causes and remedies-destructive testing methods

Advanced Welding Processes – 6L

Plasma arc welding, stud welding, friction welding, explosive welding, underwater welding, roll bonding, diffusion bonding, cold welding, welding of plastics Details of electron beam welding (EBW), laser beam welding (LBW), ultrasonic welding (USW) (Introductory)

Learning Resources:

1. Manufacturing Science by Ghosh and Mallik, East West Press Pvt. Ltd., New Delhi
2. Fundamentals of Modern Manufacturing by M. P. Groover, John Wiley and Sons, New Delhi
3. Fundamentals of Metal Forming Processes by B. L. Juneja, New Age International Ltd., New Delhi
4. Manufacturing Engineering and Technology by Kalpakjian and Schmid, Pearson Education Pvt. Ltd. New Delhi
5. Lindberg R.A., "Processes and Materials of Manufacture", Prentice-Hall of India, 1990.
6. Groover M.P., "Fundamentals of Modern Manufacturing", John Wiley & Sons 2002.
7. DeGarmo E.P., Black J.T., and Kohser R.A., "Materials and Processes in Manufacturing", Prentice-Hall of India, 1997.
8. Richard, A., Little., *Welding and Welding Technology*, Tata McGraw Hill, 2001.
9. Heine, R., and Rosenthal, P., *Principles of Metal Casting*, Tata McGraw Hill, 1985.

Course Code : PCC404	**Category :** Professional Core Courses
Course Title : Industrial Engineering	**Semester** : Fourth
L-T-P : 3-0-0	**Credit:**3

Industrial Engineering – 6L

Introduction to industrial engineering, Functions of organization, Elements of organization, Principles of organization, Types of organization and their selection.

Plant Layout and Material Handling – 8L

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.

Production Planning and Control – 8L

Functions, forecasting, routing, operations planning; Gantt chart, work order, dispatching and follow-up; CPM and PERT techniques.

Inventory Control – 4L

Scope, purchasing and storing, economic lot size, ABC Analysis.

Quality Control – 10L

Statistical quality control, control charts for variables and attributes: X bar, R, p & c charts, Concepts &Scope of TQM and QFD. Acceptance Sampling: Consumer's risk, Producers risk, LQL, AQL, OC curves, Types of sampling plans, AOQ, ATI.

Work Study – 6L

Scope, work measurement and method study, standard data, ergonomics and its industrial applications.

Learning Resources:

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

Course Code : PCC405	**Category :** Professional Core Courses
Course Title : Production Planning & Control	**Semester** : Fourth
L-T-P : 3-0-0	**Credit:**3

Introduction – 4L

Manufacturing function; Elements of production systems; Types of production systems; Objectives and functions of production planning and control.

Product Design – 10L

Identification of product ideas and selection, product development and design, product analysis: marketing aspects, product characteristics, economic analysis, profitability and competitiveness, production aspects.

Forecasting – 11L

Concepts and applications, demand forecasting, principle of forecasting, forecasting techniques, quantitative and qualitative, Delphi technique.

Production Planning – 10L

Preplanning, selection of materials, methods, machines and man power, aggregate production planning, master production planning, Break Even Analysis (BEA), concepts, make or buy decisions.

Production Control – 7L

Dispatching rules, dispatching of work card, inspection card and reports, control boards and charts, expediting, progress reporting, corrective change in schedules.

Learning Resources:

1. Buffa, E.S., Sarin, R.K., "Modern Production / Operations Management", John Willey and Sons 1994
2. Mukhopadhyaya, S.K., "Production Planning and Control – Text and Cases", Prentice Hall of India 2004 3. Adam, Jr., E.E., Ebert, R.J., "Production and Operations Management Concept, Models and Behaviour", 5th 2001 Ed., Prentice Hall of India
4. Vollman, T.E., Berry, W.L., Whybark, D.C., "Manufacturing Planning and Control Systems" 4th 1997 Ed., McGraw Hill,
5. Sipper, D., Buffin, R.L., "Production: Planning Control and Integration", McGraw Hill, . 1997

Course Code : PEC411	**Category :** Professional Elective Courses
Course Title : Solidification of Metals and Alloys	**Semester** : Fourth
L-T-P : 3-0-0	**Credit:**3

Introduction – 8L

Casting as a process of Manufacturing. Moulding Processes, Equipment and Mechanization: Different types of Moulds, Moulding Materials and Moulding processes, Pattern and other mould making equipment, forces acting on moulds, Mould factors in metal flow, Moulding factors in casting design. Different types of binders and their uses in mould and core-makings.

Melting of Metals and Alloys for casting – 8L

Brief mention of various melting units, melting and post melting treatments, melting practices as adopted for a few metals and alloys such as CI, Al, Cu, steels, cast irons.

Solidification of Metals and Alloys – 8L

Nucleation, Growth, Role of alloy constitution, Thermal conditions and inherent nucleation and growth conditions in the liquid melt, Significance, and practical control of caststructure.

Principles of Gating and Rise ring – 8L

Feeding characteristics of alloys, Types of Gates and Risers, Time of solidification andChowrinov rule, Wlodawer system for feeder head calculations, gating ratio, concept of directionality in solidification,Yield of casting and prescription for its augmentation.

Special casting Methods – 8L

Investment casting, Die casting,Centrifugal casting, Full mould casting, Vacuum sealed casting.

Casting Defects – 2L

Casting defects and analysis, their causes and prescription of remedial measures.

Learning Resources:

1. P. R. Beeley, Foundry Technology, Newnes-Buttterworths
2. P. D. Webster, Fundamentals of Foundry Technology, Portwillis press, Red hill
3. P. C. Mukherjee, Fundamentals of Metal casting Technology, Oxford IBH
4. R. W. Hein, C. R. Loper and P. C. Rosenthal, Principles of Metal casting, Mc Graw Hill

Course Code : PEC412	**Category :** Professional Elective Courses
Course Title : Rapid Manufacturing Process	**Semester** : Fourth
L-T-P : 3-0-0	**Credit:**3

Introduction to Rapid Manufacturing (RM), Product Design Process, Design for Modularity, Reverse Engineering, Principal of RP processes, Classification of RP Processes, Various Industrial RP Systems like Sterolithography, Fused Deposition Modeling, Selective Laser Sintering, Laminated Object Manufacturing, 3D Printing, Ballistic particle modeling etc., Role of Rapid Prototyping and Rapid Tooling in Product Development. Process planning for rapid prototyping, STL file generation Defects in STL files and repairing algorithms, Slicing and various slicing procedures, Accuracy issues in Rapid Prototyping, Strength of RP Parts, Surface roughness problem in Rapid Prototyping, Part deposition orientation and issues like accuracy, surface finish, build time, support structure, cost etc., Rapid tooling techniques such as laminated metallic tooling, direct metal laser sintering. Integration of reverse engineering and rapid prototyping, Rapid Product Development (CAD/CAE/CIM)

Learning Resources:

1. Chua Chee Kai, Leong Kah Fai, “Rapid Prototyping: Principles & Applications”, World Scientific, 2003.
2. Ian Gibson, David W Rosen, Brent Stucker., “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing”, Springer, 2010

3. Ali K. Kamrani, EmandAbouel Nasr, “Rapid Prototyping: Theory & Practice”, Springer, 2006.
4. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001

Course Code : PEC413	**Category :** Professional Elective Courses
Course Title : Technology of Melting and Casting	**Semester** : Fourth
L-T-P : 3-0-0	**Credit:**3

Introduction to casting processes, Classification, advantages, limitations, applications of casting, casting terms, sand mold making procedure, Technology of patternmaking, moulding and core making, Melting, pouring and feeding Introduction of furnaces for ferrous and non-ferrous casting, use, construction, charging and other furnaces, Gating and risering of castings, Design considerations and inspection of casting, Designing for economical molding and eliminating defects, defects in casting, inspection Methods: visual, dimensional, mechanical, metallurgical and NDT.

The hydrodynamics, flow processes at casting and the properties of the melt system in relation to its casting properties.Models for solidification from thermal conductivity viewpoint for different casting processes. The structure formation in different casting processes. Nucleation in and inoculation in melts. Formation of micro and macro segregation. Structural changes at heating, forming and homogenisation. The solubility of gases in melts and precipitation of gas and of secondary phases during solidification. Influence of shrinkage on solidification processes. Cooling shrinkage, thermal stress and crack formation during cooling. Analytical and numerical modelling of solidification and casting processes.

Learning Resources:

1. Heine R.W, Loper C.R and Rosenthal P.C , Principles of metal casting, Tata McGraw Hill Publication Co.1998
2. P. L. Jain , Principles of foundry technology, Tata McGraw Hill Education , New Delhi, 2003.
3. PN Rao, Manufacturing Technology – Foundry, Forming and welding, Tata McGraw Hill, New Delhi, 2006.

Course Code : PEC414	**Category :** Professional Elective Courses
Course Title : Advanced Foundry Processes	**Semester** : Sixth
L-T-P : 3-0-0	**Credit:**3

Advanced moulding process details, ingredients used, process variables and economy of the process using sodium silicate binder and organic binder process e.g. hot box, cold box ABC, silicate ester, catalysed no-bake, warm box processes, shell molding. Fluid Sand, Evaporative Pattern Casting, magnetic moulding, investment casting, frozen mould casting, vacuum sealed moulding, high pressure moulding, impact moulding explosion moulding and squeeze

casting processes. Die casting, centrifugal casting, continuous casting, Strip casting, Twin roll strip casting, spray forming, Semisolid casting: Rheocasting, thixocasting.

Learning Resources:

1. Foundry Technology by P.L. Jain
2. ASM Handbook Volume 15: Casting, ISBN: 978-0-87170-711-6
3. Principles of Metal Casting by Richard Heine, Carl Loper, Philip Rosenthal
4. Metal Casting Principles and Techniques by Lerner Yury, Posinasetti Nageswara

Course Code : PEC415	**Category :** Professional Elective Courses
Course Title : Measurement and Control in Casting and Forging Process	**Semester** : Fourth
L-T-P : 3-0-0	**Credit:**3

- Measurement of temperatures, pressure, velocity, force, strain, vibration and acceleration by transducers. Role of transducers in automatic control system and their characteristics, PID controllers; Response characteristics and compensation of electrical, hydraulic and pneumatic systems. 3D scanner,
- Part of overall production process such as chemistry, Spectrometers/Spectroscope for Chemistry, temperature, Thermal Analysis & CE meters/C-Si Analyzer, Various ways of temperature measurement in melting/ holding and heat treatment furnaces, Core drying ovens, core blowers/shooters in Heat Cured binder processes, Energy meters for furnaces,
- Moulding/ Core Making equipment and their impact on performance of equipment, Flow meters for gas/ liquids in either core making like cold box process or Degassing of Aluminium Alloys with inert gases like Nitrogen
- Controlling of casting parameters: composition, mold/die temperature, moisture level and viscosity of liquid metal
- Forging parameters: variations in billet geometry, die temperature, material properties, workpiece and forging equipment positional errors and process parameters. forging tool life and preform design.

References:

1. Engineering Metrology – K.J. Hume, Macdonald and Co.(publisher) London
2. The Springer handbook of metrology and Testing, Czichos (Ed), 2011
3. The Metrology Hand book- Jay. L.Bucher (ed), American Society for Quality, 2004
4. Industrial Metrology – Smith GT, 2002,Spinger
5. Hand book of industrial metrology – John W. Greve, Frank W. Wilson,PHI – New Delhi
6. Engineering Metrology – D.M.Anthony,Pergamon Press
7. Dimensional Metrology – Khare MK, OXFORD-IBH Publishers
8. Foundry Technology by P. L. Jain
9. Principles pf Metal Casting by Heine, Loper and Rosenthal
10. ASM Hand Book , Vol. 14, Forming and Forging.

Course Code : HEC415	**Category :** Honours Elective Courses
Course Title : Technology of Ferrous Casting	**Semester** : Fourth
L-T-P : 3-0-0	**Credit:**3

Classification of cast iron, Chemical composition, Brief history of iron making, Raw Materials for Iron Making,Molding and core making practices in iron casting, routine sand testing, Solidification process of cast iron, Fe-Gr and Fe-Fe_3C phase diagrams, microstructure, properties of cast iron, melting of cast iron, furnaces used for melting of cast iron their construction, principle, operation and charge calculation (Cupola, Reverberatory furnace, Electric arc furnace, Induction furnace), gating and risering, fluidity of grey iron, shrinkage characteristics, chill test.

Metallurgical operation: Selection of iron composition, section size, cooling rate and properties, chemical composition effect, solidification of Fe-C- Si alloy, graphitization during solidification, inoculation, microstructure and properties of cast iron

Brief history of steel making, Raw Materials for Steel Making,classification, properties and applications of steel, Fe-C phase diagrams; Solidification behavior of steel. effect of alloy additions.

Basic steps in casting production of steel, materials and types of patterns, Molding and core making practices in steel casting. Routine sand testing.

Melting furnaces used for steel: electric arc furnace, induction furnace, etc. Charge calculation for steel casting, melting practices and melt controls for steel. De-oxidation and degassing of steel, electro slag remelting(ESR)and central zone refining(CZR).

Gating and feeding practices for steel castings. Fettling, cleaning, salvaging and heat treatments of castings; Defect analysis.

Production and characterization of gray cast iron, ductile iron, austempered ductile iron, and compacted graphite iron, malleable iron, Specification of cast iron, application of cast iron.

Alloy iron, alloying elements

Cleaning and inspection of cast iron, Defect analysis,heat treatment of cast iron.

Fe-C phase diagrams; classification, properties and applications of cast irons and steel. Solidification behavior and effect of alloy additions. 1**4L**

Melting furnaces used for iron and steel: electric arc furnace, induction furnace, cupola, rotary furnace. Melting practices and melt controls for iron and steel. De-oxidation and degassing of steel; Inoculation and alloying of cast irons. **14L**

Production of grey, S.G., C.G. and malleable irons. Moulding and core making practice for iron and steel. Gating and feeding practices for iron and steel. Fettling, cleaning and heat treatments of castings; Defect analysis.**14L**

Learning Resources:

1. Foundry Technology by P.L. Jain
2. ASM Handbook Volume 15: Casting, ISBN: 978-0-87170-711-6
3. Principles of Metal Casting by Richard Heine, Carl Loper, Philip Rosenthal
4. Metal Casting Principles and Techniques by Lerner Yury, Posinasetti Nageswara
5. FOSECO Ferrous Foundryman's Handbook, John R. Brown

Course Code : PCC417	**Category :** Professional Core Courses
Course Title : Metrology and Inspection Lab	**Semester** : Fourth
L-T-P : 0-0-2	**Credit: 1**

1. To measure the acceleration of a vibrating body using strain gauges
2. To measure the acceleration and velocity of a rotating machinery using Piezo-electric sensors.
3. To measure the angle of rotation of a rotating shaft using photoelectric sensors.
4. To measure the dynamic power of a shaft using instantaneous power measuring dynamometer.
5. To measure the load of compressive nature using load cells.
6. To measure the angle of a taper rod using sine bar and slip gauges.
7. To measure the straightness of machine tool surface by sensitive spirit level.
8. To measure the gear tooth thickness by using gear tooth Vernier calliper.
9. To measure the elements of screw thread using tool maker's microscope.
10. To measure the elements of screw thread using profile projector.

Learning Resources:

1. Doeblin, E.O., "Measurement Systems: Application and Design", 5th Ed., McGraw-Hill, 2004.
2. Beckwith, T.G., Marangoni, R.D., and Lienhard, J.H., "Mechanical Measurement", 5th Ed., Addison-Wesley, 1995
3. Jain R K, "Engineering Metrology", Khanna Publishers, New Delhi, 2003.
4. Experimental Methods for Engineers, J P Holman, Tata McGraw Hill publications, 2007

Course Code : PCC418	**Category :** Professional Core Courses
Course Title : Manufacturing Science and Technology-I Lab	**Semester** : Fourth
L-T-P : 0-0-2	**Credit: 1**

1. To prepare the pattern and core.
2. To prepare a green sand mold and cast few engineering components.
3. To prepare the metal matrix composite by stir casting.
4. To fabricate the butt joint in the given sample using tungsten inert gas welding and studying the parametric effect on the weld quality.

5. To fabricate the butt joint in the given sample using metal inert gas welding process and studying the parametric effect on the weld quality.
6. To fabricate the butt joint in the given sample using submerged arc welding process and studying the parametric effect on the weld quality.
7. To study the mechanical properties of casted and welded specimens.
8. To study the metallurgical properties of casted and welded specimens.
9. Dye penetration testing, to study the defects of Casted and Welded Specimens
10. Ultrasonic flaw detection and Magnetic crack detection to study the defects of Casted and Welded Specimens

Learning Resources:

1. Rao,P.N., "Manufacturing Technology", (Vol. 2), Tata McGraw-Hill 1998
2. R. S. Parmar.," Welding Engineering and Technology" (Vol.2), Khanna Publishers, 2010

Course Code : PCC419	**Category :** Professional Core Courses
Course Title : Industrial Engineering Lab	**Semester** : Fourth
L-T-P : 0-0-2	**Credit: 1**

1. To prepare the following charts and diagrams:
   a) Outline process chart
   b) Multiple activity chart
   c) Flow process chart and Flow diagram
   d) String diagram
2. To construct Left hand and Right chart for the assembly of: (a) Nut & Bolt, (b) Parts of Pen, and (c) Parts of sine centre.
3. To conduct the method study for assembling simple components and office work.
4. Rating practice during walking.
5. Rating practice using pin board assembly.
6. Rating practice for dealing a deck of cards.
7. Rating practice for marble collection activity.
8. Determination of the standard time for a given operation using stop watch time study.
9. To conduct the office work measurement through work sampling.
10. Measurement of parameters (heart beat rate, calorie consumption) during walking.
11. Measurement and multi-correlation between pulse rate and calorie consumption during walking.

Course Code : HEC420	**Category :** Honours Elective Courses
Course Title : Technology of Ferrous Casting Lab	**Semester** : Fourth
L-T-P : 0-0-2	**Credit: 1**

1. Determination of fluidity factor of gray cast iron using spiral test.
2. Casting of Gray cast iron and its characterization
3. Casting of white cast iron and its characterization
4. Casting of S.G. Iron and its characterization

5. Casting of medium carbon steel and its characterization
6. Casting of high carbon steel and its characterization
7. Casting of alloy steel and its characterization.
8. Defects analysis of iron and steel casting
9. Heat treatments of Iron casting
10. Heat treatments of steel castings

Course Code :	**Category :**
Course Title : Mini Project	**Semester** : Fourth
L-T-P : 0-0-2	**Credit:1**

Semester-V

Course Code : PCC501	**Category :** Professional Core Courses
Course Title : Manufacturing Science and Technology–II	**Semester** : Fifth
L-T-P : 3-0-0	**Credit:**3

Metal Cutting Principle – 6L

Mechanism of Chip Formation; Types of Chips; Orthogonal and Oblique cutting, Cutting Forces and Merchant Circle Diagram, Shear angle and Friction angle, Shear Velocity and Chip Velocity, Length of shear and friction plane , Stresses in shear and friction plane, Energy in shear and friction plane, Strains in shear and friction plane, Temperature in shear and friction plane; **Cutting Tools and Fluids**: Cutting Tool Materials, Cutting Tool Life, Cutting Tool Geometries, and Cutting Fluid Applications

Cutting Machining Operations – 12L

Cutting Tool Technology, Machine Tool Technology and Holding Tool Technology, Process Geometry, Cutting Conditions, Calculation of Material Removal Rate (MRR), Surface Roughness (Ra), Cutting Forces and Power for Turning and related operations; Drilling and related operations; Milling and Gear Cutting, Shaping and Planning; Broaching and Sawing operations; Economics of Machining by Cutting

Abrasive Machining Operations – 12L

Features, Need and Classifications of Abrasive Machining; Abrasive Grinding- Wheel Specification, Wheel Life; Balancing, Truing and Dressing of Wheels; Classifications of Abrasive Grinding Processes; Chipping action in grinding, Calculation of Grinding Time and Material Removal Rate, Forces and Power, Heat and Temperature; Working Principle and Applications of grinding processes for prismatic and rotational surfaces; Abrasive Finishing-Conventional abrasive finishing-Honing, Lapping, Polishing and Buffing; Modern Abrasive Finishing - Abrasive Flow Finishing and Magnetic Abrasive Finishing

Advanced Machining Operations – 6L

Need and Classification of Erosion based Machining Processes; Process Principle, Equipments and Applications of Electro-Discharge Machining (EDM) and Beam Machining Processes (e.g. LBM, EBM, IBM,); Electro-Chemical Machining (ECM) and Chemical Machining Processes (e.g. CHM, PCM, BCM), Ultra-Sonic Machining (USM) and Jet Machining Processes (AJM, WJM, AWJM), Introduction to Hybrid Machining Processes

Jigs and Fixtures – 6L

Classification of Jigs and Fixtures, Fundamental Principles of design of Jigs and Fixtures, Location and Clamping in Jigs and fixtures, Simple design for drilling Jigs, Milling fixtures, Indexing Jigs and fixtures, etc

Learning Resources:

a) Manufacturing Science by Ghosh and Mallik**,** East West Press Pvt. Ltd., New Delhi
b) Fundamentals of Modern Manufacturing by M. P. Groover, John Wiley and Sons, New Delhi
c) Introduction to Machining Science by G. K. Lal, New Age International Ltd., New Delhi
d) Manufacturing Engineering and Technology by Kalpakjian and Schmid, Pearson Education Pvt. Ltd. New Delhi
e) Jigs and Fixtures by P. H. Joshi, Tata-McGraw Hill

Course Code : PCC502	**Category :** Professional Core Courses
Course Title : Dynamics of Machine	**Semester** : Fifth
L-T-P : 3-0-0	**Credit:**3

Force analysis – 8L
Dynamic force analysis – Inertia force and Inertia torque– D Alembert's principle –Dynamic Analysis in reciprocating engines – Gas forces – Inertia effect of connecting rod– Bearing loads – Crank shaft torque – Turning moment diagrams –Fly Wheels – Flywheels of punching presses- Dynamics of Cam- follower mechanism.
Balancing – 6L
Static and dynamic balancing – Balancing of rotating masses – Balancing a single cylinder engine – Balancing of Multi-cylinder inline, V-engines – Partial balancing in engines – Balancing of linkages – Balancing machines-Field balancing of discs and rotors.
Free vibration – 10L
Basic features of vibratory systems – Degrees of freedom – single degree of freedom – Free vibration– Equations of motion – Natural frequency – Types of Damping – Damped vibration– Torsional vibration of shaft – Critical speeds of shafts – Torsional vibration – Two and three rotor torsional systems.
Forced vibration – 8L
Response of one degree freedom systems to periodic forcing – Harmonic disturbances – Disturbance caused by unbalance – Support motion –transmissibility – Vibration isolation vibration measurement.
Mechanism for control – 10L
Governors – Types – Centrifugal governors – Gravity controlled and spring controlled centrifugal governors – Characteristics – Effect of friction – Controlling force curves. Gyroscopes –Gyroscopic forces and torques – Gyroscopic stabilization – Gyroscopic effects in Automobiles, ships and airplanes.

Learning Resources:

1. Ratan SS, "Theory of Machines", 1st Edition, Tata McGraw Hill, New Delhi (1993).
2. Theory of Mechanisms and Machines, Amitabh Ghosh and Mallik, East West Press Publication.
3. Design of Machinery, Robert L Norton, Mc. Graw Hill.
4. Theory of Machines, P.L. Ballaney, Khanna Publishers, New Delhi
5. Mechanism and Machine Theory, J.S. Rao and R.V. Dukkipati, 2nd Edition, New Age International, Delhi

Course Code : PCC503	**Category :** Professional Core Courses
Course Title : Heat and Mass Transfer	**Semester** : Fifth

L-T-P : 3-0-0	**Credit:**3

Conduction – 5L

Basic law of heat conduction – Fourier's law, thermal conductivity, its dependence on temperature, steady state heat conduction through a composite solid and its electric analogue, steady state heat conduction through cylinders, spheres and variable area of solids, different insulating materials and their applications for process equipment and pipelines, Fourier's law in three dimensions, lumped capacity method of unsteady state conduction.

Convection – 6L

Convection heat transfer and the concept of heat transfer coefficient, individual and overall heat transfer coefficient, heat transfer between fluids separated by plane wall, heat transfer between fluids separated by cylindrical wall (pipes), critical/ optimum insulation thickness, heat transfer through extended surfaces.

Forced Convection – 6L

Over a flat plate, thermal boundary layer, dimensionless groups and Dimensional analysis, Buckingham Pi-theorem, heat transfer correlations- internal and external flows, laminar and turbulent flows,

Free convection – 6L

Heat transfer correlations for free convection, free convection from flat surfaces, free convection from a cylinder.

Heat Transfer with phase change – 6L

Boiling phenomena and analysis of boiling curve, correlation for nucleate boiling, critical heat flux, condensation phenomena, film condensation on a vertical surface (Nusselt equation, effect of non-condensable gases, drop wise condensation.

Radiation – 6L

Basic principle of radiation from a surface, blackbody radiation, Planck's law, Wein's displacement law, the Stefan Boltzmann law, Kirchhoff's law, gray body, radiation exchange between black bodies & grey bodies.

Heat Exchanger – 4L

Types of heat exchangers; fouling factors; overall heat transfer coefficient; Logarithmic mean temperature difference (LMTD) method; Effectiveness-NTU method.

Introduction to Mass Transfer – 3L

Introduction; Fick's law of diffusion; Steady state equimolar counter diffusion; Steady state diffusion though a stagnant gas film.

Learning Resources:

1. Holman J P, "Heat Transfer", McGraw Hill Book Co. (1992).
2. Yunus A. Cenegel, "Heat & Mass Transfer: A practical Approach", McGraw Hill Book Co. (2007).
3. Incropera F P and DeWitt D P, "Introduction to Heat Transfer," 2nd Ed John Wiley New York (1996).
4. Geankopolis C J, "Transport Processes and Separation Process Principles", Prentice Hall of India, 4th Edition, Eastern Economy Edition (2004)
5. Kern D Q, "Process Heat Transfer", McGraw Hill Book Co. (1997).
6. Coulson J M and Richardson J F, "Chemical Engineering" Volume 1, Pergamon Press (1999).
7. Whitaker, S., Fundamental Principles of Heat Transfer, New York, Per gammon, 1997.
8. Cussler, E, L., Diffusion. Mass Transfer in Fluid Systems, Cambridge, 1985.

Course Code : PCC504	**Category :** Professional Core Courses
Course Title : Operations Research	**Semester** : Fifth

L-T-P : 3-0-0	**Credit:**3

Introduction – 2L

Definition and scope of OR; techniques and tools; model formulation; general methods for solution; classification of optimization problems; optimization techniques.

Linear optimization models – 12L

Complex and revised simplex algorithms; duality theorems; sensitivity analysis; assignment, transportation and transshipment models; travelling salesman problem as an assignment problem; integer and parametric programming; goal programming.

Game problems – 6L

Minimax criterion and optimal strategy; two person zero sum game; games by simplex dominance rules.

Waiting line problems – 8L

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.

Dynamic programming – 6L

Characteristic of dynamic programming problems (DPPs); Bellman's principle of optimality; problems with finite number of stages; use of simplex algorithm for solving DPPs.

Non- linear programming – 8L

One dimensional minimization methods; unconstrained optimization techniques; optimization techniques- characteristics of a constrained problem; indirect methods; search and gradient methods.

Learning Resources:

1. Taha H. A., “An Introduction to Operations Research”, 6th Edition, Prentice hall of 2001 India;.
2. Hillier F. J. and Lieberman G.J., “Introduction to Operations Research”, 7th 2001 3 0 4 25 0 25 50 0 Edition Holden Day Inc.
3. Loomba N.P., “Linear Programming”, 2nd Edition, Mcmillan Publishing Inc. New 1976 York.
4. Wagner H. M., “Principles of OR with Applications to Managerial Decisions”, 2nd 1975 Edition, Prentice Hall.
5. Giffin, Walter G., “Queueing Basic Theory and Applications”, Grid Inc., Ohio. 1978

Course Code : PCC505	**Category :** Professional Core Courses
Course Title : Ergonomics and Work Design	**Semester** : Fifth
L-T-P : 3-0-0	**Credit:**3

Productivity – 6L

Concept, objectives, Factors affecting productivity, Productivity measurement, causes of low productivity, Tools and techniques to improve productivity, work study and productivity

Work Study – 4L

Purpose, scope and developments, human aspects, techniques of work study and their scope

Method Study – 10L

Objectives and scope, recording techniques: operation process charts, flow process charts, two hand process chart, activity chart, other charts, their analysis, flow diagram, string diagram, critical examination techniques, development, installation and maintenance of improved methods, Principles of motion economy, Micro Motion study, Therbligs, motion analysis, preparations of motion film and its analysis, SIMO charts, memo-motion study, cyclegraph and chronocyclegraph

Time Study – 10L

Scope and objectives, concepts of measurement of work in units of time, Techniques of work measurement, stop watch time study, allowances and calculation of standard time, standard time and its applications, Work sampling and introduction to Predetermined motion time systems

Ergonomics – 6L

Introduction to industrial ergonomics, constituents areas of ergonomics, man-machine system, anthropometry and ergonomics, metabolism and organization of work, ergonomic aspects in design of controls and displays and their layout, light and vibration consideration in ergonomically designed system, working conditions and environment, ergonomics and safety

Ergonomic Design – 6L

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

Learning Resources:

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
6. Dul, J. and Weerdmeester, B. Ergonomics for beginners, a quick reference guide, Taylor & Francis 1993
7. Green, W.S. and Jordan, P .W, Human Factors in Product Design, Taylor & Francis 1999

Course Code : PEC511	**Category :** Professional Elective Courses
Course Title : Plasticity and Deformation	**Semester** : Fifth
L-T-P : 3-0-0	**Credit:**3

Fundamental of classical plasticity – 7L

Concept of stress and strain components, Mohr stress circles for two- and three-dimensional stress system, strain rate and strain rate tensors, yield criteria, yield locus and physical concepts of Tresca, Mises and twin shear stress yield criteria, effective stress and effective strain.

Mechanical properties under uniaxial tension and non-uniaxial loading – 7L

Yield criteria of different material, anisotropic material – 7L

Plastic constitutive relations of materials, flow rules – 7L

Stress and strain analysis of plane-stress metal forming processes such as tube drawing, deep drawing, tube hydroforming – 7L

Stress and strain analysis for bulk forming and sheet forming – 7L

Course Code : PEC512	**Category :** Professional Elective Courses
Course Title : Severe Plastic Deformation	**Semester** : Fifth
L-T-P : 3-0-0	**Credit:**3

Fundamentals of Severe Plastic Deformation and its industrial application, Difference between severe plastic deformation and conventional metal forming processes.

Grain refinement mechanism.

Different types of Severe Plastic Deformation process for bulk and sheet samples.

Different parameters of Severe Plastic Deformation.

Mechanical properties of ultrafine-grained and nano-structured metals.

Physical, Chemical and functional properties of ultrafine-grained and nano-structured metals.

Course Code : PEC513	**Category :** Professional Elective Courses
Course Title : Sheet Metal Forming	**Semester** : Fifth
L-T-P : 3-0-0	**Credit:**3

Metal forming process in manufacturing, Classification and description of sheet metal forming operation, Plastic deformation, strain and strain rate, flow stress, Anisotropy, Formability and Forming limit curves.

Yield criteria, flow rule and hardening rules. Materials for sheet forming.

Friction and lubrication in sheet forming.

Deep drawing of round and rectangular cups.

Sheet forming presses, mechanical presses, electromechanical servo-drive presses, hydraulic presses, cushion system for sheet metal forming.

Course Code : PEC514	**Category :** Professional Elective Courses
Course Title : Near Net Shape Processes	**Semester** : Fifth
L-T-P : 3-0-0	**Credit:**3

Concept of Shape, size, accuracy, tolerances and surface roughness. Economical and technological factors; improved material and energy efficiency, dimensional accuracy, product integrity and

reduced manufacturing cost through near net processing . Foundry processes ; Shell process, investment casting, ceramic moulding , plaster mould process, V-process, squeeze casting, rheo-casting, permanent mould casting, low pressure die casting and pressure die casting processes.

Precision Forging process like flashless forging, powder forging, Isothermal and hot die forging. Semi solid forging, Orbital forging, , liquid forging, cross wedge rolling, Superplastic forging, long forging machine, HERF, HIP, Electrical upsetters, Multi axial forging. Incremental Forging.

Electro forming; principles of electro deposition, production of dies and moulds by electro-forming

Course Code : PEC515	**Category :** Professional Elective Courses
Course Title : Rolling , Extrusion and other Hot Working Process	**Semester** : Fifth
L-T-P : 3-0-0	**Credit:**3

Classification of various metal working process, Cold and hot working of metal, Heating for working, Cooling after working, General concept of rolling, Theory of rolling, Fundamental of roll pass design.

Types of rolling process and their application. Rolling mills, Defects in rolling.

Extrusion: Classification of extrusion process, Equipment, Lubrication, Hot and cold extrusion, Defects in extrusion, Analysis of extrusion process, Extrusion press.

Rod and wire drawing, Tube drawing.

Use of FEM in above metal forming process, Tribology in metal forming process

Course Code : HEC516	**Category :** Honours Elective Courses
Course Title : Technology of Ferrous Forging	**Semester** : Fifth
L-T-P : 3-0-0	**Credit:**3

Forging – 14L

Introduction of forging, Classification of forging process, Application of forging, Technology of open die forging, application of forging, allowances and tolerances for free forging with respect to Indian and foreign standards, developing forging drawing and process chart for manufacturing of typical components such as straight, stepped, hollow shaft, rings and discs etc. Methods of blank preparation, Acceptance criteria for bars and billets in forging industry, Advanced technology for production of large forging ingots.

Technology of closed die forging – 8L

Factors affecting metal flow in the dies, Forgeability, Friction and lubrication, die temperature, size and shape factors etc.

Die material – 6L

Die failure analysis and methods for improving die life.

Forging of metals – 10L

Forging practice and forging behavior of ferrous alloys like carbon and low alloy steel, stainless steel, tool steel. Heat treatment of above alloys.

Forging defects – 4L

Forging defects and their remedial measures, Problems of gases, Overheating and burning of steels.

Course Code : PCC517	**Category :** Professional Core Courses
Course Title : Manufacturing Science and Technology–II Lab	**Semester** : Fifth
L-T-P : 0-0-2	**Credit:**1

1. Preparation of a SINGLE POINT CUTTING TOOL as per the given tool specification. Also write the process sheet for the same.
2. To make a job as per drawing on the CAPSTAN LATHE. Write the process sheet and draw the sketches of the machine tool and tools used.
3. To make a job as per drawing using RADIAL DRILLING MACHINE. Write the process sheet and draw the sketches of the machine tool and tools used.
4. Study of Indexing Mechanism for Gear Cutting and to cut gear on a gear blank using Indexing Mechanism on HORIZONTAL MILLING MACHINE. Write the process sheet and draw the sketches of the machine tool and tools used.
5. To make a slot as per drawing using VERTICAL MILLING MACHINE. Write the process sheet and draw the sketches of the machine tool and tools used.
6. To make a job as per drawing using CYLINDRICAL GRINDING MACHINE. Write the process sheet and draw the Sketches of the machine tool and tools used.
7. To make a job as per drawing using SURFACE GRINDING MACHINE. Write the process sheet and draw the Sketches of the machine tool and tools used.
8. Study of SHAPER, PLANER and SLOTTER
9. Study of MIG WELDING MACHINE and preparation of T-joint. Study the welding defects induced. Also draw the sketches of the tools used.
10. Demonstration and study about CUTTING, DRILLING AND WELDING operation on LASER BEAM MACHINE
11. Study of ELECTRICAL DISCHARGE MACHINE

Course Code : PCC518	**Category :** Professional Core Courses
Course Title : Kinetics and Dynamics of Machine Lab	**Semester** : Fifth
L-T-P : 0-0-2	**Credit:**1

1. Determination of velocity ratios of simple, compound, epicyclic and differential gear trains
2. Studying kinematics of four bar, slider crank, crank rocker, double crank, double rocker and oscillating cylinder mechanisms

3. Studying kinematics of typical mechanisms like pantograph, some straight line motion mechanisms, wiper, drafter, etc.
4. Motion studies of different cams & followers
5. Single degree of freedom Spring-mass-damper system: determination of natural frequency and damping coefficient
6. Determination of torsional natural frequency of single and double rotor systemsundamped and damped natural frequencies
7. Studying machine vibration using sensor
8. Solving simple balancing problems experimentally

Course Code : PCC519	**Category :** Professional Core Courses
Course Title : Thermal and Heat Transfer Laboratory	**Semester** : Fifth
L-T-P : 0-0-2	**Credit:**1

1. Determination of the calorific value of a given fuel and its flash & fire points
2. Determination of the p-V diagram and the performance of a 4-stroke dieselengine
3. Determination of the performance characteristics of a vapourcompressionsystem
4. Study of the heat transfer in pin fin apparatus
5. Study of the heat transfer in natural convection apparatus
6. Study of the heat transfer in the forced convection apparatus
7. Study of the StefenBoltzman apparatus and estimation of StefenBoltzman's constant
8. Study of the heat transfer in drop-wise and film wise condensation.
9. To estimate the thermal conductivity of metal bar
10. Study of the heat transfer through composite wall
11. Study of heat transfer behaviour in Heat pipe apparatus
12. Study of the emmisivity measurement apparatus
13. To estimate the thermal conductivity of insulating powder
14. To study the Heat transfer in lagged pipe apparatus
15. To estimate effectiveness in Shell-and-Tube Heat Exchanger
16. To estimate effectiveness in double pipe heat exchangers

Course Code : HEC520	**Category :** Honours Elective course
Course Title : Technology of Ferrous Forging Lab	**Semester** : Fifth
L-T-P : 0-0-2	**Credit:**1

1. Layout of forging laboratory
2. To study initial mechanical properties and microstructure of given steel
3. To study mechanical properties and microstructure of given steel after open die forging at different strain levels at room temperature
4. To study mechanical properties and microstructure of stainless steel after hot die forging at different strain levels
5. To study dependency of different forging equipment on characteristics of given steel after forging
6. To study dependency of heat treatment on characteristics of given steel after forging

Course Code : SI 591	**Category :**
Course Title : IVth Industrial Internship	**Semester** : Fifth
L-T-P : 0-0-2	**Credit:**1

Semester-VI

Course Code : PCC601	**Category :** Professional Core Courses
Course Title : Machine Design	**Semester** : Sixth
L-T-P : 3-0-0	**Credit:**3

General Introduction and Selection of Materials – 3L

Definition, Methods, Standards in Design and Selection of Preferred Size, BIS system of Designation of Steels, Steels and Alloys, Plastics and Rubbers.

Design against Static and Fluctuating Load – 4L

Concept of Three Dimensional State of Stress and Strain, Stress-Strain Relationship, Principle Stresses, Stress Concentration, Stress Concentration Factor and Notch Sensitivity Factor, Factor of Safety, Theories of Failure, Fluctuating Stress, Fatigue Failure, Endurance Limit, Design for Finite and Infinite Life, Soderberg and Goodman Criteria.

Shafts, keys and coupling – 4L

Design of Shafts against Static and Fluctuating Load, Strength and Rigidity Design, Design of Square and Flat Keys and Splines, Rigid and Flexible Couplings. 5(L)

Power Screws and Joints – 6L

Form of Threads, Square Threads, Trapezoidal Threads, Stresses in Screw, Design of Screw Jack, Screwed Joints, Riveted Joints, Welded Joint and Eccentric Loading of above Joints, Design for Fatigue Loading. 9(L)

Mechanical Springs – 5L

Helical Springs, Stress Equations, Deflection Equation, Design against Static and Fatigue Loading, Multi Leaf Springs, Spiral Springs.

Belts, Brakes and Clutches – 5L

Flat Belts, V Belts, Static Analysis of Brakes and Clutches, Internal Expanding and External Contracting Rim Brakes and Clutches, Band type Brakes and Clutches, Frictional contact Axial Clutches, Disc Brakes, Cone Clutches and Brakes

Helical Gears – 5L

Kinematics, geometry and nomenclature, force analysis, Design of helical gears: bending stress, contact stress, Crossed helical gears Worm Gears: Geometry and nomenclature, Force analysis, Friction analysis and efficiency, thermal capacity, bending and surface strength, power rating efficiency, worm gear standards and proportions.

Bevel Gears – 5L

Introduction, Geometry and terminology, Force analysis, Bending stress analysis, Contact stress analysis, Permissible bending fatigue stress, Permissible contact fatigue stress Spiral bevel gears, hypoid gears.

Antifriction bearing – 5L

Types of ball bearings, roller bearings, needle bearings, friction life of bearings, reliability considerations, selection of ball bearings, roller bearing, tapered roller bearing, thrust bearing, lubrication and sealing, Mounting of bearings.

Lubrication and sliding bearings – 5L

Type of lubrication, viscosity, hydrodynamic theory of lubrication, types of bearing, design of bearing using design charts, boundary lubrication, hydrostatic bearing, hydrodynamic thrust bearings.

Learning Resources:

1. Joseph E. Shigley, "Mechanical Engineering Design", Mc-Graw Hill Publications.
2. Richard M. Phelan, "Fundamentals of machine design" Tata Mc-graw Hill pub.
3. Robert L. Norton, "Machine Design: An Integrated approach" Prentice Hall
4. Robert C Juvinall and Kurt M. Marshek, " Fundamentals of Machine Component Design, Wiley-India
5. Nam P. Suh, "Principles of Design", Oxford University Press, 1990.
6. V. B. Bhandari, "Design of Machine Elements" 3rd Ed., Tata Mc-Graw Hill

Course Code : PCC602	**Category :** Professional Core Courses
Course Title : Production and Operations Management	**Semester** : Sixth
L-T-P : 3-0-0	**Credit:**3

Introduction – 3L

Types and characteristics of manufacturing systems, concept of manufacturing cell, system planning and design.

Operations Scheduling – 8L

Concepts, loading, scheduling and sequencing, single processor scheduling, flow shop scheduling, jobshop scheduling, scheduling criteria; Gantt charts.

Project Management – 5L

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.

Materials Planning and Control – 10L

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.

Zero Inventory Systems – 5L

Introduction to the new manufacturing concepts; JIT, lean manufacturing and agile manufacturing, pull and push systems of production; Kanban system.

Capacity Planning – 7L

Definition of capacity, capacity planning, capacity requirement planning, capacity available and required, scheduling order.

Supply Chain Management – 4L

Introduction – understanding supply chain, supply chain performance, supply chain drivers and obstacles, 4 planning demand and supply in a supply chain.

Learning Resources:

1. Russell, R.S., and Taylor, B.W., 'Operations Management", Pearson Education 2003
2. Jocobs, C.A., "Production and Operations Management", Tata McGraw Hill 1999
3. Ramamurthy, P. "Production and Operations Management", New Age International 2002
4. Adam Jr., E.E., and Ebert, R.J., "Production and Operations Management Concept, Models, and Behaviour", 5th 2001 Ed., Prentice Hall of India
5. Buffa, E.S., and Sarin, R.K., "Modern Production / Operations Management", John Willey & Sons 1994

Course Code : PCC603	**Category :** Professional Core Courses
Course Title : Product Design and Value Engineering	**Semester** : Sixth
L-T-P : 3-0-0	**Credit:**3

Product Design

Traditional and modern design processes; Organization objectives; Innovation, creation, and diffusion techniques; Evaluation of new product ideas – functional, technological, ecological, legal. **6L**

Product Modeling and Reverse Engineering

Wireframe modeling; Surface modeling – boundary representation; Solid modeling – CSG; Concept of reverse engineering. Product Data Exchange **–** Neutral file formats for product data exchange–DXF, IGES, STEP. **10L**

Introduction to Value engineering concepts: advantages, applications in product development, process improvement, service improvement and system design, problem recognition, role in productivity **5L**

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. **8L**

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. **10L**

Implementation: Action plan, record progress, report progress, review meetings, problems in implementation, human factors. **3L**

Learning Resources:

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”, 3rd Ed., Industrial Press, 2006
6. Boothroyd G., Dewhurst P., and Knight, “Product Design for Manufacture and Assembly”, 2nd Ed., Marcel Dekker., 2002
7. Chua, C. K and. Leong, K. F., “Rapid Prototyping: Principles and Applications in Manufacturing”, John Wiley & Sons, 1997

Course Code : PEC611	**Category :** Professional Core Courses
Course Title : Simulation in Casting and Forging	**Semester** : Sixth
L-T-P : 3-0-0	**Credit:**3

Length and time scales in computational modeling of materials; review of thermodynamic models, conservation and continuity equations, constitutive laws in materials engineering; introduction to computational linear algebra - linear and nonlinear system of equations, interpolation and curve fitting, numerical differentiation and integration, basic numerical optimization - applications in thermodynamics, ordinary and partial differential equations – initial and boundary value problems, numerical methods – finite difference, finite volume, and finite element methods; random numbers and random walk models, Monte Carlo simulations of phase transformations in model binary alloys, concepts of potentials and Molecular Dynamics simulations, mesoscale models, introduction to ICME concepts and tools

Development of numerical routines to solve problems involving heat transfer, fluid flow, solidification, diffusion, phase change, on MATLAB and open-source tools. Simulation of fluid Flow, heat transfer, solidification, deformation, solid flow under applied forces. Understanding the application of appropriate commercial softwares like Pro Cast, Magma Soft, Deform, Simufact etc.

Reference:

1. “Applied Numerical Analysis (7th edition)”, Curtis F Gerald and Patrick O. Wheatley, Pearson Education India
2. “Mathematical Methods for Physics and Engineering (3rd edition)”, K. F. Riley, M. P. Hobson, S. J. Bence, Cambridge University Press
3. Richard LeSar, “Introduction to Computational Materials Science: Fundamentals to Applications”, Cambridge University Press, 2013

Course Code : PEC612	**Category :** Professional Elective Courses
Course Title : Smart Manufacturing	**Semester** : Fourth
L-T-P : 3-0-0	**Credit:**3

Introduction to smart manufacturing; Definition, History/Backgrounnd, Key Components for Smart Manufacturing; Journey from Industry 1.0 to 4.0; Cyber Security in Smart Manufacturing, Computer Integrated Manufacturing: CAD, CAPP, CAM, ASRS (Automated storage and retrieval system), Computer Aided Quality Control, Introduction to robotics, Robot applications in Manufacturing industry.

Smart Manufacturing Enabling Technologies: Artificial Intelligence/ Machine Learning, Drones and driverless vehicales, Big Data, Clod Computing, Additive Manufacturing, Advanced Robot, Augmented and Virtial reality (AR/VR), Blockchain, Industrial Internet of Things (IIoT), Edge Computing, Predictive Analytics, Digital Twin, Agile Manufacturing, Mass Customization

Application of Smart Manufacturing Technologies in Foundry and Forge Industry. SMART devices and product, Smart logistics, Smart Cities, Robust Optimization for Smart Manufacturing Planning and Supply Chain Design, Case studies related to incremental Sheet Forming, Green Sand Molding and Defect Predictions.

Holistic view of AI capabilities and its impact on society, Introduction to Data Science tool: Python, Excel, R, Tableau, Minitab etc

Reference Books:

1. Luo, Zongwei, ed. Smart Manufacturing Innovation and Transformation: Interconnection and Intelligence: Interconnection and Intelligence. IGI Global, 2014.
2. Moon, Ilkyeong, et al., eds. Advances in Production Management Systems. Smart Manufacturing for Industry 4.0: Springer, 2018.

Course Code : PEC613	**Category :** Professional Core Courses
Course Title : Finite Element Analysis	**Semester** : Sixth
L-T-P : 3-0-0	**Credit:**3

Introduction:
Underlying principles of the finite element analysis; application examples and versatility; basic steps in FEA.

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.

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.

Trusses:
Plane truss, local and global coordinate systems; stress calculations; temperature effect on truss members; solution of practical problems.

Beams:
Euler-Bernoulli beam element

Two Dimensional Problems:
Plane stress and plane strain formulation; triangular and rectangular elements; isoperimetric formulation; axisymmetric problems; computer implementation; steady-state heat conduction

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.

Computer Implementation of Finite Element Analyses:

Introduction to commercial packages and their capabilities; demonstration of the modeling and solution process for representative cases.

Learning Resources:

1. Cook, R.D., Malkus, D.S., and Plesha, M.E., "Concepts and Applications of Finite Element Analysis", 3nd Ed., John Wiley & Sons., 1989
2. Bathe, K.J., "Finite Element Procedures", 2nd Ed., Prentice Hall. , 1996
3. Seshu, P., "Textbook of Finite Element Analysis", 1st Ed., Prentice Hall of India Pvt. Ltd. , 2003
4. Reddy, J.N., "An Introduction to the Finite Element Analysis", 3rd Ed., McGraw-Hill Education (ISE Editions)., 2005
5. Zienkiewicz, O.C., and Taylor, R.L., "The Finite Element Method for Solid and Structural Mechanics", 6th Ed., Elsevier Ltd. , 2006
6. Logan, D.L., "A First Course in the Finite Element Method", 4th Ed., Thomson Canada Ltd., 2007

Course Code : PEC614	**Category :** Professional Core Courses
Course Title : Computational Fluid Dynamics	**Semester** : Sixth
L-T-P : 3-0-0	**Credit:**3

Basic equations of Fluid Dynamics - 10

General form of a conservation law; Equation of mass conservation; Conservation law of momentum; Conservation equation of energy. The dynamic levels of approximation. Mathematical nature of PDEs and flow equations.

Basic Discretization techniques - 12

Finite Difference Method (FDM); Analysis and Application of Numerical Schemes: Consistency; Stability; Convergence; Fourier or von Neumann stability analysis; Modified equation; Application of FDM to wave, Heat, Laplace and Burgers equations.

Integration methods for systems of ODEs – 10

Linear multi-step methods; Predictor-corrector schemes; ADI methods; The Runge-Kutta schemes. Vorticity-stream function formulation. Solution of Navier-Stokes equations using MAC algorithm. The Finite Volume Method (FVM) and conservative discretization.

Numerical solution of the incompressible Navier-Stokes equations – 10

Primitive variable formulation; Pressure correction techniques like SIMPLE, SIMPLER and SIMPLEC; Brief introduction to compressible flows and numerical schemes – quick idea of Euler equations, homogenity and flux jacobian. Introduction to upwind schemes.

Learning Resources:

1. J. C. Tannehill, D. A. Anderson, and R. H. Pletcher, Computational Fluid Mechanics and Heat Transfer, CRC Press, 2012.
2. J. D. Anderson Jr., Computational Fluid Dynamics, McGraw-Hill International Edition, 2017.

3. S.V. Patankar, Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation, 2017.
4. J. H. Ferziger, and M. Peric, Computational Methods for Fluid Dynamics, Springer, 2001.
5. T. J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2010.
6. C. A. J. Fletcher, Computational Techniques for Fluid Dynamics, Vol. 1 and 2, Springer, 1998.
7. H. K. Versteeg and W. Malalasekera, An introduction to computational fluid dynamics: The finite volume method 3e, Pearson Education, 2007.
8. C. Hirsch, Numerical Computation of Internal and External Flows, Vol.1 and 2, John Wiley & Sons, 200

Course Code : PEC615	**Category :** Professional Core Courses
Course Title: Product and Process Optimization	**Semester** : Sixth
L-T-P : 3-0-0	**Credit:**3

Objective: This course will introduce to the students, the basic concepts, techniques and applications of engineering optimization in a comprehensive manner.

Details of Course:

1. Introduction to Design Optimization: The design process; basic terminology and notations. 2L

2. Optimum Design Problem Formulation: The problem formulation process; and illustration with examples. 3L

3. Graphical Optimization: Graphical solution process; problems with – bounded (single or multiple) and unbounded solutions. 3L

4. Optimum Design Concepts: Local and global optima; necessary and sufficient optimality conditions for unconstrained and constrained multivariate functions. 6L

5. Linear Programming Methods for Optimum Design: Basic concepts; simplex method; two-phase simplex method; post-optimality analysis. 4L

6. Numerical methods for Unconstrained and Constrained Optimum Design: Gradient-based and direct search methods; Sequential linear and quadratic programming. 6L

7. Multi-objective Optimization: Fundamental shift from single-objective optimization; Pareto-set and Pareto-optimal Front. 4L

8. Evolutionary Techniques for Optimization: Genetic algorithms; Differential Evolution Algorithms; Ant colony Optimization; and Particle Swarm Optimization. 6L

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. 4L

10. Practical applications of optimization: Illustration on engineering problems with single and multiple objectives. 4L Total 42L

Suggested Books:

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

Course Code : PEC616	**Category :** Professional Core Courses
Course Title : Reverse Engineering and Remanufacturing	**Semester** : Sixth
L-T-P : 3-0-0	**Credit:**3

Objective: To teach students various tools and techniques used for the reverse engineering processes and applications.

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

Suggested Books:

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

Course Code : PEC617	**Category :** Professional Core Courses
Course Title : Total Quality Management	**Semester** : Sixth
L-T-P : 3-0-0	**Credit:**3

Objective: To facilitate the understanding of total quality management principles and processes.

Contents: Module-I Introduction, evolution of quality control; Definitions of quality, Quality and productivity; Basic concepts of TQM, TQM framework, contributions of Deming, Juran and Crosby.; Quality conformance, customer need, customer orientation & satisfaction, customer complaints; Quality cost, product & service costing, measuring quality cost (8 Hrs).

Module-II TQM principles; leadership, strategic quality planning; Quality councils-employee involvement, motivation; Empowerment;6 Hrs.

Module-III Team and Teamwork; Quality circles, recognition and reward, performance appraisal; Continuous process improvement; PDCA cycle, 5S, Kaizen; Supplier partnership, Partnering, Supplier rating & selection. 8 Hrs.

Module-IV The seven traditional tools of quality management; New management tools; Six sigma concepts, methodology, applications to manufacturing, Bench marking process, evaluation; FMEA-stages, types. 6 Hrs.

Module-V TQM tools and techniques, control charts, process capability, concepts of six sigma, Quality Function Development (QFD), Taguchi quality loss function; TPM- concepts, improvement needs, performance measures.8 Hrs.

Module-VI Quality systems, need for ISO 9000, ISO 9001-9008; Quality system- elements, documentation; Quality auditing, QS 9000, ISO 14000-concepts, requirements and benefits; TQM implementation in manufacturing and service sectors.6 Hrs.

Course Outcomes: At the end of course, the students will be able to 1. Understand the importance of quality and its assurance. 2.Analyze quality statements, customer focus and market plan. 3.Evaluate quality-based products & methods. 4.Develop tools, methodology for the assurance of quality. 5.Apply & use the tools and techniques of TQM in manufacturing and service sector.

Textbooks: 1. Besterfield D.H. et al., Total Quality Management, 3rd ed., Pearson Education Asia, 2006. 2. Evans J.R. and Lindsay W.M., The management and Control of Quality, 8th ed., first Indian edition, Cengage Learning, 2012.

3. Janaki raman B. and Gopal R.K., Total Quality Management, Prentice Hall India, 2006.

4. Suganthi L. and Samuel A., Total Quality Management, Prentice Hall India, 2006.

Course Code : PEC618	**Category :** Professional Core Courses
Course Title : Supply Chain Management	**Semester** : Sixth
L-T-P : 3-0-0	**Credit:**3

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.

Details of Course:

1 Introduction: Understanding supply chain, supply chain performance; supply chain drivers and obstacles. (4 Hrs)

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 Hrs)

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 Hrs)

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 Hrs)

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 Hrs) Total 42 (Hrs)

Suggested Books:

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

Course Code : PEC619	**Category :** Professional Core Courses
Course Title : Engineering Economics	**Semester** : Sixth
L-T-P : 3-0-0	**Credit:**3

COURSE OUTLINE: The basic purpose of this course is to provide a sound understanding of concepts and principles of engineering economy and to develop proficiency with methods for making rational decisions regarding problems likely to be encountered in professional practice.

Module -1 Introduction: Nature and purpose of engineering economy studies, functions of engineering economy, physical and economic laws, consumer and producer goods. (3 Hrs).

Module -II 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 Hrs)

Module III Industrial Costing and Cost analysis: Classification of costs: direct material, direct labour and overheads, fixed and variable cost, semifixed 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 Hrs)

Module -IV Replacement Studies: Reason of replacement, evaluation of proposals, replacement because of inadequacy, excessive maintenance, declining efficiency, obsolescence; MAPI formula. (7 Hrs)

Module -V 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, 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. (10 Hrs)

Module -VI Economy Study Patterns: Basic economy study patterns and their comparison, effect of taxation on economic studies. (4 Hrs)

RECOMMENDED BOOKS:-

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”, 8th 2001 Ed., John Wiley & Sons Inc

3. Eschenbach , T.G., “Engineering Economy by Applying Theory to Practice (Engineering Technology)”, 2nd 2003 Ed., Oxford University Press, USA

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

Course Code : HEC 621	**Category :** Professional Core Courses
Course Title : Technology of Non-Ferrous Casting	**Semester** : Sixth
L-T-P : 3-0-0	**Credit:**3

Non-ferrous alloys based on Al, Cu, Zn, Mg, Tiand Ni. their properties and applications, classification of alloys, solidification and microstructure of important non ferrous alloys.

Melting, fluxing, degassing and pouring practices, electro slag remelting(ESR)and central zone refining(CZR). Filtration of non- ferrous melts. Melt treatment: modification and grain refinement.

Charge calculation, Oxidation and gas absorption in metals and alloys, detection of gases.

Moulding and core making practices, metal-mould reaction, gating and feeding practices. Defect analysis, salvaging of castings, heat treatment.

Different casting techniques of Al, Cu, Mg, Ti, Ni, Zr and other precious metals like Au, Ag and Pt, effect of **a**ddition of alloying element,Casting defects.

Learning Resources:

1. Foundry Technology by P.L. Jain
2. ASM Handbook Volume 15: Casting, ISBN: 978-0-87170-711-6
3. Principles of Metal Casting by Richard Heine, Carl Loper, Philip Rosenthal
4. Metal Casting Principles and Techniques by Lerner Yury, Posinasetti Nageswara
5. FOSECO Non-Ferrous Foundryman's Handbook, John R. Brown

Course Code : OCE 617	**Category :** Open Elective Courses
Course Title : Physical Metallurgy for Casting and Forging Processes	**Semester** : Sixth
L-T-P : 3-0-0	**Credit:**3

Crystal structure and bonding characteristics of metals, alloys, structure of surfaces and interfaces, nano-crystalline and amorphous structures; imperfection in crystal, solid solutions; Theory of solidification: Nucleation and growth, mechanism of nucleation and driving force for growth. Morphology, Zone refining, crystal growth, spinodal decomposition. Mechanism and kinetics of precipitation of age hardenable alloys. solidification; phase transformation and binary phase diagrams; Solidification of metals & alloys, Casting grain structure; Ingot structure dendritic and cellular dendritic growth, multiphase microstructures. Micro & Macro segregation, Micro & Macro porosity and residual stresses in casting.

Elastic and plastic deformation (atomistic mechanisms), modulus, slip in perfect crystal, CRSS, Dislocations and their role in plastic deformation, twinning, deformation in single crystals. Hot and cold working of metals & alloys, recovery, recrystallisation and grain growth. principles of heat treatment of steels, cast iron and aluminum alloys; surface treatments; industrially important ferrous and non-ferrous alloys.

Metallography: Metallurgical microscope, Specimen preparation, Techniques for microscopic observation. High temperature microscopy, Quantitative metallography.

X- Ray crystallography; principles of scanning and transmission electron microscopy.

Reference:

1. Reed-Hill, R. E. (1972). Physical Metallurgy Principles, John Wiley & Sons, Incorporated.
2. Avner, S. H. (1974). Introduction to Physical Metallurgy, McGraw-Hill.
3. Raghavan, V. (2006). Physical Metallurgy: Principles and Practice, PHI Learning.
4. Haasen, P. and B. L. Mordike (1996). Physical Metallurgy, Cambridge University Press.
5. Mechanical Metallurgy, George E. Dieter, 3rd edition, McGraw-Hill,
6. Mechanical Behavior of Materials, Thomas H. Courtney, MeGraw-Hill. 1990
7. Mechanical Metallurgy, Principles and Applications, Marc Andre Meyers and Krishan Kumar Chawla.

Course Code : OCE 618	**Category :** Open Elective Courses
Course Title : Industrial Psychology	**Semester** : Sixth
L-T-P : 3-0-0	**Credit:**3

Scope of scientific Psychology and Industrial Psychology.
Basic process: Perception.
Training and learning: Human variables, selection and placement: Intelligence, MA & IQ measurement.
Personality: Development, approaches, assessment and tests.
Selection and placement: Job analysis, interviewing, psychological tests, decision making process.
Motivation and work: Needs, hierarchy of needs, leadership supervision.
Ergonomics: Three processes
Work space and Human Factors in job design: Working environment, noise, atmospheric conditions and illumination.

Course Code : OCE 619	**Category :** Open Elective Courses
Course Title : Environmental Pollution Control in Industries	**Semester** : Sixth
L-T-P : 3-0-0	**Credit:**3

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.

Details of Course:

Module-1 Concept and scope of Environment science, components of environment, environmental segment and their importance. (2 Hrs)

Module-II Ecology: Ecosystem and its characteristics features, structure and function of forest ecosystem, grassland ecosystem, desert ecosystem and aquatic ecosystem, ecological balance and consequences of imbalance. (4 Hrs)

Module-III Atmosphere: Atmospheric composition, energy balance, climate, weather, depletion of ozone layer, greenhouse effect, acid rain, particles, ions and radicals in the atmosphere, chemical and photochemical reactions in the atmosphere.

Module-IV Air pollution and control: Air pollutants, sources and effect of air pollutants, primary and secondary pollutants, photochemical smog, fly ash, inorganic and organic particulate matter. Air quality standards, sampling, monitoring and control measures for pollutants. (4 Hrs) Module-V Water pollution and control: Aquatic environment, water-pollution, sources and their effect, lake and ground water-pollution, eutrophication, water quality standard and water pollution control measures, wastewater treatment.

Module-VI (4 Hrs) Land pollution; Lithosphere, composition of soil, acid base and ion exchange reactions in soil, soil erosion, landslides, desertification, pollutants (municipal, industrial, commercial, agricultural, hazardous solid wastes), origin and effects, collection and disposal of solid wastes, recovery and conversion methods.

Module-VII Noise pollution; Noise classification and its sources, effects and measurement, noise pollution hazards, standards and noise pollution control. (2 Hrs)

Books and References:

1. Master, G.M Introduction to environment engineering and science, Pearson Education.

2. Nebel, B.J., Environment science, Prentice Hall Inc.

3. Odum, E.P. Ecology: The link between the natural and social sciences. IBH Publishing Company Delhi

4. De, A.K. Environmental Chemistry, Merrut.

5. Sharma B.K Envrionmental Chemistry, Krishna Prakashan Media Merrut.

6. Kaushik, A and Kaushik, C.P. Perspectives in Environmental studies, New Age International Publication.

7. Menon, S.E. Environmental Chemistry.

8. Air Pollution: Its Origin and Control; Kenneth Wark, Cecil F. Warner, Wayne T. Davis; Prentice Hall(3rd ISBN-13: 978-0673994165 Edn.) ; ISBN-10: 0673994163 , 1997

9. Internal Combustion Engine Fundamentals; John Benjamin Heywood; McGraw Hill; ISBN-10: 0071004998, ISBN-13: 978-0071004992 1989

10. Energy and the Environment; Robert A. Ristinen, Jack P. Kraushaar; Wiley; (2nd 2005 Edn.); ISBN-10: 0471739898, ISBN-13: 978-0471739890

11. Air Pollution Control Engineering; Norman C. Pereira, Norman C. Pereira, Wei Yin Chen (Editors); Springer-Verlag; ISBN: 1588291618, ISBN-13: 9781588291615 200

Course Code : OCE 620	**Category :** Open Elective Courses
Course Title : Management Concepts and Techniques	**Semester** : Sixth
L-T-P : 3-0-0	**Credit:**3

Objectives: • To understand the principles of Management and their application to the functioning of organization

Details of Course:

Module- I Definition of management, science or art, manager vs. entrepreneur; Types of managers managerial roles and skills; Evolution of management-scientific human relations, system and contingency approaches. (6 hrs)

Module- II Types of Business organizations, sole proprietorship, partnership, company, public and private enterprises; Organization culture and environment; current trends and issues in management, Nature and purpose of planning, types of planning, objectives, policies , Strategic Management, planning Tools and Techniques, Decision making steps & processes. (8 hrs)

Module- III Nature and purpose of Organizing, formal and informal organization, organization structure,types, line and staff authority, departmentalization, delegation of authority, centralization and decentralization. Job design, human resource management, HR planning, Recruitment selection,Training & Development, Performance Management, carrier planning and Management. (8 hrs)

Module- IV Directing, individual and group behavior, motivation, motivation theories, motivational techniques, Job satisfaction, job enrichment, leadership, types and theories of leadership, effective communication. (6 hrs)

Module- V Production planning and control: Forecasting models, aggregate production, and planning, scheduling, materials requirement planning; Controlling, system and process of controlling, budgetary and non-budgetary control techniques (8 hrs)

Module- VI Inventory Control: Deterministic models, safety stock inventory control system Use of computers and IT in management control, productivity problems and management, control and performance, direct and preventive control, reporting. (6 hrs)

Course Outcomes: Upon completion of this course, the students will 1. Get a clear understanding of management functions in an organization 2. Develop leadership quality to guide their work force to get done assigned jobs in time. 3. Maintain correct stock of spares and material for sustained production 4. Maintaining and hiring human resources of required skill and experience in time 5. Preparation of master budget and other budget to arrange required funds to carry out planned activities of organization

Textbooks:

1. Robbins S.P. and Couiter M, Management, Prentice Hall India, 10th ed., 2009

2. Stoner JAF, Freeman RE and Gilbert DR, Management, 6th ed., Pearson Education 2004.

3. Tripathy PC & Reddy PN, Principles of Management, Tata Mcgraw Hill, 1999.

4. O.P.Khanna - Industrial Engineering and Management – Dhanpat Rai PublicationsO.P.Khanna

Course Code : PCC623	**Category :** Professional Core Courses
Course Title : Machine Design Lab	**Semester** : Sixth
L-T-P : 0-0-2	**Credit:**1

Assembly drawing of machine elements using AutoCAD/Solid works
a) Threaded joints.
b) Cotter and Knuckle joint.
c) Couplings.
d) Screw Jack.
e) Tailstock.
f) Plummer block.
g) Rams bottom safety value.
h) Cylinder relief value.
i) Blow-off cock.
j) Tool post.
k) Gear box.

Course Code : PEC 624-628	**Category :** Professional Core Courses
Course Title : Professional Elective Course # III Laboratory	**Semester** : Sixth
L-T-P : 0-0-2	**Credit:**1

Semester-VII

Course Code : PEC711	**Category :** Professional Elective Courses
Course Title : Heat treatment of Casting and Forging	**Semester** : Seventh
L-T-P : 3-0-0	**Credit:**3

Objectives and variables involved in heat treatment. Role of alloying elements including microalloying. Decomposition of Austenite, Pearlitic, Bainitic and Martensitic transformations. Limitations of Fe- C diagram. TTT and CCT diagrams. Annealing: (Full, Homogenising, spheroidisation and stress relieving), Normalising, Comparison of annealing and normalizing. Hardening: Objectives, Volume and surface hardening, Austenitising temperature and internal stresses, Quenching medium and methods, Retained austenite and defects in hardening. Tempering of steels, Aims and stages of tempering, Tempering of alloy steels and multiple tempering. Thermomechanical treatment of steels, Principles and practices. Ausforming and isoforming; Heat treatment of alloy steel castings and forgings. Heat treatment of cast iron, malleable cast iron and S.G iron. Heat treatment of general engineering steels: Stainless steel, Hadfield steel, Spring steels, Bearing steels, Tool steels, HSLA steels, Maraging steels and dual phase steels. Heat treatment of Non ferrous metals and alloys, Brasses, Bronzes, Al and Mg - alloys. Heat treatment defects and their rectification. Advances in heat treatment technology.

Learning Resources:

1. Reed Hill R.E., Physical Metallurgy Principles, Affiliated East West.
2. Sharma R.C., Principles of Heat Treatment of Steels, New Age International.
3. Sinha A.K., Physical Metallurgy Handbook, McGraw Hill.
4. Singh V., Heat Treatment of Metals, Standard Publishers.
5. Brooks C.R., Heat Treatment, Structure and Properties of Non Ferrous Alloys, ASM

Course Code : PEC712	**Category :** Professional Elective Courses
Course Title : Industrial Tribology	**Semester** : Seventh
L-T-P : 3-0-0	**Credit:**3

Tribology in design, tribology in industry Viscosity, flow of fluids, viscosity and its variation absolute and kinematic viscosity, temperature variation, viscosity index determination of viscosity, different viscometers, Tribological considerations Nature of surfaces and their

contact; Physic mechanical properties of surface layer, Geometrical properties of surfaces, methods of studying surfaces; Study of contact of smoothly and rough surfaces. (12 hrs.)

Role of friction and laws of static friction, causes of friction, theories of friction, Laws of rolling friction; Friction of metals and non-metals; Friction measurements. Definition of wear, mechanism of wear, types and measurement of wear, friction affecting wear, Theories of wear; Wear of metals and non-metals, abrasive wear, corrosive wear, surface fatigue wear (10 Hrs.)

Principle of hydrostatic lubrication, General requirements of bearing materials, types of bearing materials., Hydrostatic step bearing, application to pivoted pad thrust bearing and other applications, (7 Hrs.)
Hydrostatic lifts, hydrostatic squeeze films and its application to journal bearing, optimum design of hydrostatic step bearing. (5 Hrs.)

Selection of bearing and lubricant; bearing maintenance, diagnostic maintenance of Tribological components and considerations in IC engines and automobile parts, roller chains and wire rope, lubrication systems; Filters and filtration (8 Hrs.)

Reference books:

1. Fundamentals of Tribology, Basu, SenGupta and Ahuja/PHI
2. Tribology in Industry : Sushil Kumar Srivatsava, S. Chand &Co.
3. Tribology H.G.Phakatkar and R.R.Ghorpade Nirali Publications
4. Tribology – B.C. Majumdar, McGraw Hill Co Ltd.
5. Standard Hand Book of Lubrication Engg., O'Conner and Royle, McGraw Hills C
6. Introduction to Tribology, Halling , Wykeham Publications Ltd.

Course Code : PEC713	**Category :** Professional Elective Courses
Course Title : Fuels, Furnaces and Refractories	**Semester** : Seventh
L-T-P : 3-0-0	**Credit:**3

Conventional and newer sources of energy, Characterization of fuels:Analysis and calorific value with problems, Principles of conversion of fuels: Carbonization, Gasification and Hydrogenation, Principles of fuel combustion and Numerical problems.

Raw materials and manufacturing process of refractories, Classification of refractories and their service properties.

Classification of furnaces, Basic working principles of fuel fired, Resistance, Induction and Arc Furnaces, Energy conservation measures in furnaces, advantages, and disadvantages of various kinds of furnaces.Use of regenerative and recuperative devices for improving furnace efficiency.

Heat transfer in furnaces: Conduction, convection, and radiation with suitable examples to design refractory lining, and heating of load through flame and convection. Heat balance diagrams with illustrations, Fuel economy in industrial furnaces, Oxygen addition to combustion process, Energy efficient operation of furnaces with illustrations, Instrumentation, and control in furnaces.

Learning Resources:

1. Elements of Fuels, Furnaces and Refractories, O. P. Gupta, Khanna publication.
2. Fuels, Furnaces and Refractories, J. D. Gilchrist
3. Fuels, Furnaces, Refractories and Pyrometry,-A.V.K. Suryanarayana, B. S. Publication
4. Industrial Furnaces - Vol. I & II, W. Trinks and M. H. Mawhiney, Wiley
5. Refractories, F.H.Norton, McGraw-Hill 6. Refractories, M. L. Mishra

Course Code : PEC714	**Category :** Professional Elective Courses
Course Title : Fracture Mechanics	**Semester** : Seventh
L-T-P : 3-0-0	**Credit:**3

History of failure by Fracture; failure of structures, bridges, pressure vessels and ships, brittle fracture, development of testing for failure, identification of reasons for failure, existence of crack, Griffith crack and experiment, energy release rate and stress for failure in presence of crack. Stress Field around Crack Tip; Airy's stress function for crack tip stress field with crack emanating from straight boundary, stress state in crack tip vicinity, modes of crack face deformation, stress intensity factor and Irwin's failure criterion, fracture toughness. Determination of Stress Intensity Factor, different specimen configuration Crack Propagation; law of fatigue crack propagation, life calculation when a crack is present and loaded, microscopic aspects of crack propagation, elastic crack and plastic relaxation at crack tip. (24 Hrs.)

Failure analysis, conventional design concepts & its limitations, mechanics of fracture - fracture toughness, determination of fracture toughness - ASTM standards, Brittle and ductile fractures, cleavage fracture, cleavage cracks, crystallographic mechanism, designing and testing for fracture resistance, design, improved toughness in ceramics, composites, case studies in failure analysis. (18 Hrs.)

References

1. D. Boreck, Elementary Engineering Fracture Mechanics, Marines Nijhoff, Dordredet (1986).
2. E. J. F. Knott Fundamentals of Fracture Mechanics, Butterworths (1973).
3. S. Teteleman and A. J. MCEvily, Facture of Structural Materials, John Wiley and Sons, (1961).
4. Fracture Mechanics: Fundamentals and Applications by Surjya Kumar Maiti, Cambridge University Press, 2016.
5. Engineering Fracture Mechanics -S.A. Meguid Elsevier & Karen Heltan.
6. Introduction to fracture mechanics, Mc Graw hill by S.A Meguid.
7. Engineering fracture Mechanics Elsevier Publications Karen Hettan.
8. Introduction to Fracture Mechanics, Mcgraw Hill Publications by Anderson.
9. Fracture Mechanics-Fundamentals and Applications, T.L. CRC Press 1998 by David Brock.
10. Elementary Engineering Fracture Mechanics by Noordhoff

Course Code : OEC 714	**Category :** Open Elective Courses
Course Title : Equipment and Tooling for Foundry and Forging	**Semester** : Seventh
L-T-P : 3-0-0	**Credit:**3

Sand Preparation Machines: Sand Mullers, Sand Mixers, Sand Driers, Sand Siever, Lump Breaker / Lump Crusher, Intensive Mixers, Cooler classifiers

Moulding machines: Jolt molding machine, squeeze molding machine, jolt squeeze moldingmachinelines, sand slinger, high pressure molding line

Core shops equipment: Core Shooter, Core Oven, resin coating mixer, sand siever, sand dryer, shell molding machine.

Sand reclamation plants

Fettling and cleaning equipments like shot blasting/grinding machines,

Different types of forging hammers(gravity, power and counter blow), presses(mechanical and hydraulic), upsetters and their working principles, reduce roller, cross wedge rolling.Induction billet heating furnace for forging, oil and gas fired furnaces, resistance heating furnaces. Die sinking machine(EDM, wire EDM, copy milling machine etc.), laser and optical profilometer, high speed machining, Vertical machining centre, Automated line for forging, Computerized controlled forging equipment, Die finishing operation, flood welding die repair.

Learning Resources:

1. Foundry Technology by P.L. Jain
2. ASM Handbook Volume 15: Casting, ISBN: 978-0-87170-711-6
3. ASM Hand Book , Vol. 14, Forming and Forging

Course Code : OEC 715	**Category :** Open Elective Courses
Course Title : Probability and Statistics for Engineers	**Semester** : Seventh
L-T-P : 3-0-0	**Credit:**3

Course Objectives: This course introduces students: 1. To the elementary concepts of descriptive and inferential techniques of statistical methodology. 2. To extend and formalize knowledge of the theory of probability and random variables.

Course Outcomes: At the end of the course, the students will be able to apply appropriate statistical concepts, methodologies and technologies in organizing, analyzing and interpreting various real-world situations and in coming up with relevant decisions:

Details of Course:

Module I. Basics of Statistics: Population, Sample, Attribute and Variable (Discrete and Continuous). Classification and Tabulation of Data. Graphical Representation of Data - Histogram, Frequency Polygon, Stem-and-Leaf Plots, Box Plot, Bar & Pie Charts.

Module II. Descriptive statistics: Measures of Central Tendency - Mean, Median, Mode. Dispersion and its Measures – Range, Quartile Deviation, Mean Deviation, Standard Deviation. Skewness and Kurtosis.

Module III. Probability: Random Experiment, Sample Space, Event, Types of Events. Three Approaches To Probability, Additive And Multiplicative Laws Of Probability, Conditional Probability, Total Probability Theorem and Bayes' Theorem.

Module IV Random Variables: Random Variable – Introduction: Probability Mass Function (PMF), Probability Density Function (PDF) and Cumulative Distribution Function (CDF). Moments of Random a Variable - Mean and Variance. Moment 6 Approved in Academic Council held on 25.10.2018 Generating Function of a Random Variable (Definition & Properties). Bernoulli, Binomial, Poisson and Normal Distributions – Problems with Applications.

Module V Statistical Inference: Introduction to Random Sampling - The Central Limit Theorem, Sampling Distribution. Concept of Estimation and Testing of Hypotheses: Type-I & Type-II Errors, Level of Significance, Confidence Interval, P-Value, Critical Value, Critical Region; Tests for Population Means and Variances for Single and Double Samples (Z-Test, T-Test and F-Test). ChiSquare Test of Goodness of Fit and Independence of Attributes (mxn Contingency).

Module VI Correlation And Regression: Bivariate Data, Scatter Plots. Pearson ProductMoment and Spearman's Rank Correlation Coefficients, Properties of Correlation Coefficient. Simple Linear Regression - Regression Equations. [CO-4] 6 7 ANOVA and Simple Designs: One-Way and Two-Way (Without and With Interaction) ANOVA. Concept of Three Basic Principles of Design of Experiments, CRD and RBD.

Suggested Textbook(s):

1. Ronald E. Walpole , Raymond H. Myers , Sharon L. Myers and Keying E. Ye, ``Probability and statistics for engineers and scientists'', 9th Edition, Pearson, 2011.

2. Jay L. Devore, ``Probability and statistics for engineering and the sciences", Cengage Learning, 8th Edition, 2011.

3. P. Kousalya, "Probability, statistics and random processes", Pearson Education, 2013.

4. Rohatgi, V K. and Saleh , A. K. Md. Ehsanes, "An Introduction to Probability and Statistics", (John Wiley and Sons) , (2nd 2000 edition)

5. Hogg, R. V. and Craig, A., "Probability and Statistical Inference", (Pearson Education), (6th 2006 Edition)

6. Johnson, R. A., Miller, I. and Freund, J. E., "Miller & Freund's probability and statistics for engineers", (Prentice Hall PTR), (8th 2011 edition)

7. Hines, W. W., Montgomery, D. C., Goldsman, D. M. and Borror, C. M., 2003 "Probability and Statistics in Engineering", (John Wiley & sons), (4th Edition)

8. Papoulis, A. and Pillai, S. U., "Probability, Random Variables and Stochastic Processes", (Tata McGraw-Hill), (4th 2002

Other Useful Resource(s):

1. Link to NPTEL Course Contents: i. https://nptel.ac.in/courses/111106112/ ii. https://nptel.ac.in/courses/111105090/ iii. https://nptel.ac.in/courses/111105041/ iv. https://nptel.ac.in/courses/102106051/v. https://nptel.ac.in/courses/102101056/

2. Link to Topics Related to Course: i. https://nptel.ac.in/courses/111106112/1- 5/ ii. https://nptel.ac.in/courses/111106112/12-17/ iii. https://nptel.ac.in/courses/111106112/18-21/ iv. https://nptel.ac.in/courses/111105090/1-32/ v. https://nptel.ac.in/courses/111105090/49-54/ vi. https://nptel.ac.in/courses/111105090/61-79/ vii. https://nptel.ac.in/courses/111105041/3-40/ viii. https://nptel.ac.in/courses/102106051/32/ ix. https://nptel.ac.in/courses/102106051/1-24/ x. https://nptel.ac.in/courses/102101056/1-12/ xi. https://nptel.ac.in/courses/102101056/15-40/

Course Code : OEC 716	**Category :** Open Elective Courses
Course Title : Design and Analysis of Experiments	**Semester** : Seventh
L-T-P : 3-0-0	**Credit:**3

Overview and basic principles - Simple designs and analysis of variance (ANOVA) - Block designs, Latin squares and related designs - Full factorial designs - 2-level full factorial and fractional factorial designs - Overview of response surface methods and designs - Designs with random factors, nested designs and split plot designs - Examples of scientific and engineering applications - DOE software. 42L

Reference Books:

1. D.C. Montgomery, Design and Analysis of Experiments, John Wiley & Sons, Inc., Eighth Edition, 2013.
2. Angela Dean and Daniel Voss, Design and Analysis of Experiments, Springer- Verlag New York, Inc.-1999.

Course Code : OEC 717	**Category :** Open Elective Courses
Course Title : Computer Aided Manufacturing and Computer Integrated Manufacturing	**Semester** : Seventh
L-T-P : 3-0-0	**Credit:**3

Details of Courses:

Module I: Introduction to production layout, group technology and process planning - variant process planning and generative process planning - flexible manufacturing systems - just-in-time - material requirement planning - MRP II - computer integrated manufacturing. (7 Hrs.)

Module II: Introduction to NC/CNC/DNC - basics elements of CNC - 2, 2½ and 3-axis machines - multiple axis machines - conditions where CNC machines are most suitable - economics of CNC machines - part programming for milling (basic): G and M codes - 2-axis programming (milling) - absolute and incremental programming - G54 and G92 - 2½-axis programming - G02 and G03 programming - cutter radius compensation programming. (7 Hrs.)

Module III: Part programming for milling (canned cycles and advanced techniques) - canned cycles: drilling and boring - cutter length compensation - multiple tools - do and nested do loops - subroutines - mirror image - polar rotation - pocket milling. (7 Hrs.)

Module IV: Part programming for turning: G and M codes - 2-axis programming (turning) - absolute and incremental programming - program for machining of castings - G90 box turning cycle and taper turning cycle - G94 facing cycle and taper turning cycle - G71

multiple turning cycle - G72 multiple facing cycle - G73 pattern repeating cycle - threading cycles and double start thread - peck drilling cycle - grooving cycle - boring. (10 Hrs.)

Module V: APT, freeform curves and surfaces: APT structure - geometric statements - motion commands - processor and post processor - tolerance - freeform curves: cubic splines and Bezier curves - parameterization - introduction to Bezier surface - surface interpolation. (5 Hrs.)

Textbooks / References

1) Chang, T. C., R. A. Wysk and H. P. Wang, Computer Aided Manufacturing, Prentice Hall.

2) Groover, M. P., Automation, Production Systems, and Computer Integrated Manufacturing, Prentice Hall India.

3) Fanuc CNC Program Manual gcodetraining.

4) Seames, W., Computer Numerical Control: Concepts and Programming, Delmar Thomson Learning / Cengage Learning.

5) Smid, P., CNC Programming Handbook, 2nd Edition, Industrial Press Inc.

Course Outcomes

After taking this course the students should be able to

1) Decide on type of layout to be used.

2) Understand the basic of process planning.

3) Understand the basics of MRP, MRP-II, and the issues involved in FMS and CIM.

4) Develop CNC program for machining components using CNC turning and 2½-axis milling machines.

5) Develop programs in APT language for machining components using 2½-axis milling machine

Course Code : OEC 718	**Category :** Open Elective Courses
Course Title : Manufacturing Process Design	**Semester** : Seventh
L-T-P : 3-0-0	**Credit:**3

Classification of manufacturing processes, Basics of Effective Design for Manufacturing, design simplicity, alignment and compliance, Selection of manufacturing processes, Design for manufacture and assembly, Application of DFMA principles to the design of any assembly, Factors to be considered when selecting casting as a manufacturing process, Design considerations for forged components.
Product development: Integrated product development and concurrent engineering, Functional product development, Engineering design,

Product life-cycle analysis: Product data management and product life-cycle management, Cost estimation

Design for manufacturing: Casting design, forging desigm

Virtual manufacturing: Computer-aided manufacturing, Simulations of manufacturing processes using finite element analysis

Knowledge-based engineering: Expert systems, Case-based reasoning, Combining rule-based approaches and case-based reasoning, Design for manufacturing using knowledge engineering. Case study of casting component design from 2D component drawing to casting drawing and development of pattern. Case study of a forged component drawing to billet/ingot selection.

Reference Books:

1. Manufacturing Process Design and Costing: An Integrated Approach, by Simmy Grewal
2. Manufacturing Processes for Design Professionals, by Rob Thompson
3. Foundry Technology by P.L. Jain.
4. ASM Handbook Volume 15: Casting, ISBN: 978-0-87170-711-6
5. ASM Hand Book, Vol. 14, Forming and Forging.

Course Code : OEC 719	**Category :** Open Elective Courses
Course Title : Design for Manufacturing	**Semester** : Seventh
L-T-P : 3-0-0	**Credit:**3

Objective: • To educate students on factors to be considered in designing parts and components with focus on manufacturability. . • To impart the knowledge on design considerations for designing components produced using various machining operations.

Details of Course:

Module-I Introduction: Overview of the course, Design for manufacturing, Typical Case studies, Innovative product and service designs. (4hrs)

Module-II Material Selection: Requirements for material selection, systematic selection of processes and materials, ASHBY charts (4hrs)

Module-III Design for Casting: Basic characteristics and Mold preparation, Sand casting alloys, Design rules for sand castings, Example calculations, Investment casting overview, Cost estimation, Number of parts per cluster, Ready to pour liquid metal cost, Design guidelines for Investment casting, Die casting cycle, Determination of optimum number of cavities, appropriate machine size, Die cost estimation, Design principles. (8hrs)

Module-IV Design for Injection molding: Injection molding systems, Molds, molding cycle time, mold cost estimation, estimation of optimum number of cavities, Assembly techniques, Design Guidelines. (5hrs)

Module-V Design for Hot Forging: Characteristics of the forging process, forging allowances, flash removal, die cost estimation, Die life and tool replacement costs. (5hrs)

Module-VI Design for Sheet metal working: Press selection, press brake operations, Design rules. (2hrs) Module-VII Design for Powder Metal processing: Powder metallurgy, tooling and presses for Compaction, Sintering, materials, heat treatments, Design guidelines. Design for machining: Machining using single point cutting tools, multipoint cutting tools, abrasive wheels, Assembly, cost estimation for machined components, Design guidelines. (10)

Module VIII: Design for Assembly: Design guidelines for manual assembly, large assemblies, analysis of an assembly, rules for product design for automation, design for robot assembly, Design for manufacture and Computer aided design. (4hrs)

Course Outcomes: • Understand the design principles of design for manufacturing processes • Estimates the cost of dies, molds and machined components based on die life. • Understand the design for manual assembly and automated assembly. • Design typical assemblies using principles of design for X concepts. • Understand the design rules for machining with single point and multi point cutting tools.

Textbooks:

1. Geoffrey Boothroyd, Dewhurst.P, Knight.W, roduct design for manufacture and assembly,

2. CRC press, 2002

3. George E Dieter, Engineering Design-A material processing approach, Mc Grawhill international, 2003. 4. ASM Handbook, Design for manufacture, 2000.

Course Code : OEC 720	**Category :** Open Elective Courses
Course Title : Artificial Intelligence and Data Analytics	**Semester** : Seventh
L-T-P : 3-0-0	**Credit:**3

Details of Course:

Module I: Introduction to Artificial Intelligence (AI), Definitions of intelligence and artificial intelligence - Human mental capabilities: association, stereotyping, reasoning and vision - Artificial intelligence: components, scope and application areas. (8 Hrs.)

Module II: AI Languages, Programming in Prolog. (10 Hrs.)

Module III: Expert Systems, Knowledge-based or expert systems: definition, structure, characterization and justification - Knowledge sources - Expert - Knowledge acquisition and representation - Knowledge base - Interference strategies: forward and backward chaining. (8 hrs.)

Module IV: Expert Systems Tools and Applications, Expert system languages - Expert system shells: typical examples of shells - CLIPS programming - Expert system software for manufacturing applications in CAD, CAPP, MRP, adaptive control, robotics, process control, fault diagnosis, failure analysis, process selection, group technology, etc. (8 Hrs.)

Module V: Artificial Neural Networks, Fuzzy Logic and Genetic Algorithms, Concepts of artificial neural networks, fuzzy logic and genetic algorithms - Manufacturing applications of neural networks, fuzzy logic and genetic algorithms - Case studies of typical applications in tool selection, process selection, part classification, inventory control, process planning, etc. (8 Hrs.)

Textbooks

1) Clocksin, W. F. and C. S. Mellish, Programming in PROLOG, Narosa Publishing House, New Delhi.

2) Giarratano, J. C. and G. D. Riley, Expert Systems - Principles and Programming, Cengage Learning, New Delhi. 12

3) Padhy, N. P., Artificial Intelligence and Intelligent Systems, Oxford University Press, New Delhi.

4) Rajasekaran, S. and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic and Genetic Algorithms, PHI Learning Private Limited, New Delhi.

Course Outcomes

1) This course systematically introduces the aspects of artificial intelligence, in the context of manufacturing engineering, which has very good potential in modern industries. 2) The

students will become familiar with the tools required for creating artificial intelligence applications in the manufacturing domain.

Course Code : OEC 721	**Category :** Open Elective Courses
Course Title : Cyber Physical System	**Semester** : Seventh
L-T-P : 3-0-0	**Credit:**3

- Introduction to Internet of Things (IoT), Basics of Industrial IoT,
- Industrial Sensing & Actuation, Industrial Internet Systems.
- Smart and Connected Business Perspective,
- Cyber-Physical Systems (CPS) in the real world and Next Generation Sensors, Basic principles of design and validation of CPS
- Collaborative Platform and Product Lifecycle Management, Augmented Reality
- and Virtual Reality,
- Introduction to Cloud Computing, Cloud Computing Architecture, Sensor-Cloud
- Basics of Networking, Communication Protocols, Sensor Networks, Machine-to machine Communications
- Introduction to Arduino and Raspberry Pi, Implementation of IoT with Arduino &
- Raspberry Pi
- Cybersecurity in Industry 4.0, Industrial IoT case studies (Total 42 Hrs.)

Text Books / References:

1. E. A. Lee and S. A. Seshia, "Introduction to Embedded Systems: A Cyber-Physical Systems Approach", 2011.
2. R. Alur, "Principles of Cyber-Physical Systems," MIT Press, 2015.
3. T. D. Lewis "Network Science: Theory and Applications", Wiley, 2009.
4. P. Tabuada, "Verification and control of hybrid systems: a symbolic approach", Springer-Verlag 2009.
5. C. Cassandras, S. Lafortune, "Introduction to Discrete Event Systems", Springer 2007.
6. Constance Heitmeyer and Dino Mandrioli, "Formal methods for real-time computing", Wiley publisher, 1996.

Course Code : OEC 722	**Category :** Open Elective Courses
• **Course Title** : Future Materials Processing	**Semester** : Seventh
L-T-P : 3-0-0	**Credit:**3

1. **Composite material processing:** Definition, Reason for composites, Types, constituents, interface, Role of interface, bonding mechanisms and bond strength. Production of composites
2. Metal Injection Moulding (MIM) Metal Injection Moulding: Introduction, Steps in MIM, Advantages, Requirements, Materials Processed by MIM.

3. ADDITIVE MANUFACTURING: Definition of Additive Manufacturing, Direct Processes, Indirect Processes, Nomenclature of AM machines, Generic AM Process, Comparison of CNC with AM, Reverse engineering, haptic based CAD.
4. Self-Propagating high temperature synthesis (SHS) Process: Introduction, Advantages, Process, Parameters to be considered, Types of products and Applications
5. High Velocity Forming Process: introduction - comparison of conventional and high velocity forming methods - Types of high velocity forming methods- explosion forming process-elector hydraulics forming magnetic pulse
6. Powder Metallurgy Processes Introduction to powder metallurgy, Benefits of Powder Metallurgy, Limitations and Applications, Production of Powders, Powder Treatment, Powder Characteristics, Compaction of powders, High temperature compaction, Pre Sintering and Post Sintering operations,
7. Mechanical Alloying: Introduction, Process, Milling parameters, Process Control Agents, Process Variables, Mechanism of Alloying, Powder Contamination, Consolidation, Types of Mills, Oxide dispersion strengthened alloys, Reactive milling, Applications.
8. Ceramic Materials Processing: Properties and applications of ceramics. Processing of ceramics, Ceramic shell casting, Forming – Pressing, dry-pressing, isostatic pressing, hot pressing, slip casting, extrusion, thermal treatment, vitrification.

Reference:

1. Dominic V. Rosato, Injection molding handbook, CBS publishers
2. Rao, P.N, 'Manufacturing Technology', Tata McGraw Hill, 1996.
3. Kalpakjian, S, 'Manufacturing Engineering and Technology', Addison-Wesly, 1995.
4. Suryanarayana, Mechanical Alloying an Introduction.

Course Code : OEC 723	**Category :** Open Elective Courses
• **Course Title** : Foundry and Forge Shop Environment Management	**Semester** : Seventh
L-T-P : 3-0-0	**Credit:**3

Various types of solid, liquid and gaseous pollutants and their harmful effects; Environmental impact assessment in Foundry, forging industries and other allied metallurgical Industries; Pollutant emissions from foundry and forging industries, integrated iron and steel plants, Environmental audit; Preventive measures to reduce atmospheric pollution from these industries; scope of alternative energy sources to combat pollution from foundry and forge industries. Environmental legislation related to metallurgical industries. Environment Protection Act, Environment Protection (Air, water and noise) Policy, Management of standards for emissions in the waste streams of all foundries/forging industries: air quality (dust, fumes, furnace emissions, odor etc.), noise, waste generation and disposal. Use of safety equipments in foundry and forge industries.

Reference Books:

1. Pandey, G.N, A Text book for energy system engineering, Vikas publishing

2. Rao, C.S, Environmental pollution control Engineering, Wiley Eastern Limited
3. Ray, H.S et al (ed), Energy and the mineral and metallurgical industries, Allied publishers
4. Nathanson, J.A, Basic environmental Technology, Prentice Hall

Course Code : OEC 724	**Category :** Open Elective Courses
Course Title : Financial Management	**Semester** : Seventh
L-T-P : 3-0-0	**Credit:**3

Objective: To provide detailed insight of the financial requirements in industries besides techniques of financial planning, control and managerial decisions.

Details of Course:

Module I: Nature and Scope: Function of finance, jobs and objectives of a financial manager, various forms of business organizations, sourceof finances: short term finances- term credit, accrued expenses and deferred income, bank finance for working capital; long term finances-common shares, right issues, debentures, preference shares, lease financing, term loan. (12 Hrs)

Module II: Financial Accounting:Purpose, functions, difference between 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 Hrs)

Module III: Cost: Nature and classification of costs in a manufacturing company, costing concepts, cost allocation,Break-even analysis (BEA), operating leverage, effect of change in profit, utility and limitation of BE Analysis. (8 Hrs)

Module IV: Capital Budgeting (CB): Meaning, importance and difficulties of CB, kinds of capital budgeting decisions, cash in flow and out flow estimates. Capital structure,Concepts, needs, determination, and dimension of working capital management, estimation of working capital needs, financing current assets. (8 Hrs)

Module V: Financing and Dividend Decision: Meaning and measure of financial leverage, effect on the share holders return, dividends, dividend policy, practical consideration, constraints of paying dividends, advantages and disadvantages of bonus shares etc. (6 Hrs) Total 42 Hrs

Suggested Books:

1. Bose, D.C., “Fundamental of Financial Management”, Prentice Hall 2006

2. Martin, K., Scott Jr., P., “Financial Management Principles and Applications”, 10th 2006 Ed., Academic Internet Publishers

3. Higgins, R.C., “Analysis for Financial Management”, 8th Ed., 2005 McGraw-Hill/Irwin

4. Brigham, E.F., and Ehrhardt, M.C., “Financial Management: Theory and Practice with Thomson ONE”,11th 2004 Ed., South-Western College Pub.

5. Horne, J.C.V., “Financial Management Policy”, Pearson 2004

Course Code : OEC 725	**Category :** Open Elective Courses
Course Title : Robotics and Automation	**Semester** : Seventh
L-T-P : 3-0-0	**Credit:**3

Module I: Importance of robotics and automation in the manufacturing industry. Use of mechatronics in Automation. Introduction to robotics - History, growth; Robot applications- Module II: Manufacturing industry, Essential elements of an automated system, working principle and examples. Fabrication or selection of various components of an automated system.

Module III: Robot mechanisms; Kinematics- coordinate transformations, Principles of Automated Control Design: Dynamical Systems and Stability, Controller Design Techniques.

Module IV: Sensors: Common sensors in an automated manufacturing system. Construction and principle of operation of sensors.

Module V: Introduction to Signal conditioning and data acquisition, microprocessor or micro controllers. Actuators (electrical)- DC motors, BLDC servo motors, Introduction to Reinforcement Learning,

Module VI: Probabilistic robotics, Path planning, BFS; DFS; Dijkstra; A-star; D-star; Voronoi; Potential Field; Hybrid approaches, Simultaneous Localization and Mapping

Course Code : HEC726	**Category :** Honours Elective Courses
Course Title : Technology of Non-Ferrous Forging	**Semester** : Seventh
L-T-P : 3-0-0	**Credit:**3

Classification, Properties, Metallurgical characteristics and applications of non-ferrous alloys like Aluminum, Magnesium, Titanium and Copper.

Forging practice and forging behavior of following nonferrous alloys: Aluminum, Magnesium, Titanium and Copper.

Heat Treatment Technology of important non-ferrous alloys for example: Aluminum, Magnesium, Titanium and Copper.

Current Forging Technology for aerospace materials, Forging of Aluminum-Lithium alloys.

Tribological behavior during forging.

Course Code : HEC727	**Category :** Honours Elective Courses
Course Title : Foundry Tooling and Methoding	**Semester** : Seventh
L-T-P : 2-1-0	**Credit:**3

Pattern materials; wood, manufactured timber, metals, plaster, plastics, rubbers, & their characteristics & criteria for selection, design and constructional features suiting to various moulding machines.

Use and types of core prints; pattern accessories; pattern allowances and their selection; pattern layouts & material required. Pattern making hand tools and machinery; pattern coatings storage & Repair of patterns.

Core Boxes: type, materials used, design and constructional features for core blowing and shooting machines.

Special design features for high pressure moulding machines, Special features for shell core shooters, Core print. Gravity Die casting: Die-Types, and design features. Pressure Die-casting: die- design features, Application of CAD, cam and additive manufacturing for pattern development and design.

Principle of solidification of castings; Elements of gating system. Design of gating systems: gating ratio; pressurized and un- pressurized systems; types of gates; Slag traps and filters etc. with reference to different cast metals and alloys.

Design of feeding systems: - Directional and progressive solidification; design and positioning of feeders; feeding range and controlled directional solidification; feeding efficiency. Principles of casting design.
Module VI: Design of feeding systems: - Directional and progressive solidification; design and positioning of feeders; feeding range and controlled directional solidification; feeding efficiency. Principles of casting design.

Reference Books:

1. Foundry Technology by P.L. Jain
2. ASM Handbook Volume 15: Casting, ISBN: 978-0-87170-711-6
3.Foundry Technology by Peter Beeley
4. Pattern Making and Foundry Practice, by L. H. Hand

Course Code : HEC728	**Category :** Honours Elective Courses
Course Title : Forging Die Design and Product Realization	**Semester** : Seventh
L-T-P : 2-1-0	**Credit:**3

Job analysis, Product drawing, Standard for allowances and tolerances for closed die forging, Development of forging drawing and its simplification from die design point of view, Criteria for selection of parting line, Preliminary design considerations like parting line position, rib and web dimensions, draft angle, fillet and corner radii etc.

Importance of flash and gutter, Load and displacement curve, Design of flash and gutter dimensions. Design of preform impressions, Design of reduce roll die, Design of blocker, Design of finisher

Design of trimming and piercing tool, die clearance between punch and die. Design of stripping tool. Assembly detail for trimming. Laws governing the design of the dies of horizontal forging machine. Design of punches and heading tools for up setter (horizontal forging machine). upsetting rule, Coning tool design method.

Determination of stock size, Capacity calculation of drop hammer, mechanical press, Determination of capacity of trimming and piercing press. Instruction for mounting, setting and working of dies, die materials and die sizes, Die life improvement

Computer aided design of forging dies, Optimization of die design parameters, Optimum material utilization, Modelling and analysis of forging process using software.

Die Design of forge components like Drive shaft, Connecting Rod, Stub Axle, Crankshaft, Axle beam, Steering arm etc.

Course Code : PEC 729 - 732	**Category :** Professional Elective Courses
Course Title : Professional Elective Course # V Laboratory	**Semester** : Seventh
L-T-P : 0-0-2	**Credit:1**

Course Code : HEC 734	**Category :** Open Elective Courses
Course Title : Technology of Non-Ferrous Forging Laboratory	**Semester** : Seventh
L-T-P : 0-0-2	**Credit:1**

1. To study initial mechanical properties and microstructure of given Aluminum alloys

2. To study mechanical properties and microstructure of given aluminum alloys after open die forging at different strain levels at room temperature
3. To study mechanical properties and microstructure of given aluminum alloys after hot die forging at different strain levels
4. To study dependency of different forging equipment on characteristics of given Al alloys after forging
5. To study dependency of heat treatment on characteristics of given Al alloys after forging
6. To study mechanical properties and microstructure of given aluminum alloys after closed die forging at different strain levels at room temperature
7. To study mechanical properties and microstructure of given magnesium alloys after hot die forging at different strain levels

Course Code : HEC735	**Category :** HonoursElective Courses
Course Title : Foundry tooling and Methoding Lab	**Semester** : Seventh
L-T-P : 0-0-2	**Credit:**1

1. Introduction of hand tools & machine tools for pattern making
2. Demonstration for study of component drawing
3. Layout and construction of a pattern
4. Development of 3D model of pattern from component drawing using CAD software
5. Demonstration of pattern manufacturing
6. Pattern making of supplied drawing of various component V-block, corner bracket and rope pulley
7. Molding and casting of V-block, corner bracket and rope pulley
8. Study of the dimensional variations of the castings produced.
9. Effect of temperature on fluidity of metal.
10. Study of metal flow in different types of gates
11. Experiment on flow of liquid in different type of gating system via water model.
12. Study of shrinkage of an alloy
13. Study of shrinkage in different types of junctions
14. Experiments on open riser and blind riser provided on a casting
15. Study of internal and external chill to a casting
16. Effect of exothermic material on efficiency of riser.
17. Visit of any pattern making and core making shop of a Foundry

Course Code : HEC 736	**Category :** Open Elective Courses
Course Title : Forging Die Design and Product realization Laboratory	**Semester** : Seventh
L-T-P : 0-0-2	**Credit:1**

1. Study of die material for cold forging
2. Study of die material for hot forging
3. Study die wear during forging
4. Study of different lubrications for dies during forging

5. Design of die for given material and components
6. Study of different allowances for design of die for given component
7. Develop Forging drawing of at least three components like drive shaft, connecting rod, crank shaft, piston arm etc.
8. Design of preform of complex component shape