

Course Structure for B. Tech. (Hons)**Production & Industrial Engineering**First Semester

S. No	Subject Code	Subject Name	L-T-P	Credits
1.	CH11XX	Engineering Chemistry	3-1-0	4
2.	MA1101	Engineering Mathematics-I	3-1-0	4
3.	ME1101	Engineering Mechanics	3-1-0	4
4.	HS1101	English for Communication	3-1-0	4
5.	CS1101	Computer Programming	2-0-2	3
6.	ME1102	Engineering Mechanics Laboratory	0-0-3	2
7.	CH1102	Engineering Chemistry Laboratory	0-0-3	2
8.	PI1101	Workshop Practice	0-0-3	2
		<b>Total</b>	<b>14-4-11</b>	<b>25</b>

Second Semester

S. No	Subject Code	Subject Name	L-T-P	Credits
1.	PH1201	Engineering Physics	3-1-0	4
2.	MA1202	Engineering Mathematics-II	3-1-0	4
3.	EE1201	Basic Electrical and Electronics Engineering	3-1-0	4
4.	CE1201	Environment and Ecology	3-0-0	3
5.	MM1201	Material Science	3-0-0	3
6.	PH1202	Engineering Physics Laboratory	0-0-3	2
7.	EE1202	Basic Electrical & Electronics Laboratory	0-0-3	2
8.	ME1203	Engineering Graphics	2-0-2	3
9.		Yoga/ NSS/ NCC/ Life Skills		
		<b>Total</b>	<b>17-3-8</b>	<b>25</b>

Third Semester

S. No	Subject Code	Subject Name	L-T-P	Credits
1.	MA1301	Engineering Mathematics-III	3-0-0	3
2.	HS1302	Introduction to Soft Skills	2-1-0	3
3.	ME1304	Engineering Thermodynamics	4-0-0	4
4.	PI1302	Quality Assurance and Reliability	3-1-0	4
5.	ME1305	Mechanics of Solids	3-1-0	4
	ME1306	Fluid Mechanics and Machinery	4-0-0	4
8.	ME1307	Fluid Mechanics and Machinery Laboratory	0-0-3	2
9.	ME1308	Mechanics of Solids Laboratory	0-0-3	2
		<b>Total</b>	<b>17-3-6</b>	<b>26</b>

Fourth Semester

S. No	Subject Code	Subject Name	L-T-P	Credits
1.	PR401	Metrology	3-0-0	3
2.	PR402	Numerical Methods and Applications	3-1-0	4
3.	PR403	Manufacturing Processes-I	4-0-0	4
4.	PR404	Theory of Machines	3-1-0	4
5	PR405	Production Management-I	3-0-0	3
6.	PR406	Industrial Economics and Accountancy	3-1-0	4
7.	PR407	Metrology Laboratory	0-0-3	2
8.	PR408	Casting, Welding & Forming Laboratory	0-0-3	2
<b>Total</b>			<b>19-3-6</b>	<b>26</b>

#### Fifth Semester

S. No	Subject Code	Subject Name	L-T-P	Credits
1.	PR501	CAD/CAM	4-0-0	4
2.	PR502	Machine Design	3-1-0	4
3.	PR503	Manufacturing Process-II	4-0-0	4
4.	PR504	Production Management-II	3-0-0	3
5.	PR505	Design of Production Tooling	4-0-0	4
6.	PR506	Additive Manufacturing	3-0-0	3
7.	PR507	Machining Laboratory	0-0-3	2
8.	PR508	Machine Design Laboratory	0-0-3	2
<b>Total</b>			<b>21-1-6</b>	<b>26</b>

#### Sixth Semester

S. No	Subject Code	Subject Name	L-T-P	Credits
1.	PR601	Design for Manufacturing & Assembly	3-0-0	3
2.	PR602	Metal Forming	3-0-0	3
3.	PR603	Operation Research	4-0-0	4
4.	PR604	Non-traditional Manufacturing Processes	4-0-0	4
5.	PR605	Total Quality Management	3-1-0	4
6.	PR606	Professional Elective-I	3-0-0	3
7.	PR607	Non-traditional Manufacturing Processes Laboratory	0-0-3	2
8.	PR608	CAD/CAM Laboratory	0-0-3	2
<b>Total</b>			<b>20-1-6</b>	<b>25</b>

#### Professional Elective I (PR606)

1.	Digital Manufacturing
2.	Finite Element Methods

3.	Surface Engineering
4.	Production Planning and Control
5.	Concurrent Engineering
6.	Reliability Engineering
7.	IC Engines and Gas Turbines

### Seventh Semester

S. No	Subject Code	Subject Name	L-T-P	Credits
1.	PR701	Automation and Robotics	4-0-0	4
2.	PR702	Supply Chain Management	3-0-0	3
3.	PR703	Professional Elective-II	3-0-0	3
4.	PR704	Professional Elective-III	3-0-0	3
5.	PR705	Open Elective-I (Any professional elective subject from other branches)	3-0-0	3
6.	PR706	Flexible Manufacturing Systems Laboratory	0-0-3	2
7.	PR707	Minor Project	0-0-4	4
8.	PR708	Industrial Training	0-0-3	2
<b>Total</b>			<b>16-0-10</b>	<b>24</b>

### Professional Elective II (PR703)

1.	Precision Engineering
2.	Lean Manufacturing
3.	Organizational Behavior and Industrial Psychology
4.	Production Design and Process Planning

### Professional Elective III (PR704)

1.	Theory of Abrasive Machining
2.	Product Design and Development
3.	Project Management
4.	Advanced Welding Processes

### Eighth Semester

S. No	Subject Code	Subject Name	L-T-P	Credits
1.	PR801	Work Study Design & Ergonomics	4-0-0	4
2.	PR802	Professional Elective-IV	3-0-0	3
3.	PR803	Open Elective-II (Any professional	3-0-0	3

		elective subject from other branches)		
4.	PR804	Major Project	0-0-8	8
5.	PR805	Industrial Engineering and Ergonomics Laboratory	0-0-3	2
6.	PR 806	Comprehensive Viva		2
		<b>Total</b>	<b>10-0-11</b>	<b>22</b>

Professional Elective IV (PR804)

1.	Manufacturing of Composite Materials
2.	Energy Conservation and Management
3.	Tribology
4.	Quantity Production Methods
5.	Entrepreneurship Management
6.	Knowledge Management
7.	Human Resource Management
8.	Industrial Relation and Safety

**Total Credits: 199**

## **Syllabus for B. Tech. (Hons.) Production & Industrial Engineering**

### **FIRST SEMESTER**

#### **CH101: Engineering Chemistry (3-1-0)**

Thermodynamics: Laws of thermodynamics, system, thermodynamic functions, state of a system, equilibrium, enthalpy, work done in different processes,  $C_p$ ,  $C_v$ , adiabatic PVT relations,

Carnot cycle, concept of entropy, Clausius-Clapeyron equation & its applications, Maxwell relations, concept of free energy, chemical potential, Maxwell relations.

Electrochemistry and corrosion: Electrochemical cells, origin of electrode potential, standard potential, Nernst equation, EMF series, rechargeable batteries, Types of corrosion, galvanic series, Cathodic and anodic reactions, differential aeration cells, corrosion prevention methods.

Kinetics & Solution Chemistry: Kinetics of chemical reaction, 1<sup>st</sup>, 2<sup>nd</sup> order reactions, reversible, consecutive and parallel reaction. Steady state approximations, Arrhenius equation, Chain reactions, photo chemical reactions, Solution chemistry and colligative properties, Real and ideal solutions, Diffusion, Osmosis, Osmotic pressure, Lowering of vapor pressure, Elevation in boiling point, Depression of freezing point, Abnormal molecular weight, Degree of association and dissociation.

Chemical Bonding & Co-ordination chemistry: Bonding models in inorganic chemistry, Molecular orbital theory (MOT), Valence bond theory (VBT), and crystal field theory (CFT), Co-ordination chemistry: Co-ordination number, Chelate effect, EAN rule, splitting of 'd' orbital in octahedral, tetrahedral and square planar complex, Example of Bio-inorganic & metals in biological systems

Industrial chemistry: Polymers: types of polymer, polymerization, applications, important synthetic polymers. Refractory & ceramics material: Classification, manufacturing and Applications, Water treatment, Air pollution and Control techniques

### **Text and Reference Books**

1. Chemistry for Engineers, by S. Vairam and Suba Ramesh; Wiley India
2. Textbook of Engineering Chemistry by Dr. Gopal Krishna Bhatt, Acme Publishers
3. Chemistry (9th ed), by Raymond Chang, Tata McGraw-Hill
4. Engineering Chemistry Author: Abhijit Mallick, Viva Books
5. Text Book of Engineering Chemistry by Harsh Malhotra; Sonali Publications
6. Organic Chemistry (6 ed) by Morrison & Boyd; Pearson Education
7. Physical Chemistry by Gordon M. Barrow; Mc-Graw Hill
8. Organic Chemistry, Volume 1(6 ed)& 2 (5ed) by I. L. Finar; Pearson Education
9. Atkins' Physical Chemistry by Peter Atkins & Julio De Paula; Oxford University Press

### **MA101: Engineering Mathematics-I (3-1-0)**

Successive differentiation, Leibnitz theorem, Taylor's and Maclaurin's theorem with remainders, Indeterminate forms, Concavity and Convexity of a curve, Points of inflexion, Asymptotes and Curvature.

Limit, Continuity and Differentiability of function of several variables, partial derivatives and their geometrical interpretation, Directional derivatives of composite and implicit functions.

Euler's theorem on homogeneous functions, Taylor's expansion of functions of several variables, maxima and minima of functions of several variables, Lagrange's method of multipliers.

First order differential equations: Exact, Linear and Bernoulli's form, Second order differential equations with constant coefficients, Method of undetermined coefficients, variation of parameters, Euler's equations, system of differential equations. Review of limit, continuity, differentiability of functions of complex variables, Analyticity of functions, Cauchy- Riemann equations, Harmonic functions.

Reduction formula for indefinite and definite integrals of type and their evaluation.

### **Text and Reference Books**

1. E. Kreyszig, Advanced Engineering Mathematics, John-Wiley & Sons
2. B. V. Ramana, Higher Engineering Mathematics, Tata Mcgraw- Hill Publishing Company Ltd.
3. R.K.Jain & S.R.K. Iyenger, Advance Engineering Mathematics, Narosa Publishing House.

4. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers
5. Peter V. O' Neil, Advanced Engineering Mathematics, Thomas ( Cengage) Learning.
6. Thomas & Finley, Calculus, Narosa Publishing House
7. Rukmangadachari, Engineering Mathematics – I, Pearson Education.
8. A.C.Srivastava & P. K. Srivastava, Engineering Mathematics, Vol. I, PHI Learning Pvt. Limited, New Delhi

### **ME101: Engineering Mechanics (3-1-0)**

Fundamental principles of mechanics: Idealization of mechanics, Laws of mechanics, Force vector in 2D & 3D, Directions cosines, Dot and vector product, Moment of a force, Component of moment an axis, Couple & Couple moment, Force system, Reduction of complex force system to simplest form, Equivalent force system, Wrench.

Equilibrium: Definition, Conditions & Criteria of equilibrium, Free body diagram, 2 D & 3D problems on engineering applications. Plane Truss: Simple truss, Idealization of plane truss, Methods of sections & Joints.

Friction: Coulomb's law of dry friction, Roller, wedge & belt friction, Screw jack.

Kinematics and kinetics of a particle: Types of motion, Rectilinear & curvilinear translation, Relative velocity and relative acceleration, Dependent motion, kinematics w.r.t. a moving frame of reference, Kinematics in normal & tangential component & polar coordinates, Kinetics of particle, D'Alembert's principle, Principle of work & energy, Principle of Impulse & momentum, Collision of two bodies, Central & oblique impact.

Kinematics and Kinetics of rigid body: Kinematics of rotation, Non-Centroidal rotation Plane motion, Instantaneous centre of rotation, D'Alembert's principle, Principle of work & energy & principle of impulse-momentum of rigid body.

Axial force, shear and bending moment: Concept of Internal forces, Relation between axial force, shear force and bending, Shear force and bending moment diagram, Summation method and Singularity function.

#### **Text and Reference Books**

1. Engineering Mechanics: Statics, J.L Meriam , Wiley
2. Engineering Mechanics: Dynamics, J.L Meriam , Wiley
3. Engineering Mechanics, F L Singer
4. Engineering Mechanics : Statics and Dynamics, R. C. Hibbler, Pearson
5. Engineering Mechanics, Timoshenko & Young , 4ed, Tata McGraw Hill
6. Engineering Mechanics: Statics and Dynamics, A. Nelason, McGraw-Hill
7. Engineering Mechanics, V. Jayakumar and M. Kumar, PHI

### **HS101: English for Communication (3-1-0)**

Art of communication: Basic grammatical concept, Elementary theories of phonetics, sound of English, Mechanics of sound production, Rules of phonetics with examples, reading, listening and advanced writing skills.

Business Letters, effective speaking (interactive sessions).Essay, poems and stories; The world is too with us: William words worth, the scientific point of view: JBS Haldane, Strange Meeting: Wilfred Owen, If: Rudyard Kipling, The Necklace: G D Maupassant, Piano: D H Lawrence  
Basic concepts in Communications: Nature of communication, Types of communication, Process of communication, Barriers to communication, Characteristics of successful communication, Informal communication: Chat, the grapevine, Rumour. Merits and limitations.

#### **Text and Reference Books**

1. Improve your Writing ed. V.N. Arora and Laxmi Chandra, Oxford Univ. Press, 2001, New Delhi.
2. Technical Communication- Principles and Practices by Meenakshi Raman & Sangeeta Sharma, Oxford Univ. Press, 2007, New Delhi.
3. Functional skills in Language and Literature, by R.P. Singh, Oxford Univ. Press, 2005, New Delhi.
4. Communication Skills for Engineers and Scientists, Sangeeta Sharma et.al. PHI Learning Pvt. Ltd, 2011, New Delhi.
5. Business Correspondence and Report Writing by Prof. R.C., Sharma & Krishna Mohan, Tata McGraw Hill & Co. Ltd. , 2001, New Delhi.
6. Word Power Made Easy by Norman Lewis, W.R. Goyal Pub. & Distributors, 2009, Delhi.
7. Developing Communication skills by Krishna Mohan, Mecra Bannerji- Macmillan India Ltd. 1990, Delhi.
8. Manual of Practical Communication by L.U.B. Pandey: A.I.T.B.S. Publications India Ltd.; Krishan Nagar, 2013, Delhi.
9. English Grammar and Usage by R.P.Sinha, Oxford University Press, 2005, New Delhi.
10. Spoken English- A manual of Speech and Phonetics by R.K. Bansal & J.B. Harrison Orient Blackswan, 2013, New Delhi

### **CS101: Computer Programming (2-0-2)**

Digital computer fundamentals: Historical perspective, Early computers, the von Neumann architecture. Pseudo code, and Flowchart. Memory, Variables, Values, Instructions, Programs. Assembly language, High level language, Compiler, Assembler, Operating Systems. Binary and other number system representations and conversion between them.

The C language. Phases of developing a running computer program in C.

Data Concepts in C: Constants, Variables, Expressions, Operators, and operator precedence in C. Managing input and output statements, Sequential control statements, Decision making statements (If-Else constructs), Loop control statements (While construct, Do While construct, For construct).

Different basic data types and their sizes. One-dimensional Arrays: Declaration and Initialization, Two-dimensional Arrays: Declaration and initialization, Multidimensional Arrays. String variables, Reading and writing strings, Arithmetic operations on characters, Putting strings together, Comparison of two strings.

Functions: The prototype declaration, Function definition.

Function call: Passing arguments to a function (by value, by reference). Scope of variables.

Recursive function calls, Tail recursion, Tree of recursion.

Sorting problems: Selection sort, Insertion sort. Sorting in multidimensional arrays. Sorting in arrays.

Search problems: Linear search and binary search. Recursive and iterative formulations.

Pointers: Declaring and dereferencing pointer variables. Pointer arithmetic. Accessing arrays through pointers. Pointer types, Pointer and strings.

Structures in C: Motivation, examples, declaration, and use. Operations on structures. Passing structures as function arguments. Type defining structures.

Self-referential structures, Dynamic data structures, Linked lists with examples.

File operations in C: Input, output, and error streams. Opening, closing, and reading from files.

Searching through files using functions such as fseek(), ftell(), and rewind(). Programming for command line arguments.

### **Text and Reference Books**

1. The C programming by Kernighan Brain W. and Ritchie Dennis M., Pearson Education .
2. Computer Basics and C Programming by V.Rajaraman , PHI Learning Pvt. Limited – 2015.

3. Programming in C by Kochan Stephen G. Pearson Education – 2015.
4. Computer Concepts and Programming in C by D.S. Yadav and Rajeev Khanna, New Age International Publication .
5. Computer Concepts and Programming in C by Vikas Gupta, Wiley India Publication
6. Computer Fundamentals and Programming in C. Reema Thareja, Oxford Publication
7. Computer Concepts and Programming in C, E Balaguruswami, McGraw Hill
8. Computer Science- A Structured Programming Approach Using C, by Behrouz A. Forouzan, Richard F. Gilberg, Thomson, Third Edition , Cengage Learning - 2007.
9. Problem Solving and Program Design in C, by Jeri R. Hanly, Elliot B. Koffman, Pearson Addison-Wesley, 2006.
10. Computer Concepts and Programming by Anami, Angadi and Manvi, PHI Publication
11. Computer Fundamental and C programming by K K Gupta, Acme Learning Publication

## **SECOND SEMESTER**

### **PH101: Engineering Physics (3-1-0)**

Electromagnetic Waves: Introduction to del operator, gradient of a scalar, divergence and curl of vectors, Gauss divergence theorem, Stake's theorem, equation of continuity, Introduction to displacement current, Maxwell's Equations, Wave Equation, Plane electromagnetic waves, Poynting's Theorem, Electromagnetic Boundary Conditions, Reflection and Refraction.

Polarization: Unpolarised light, Production of plane polarized light by grid polarizer, Polarization by reflection and Brewster's Law, Malus' Law, Double refraction, quarter wave plate, half wave plate, Production and analysis of various kinds of polarized lights.

Magnetic properties of matter: Dia, Para and Ferromagnetic materials, Magnetic domains, Magnetic Hysteresis, Calculation of Hysteresis loss, Three magnetic vectors, Magnetic circuit. Interaction of Radiation with Matter: Compton Effect and pair production (qualitative).

Laser: Coherent waves and interference, Temporal and Spatial coherence, Metastable states, Optical pumping, Population inversion, spontaneous and stimulated emission, Einstein's A and B coefficients, He-Ne laser.

Wave Mechanics: Failure of classical physics, Qualitative review of relevant experiments, de Broglie waves, Phase and Group velocities, Davisson and Germer experiment, Uncertainty principle, wave function and Schrodinger equation, probability interpretation, Application of time-independent Schrodinger equation -Particle in a box.

### **Text and Reference Books**

1. Concepts of Modern Physics - Aurthur Beiser (Mc-Graw Hill)
2. Introduction to Special Theory of Relativity- Robert Resnick (Wielly)
3. Optics –Ajoy Ghatak ( Tata McGraw Hill Education Private Ltd. New Delhi)
4. Optics - Brijlal & Subramanian (S. Chand )
5. Engineering Physics- C. Mani Naidu(Pearson)
6. Lasers Principles, Types and Applications- K R Nambiar (New Age)
7. Applied Physics for Engineers- Neeraj Mehta (PHI Learning, New

### **MA102: Engineering Mathematics-II (3-1-0)**

Linear dependence and independence, rank and inverse of a matrix, solution of algebraic equations- consistency conditions. Eigen values and Eigen vectors, Hermitian and skew Hermitian matrices.

Convergence of improper integrals, test of convergence, Beta and Gamma functions elementary properties, differentiation under the integral sign.

Series solution, Frobenius Method, Legendre's and Bessel's differential equation, Recurrence formula, Generating functions, orthogonality.



Rectification, double and triple integrals, computations of surfaces and volumes, change of variables in double integrals, Jacobians of transformations.

Scalar and vector fields, level surfaces, directional derivative, Gradient, Divergence, Curl, Laplacian, line and surface integrals, theorems of Green, Gauss and Stokes.

Finite differences, Newton's forward and backward interpolation formulae, Central difference interpolation. Lagrange's interpolation. Trapezoidal rule and Simpson's 1/3 rule of integration. Solution of polynomial and transcendental equations-bisection method, Newton-Raphson method and Regula-falsi method

### **Text and Reference Books**

1. E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.
2. B. V. Ramana, Higher Engineering Mathematics, Tata Mc Graw- Hill Publishing Company Ltd.
3. R.K.Jain & S.R.K. Iyenger, Advance Engineering Mathematics, Narosa Publishing House.
4. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers.
5. Peter V. O' Neil, Advanced Engineering Mathematics, Thomas (Cengage) Learning.
6. Chandrika Prasad, Advanced Mathematics for Engineers, Prasad Mudranalaya
7. A. C. Srivastava & P. K. Srivastava, Engineering Mathematics, Vol. – II, PHI Learning Pvt. Ltd.

### **EE101: Basic Electrical and Electronics Engineering (3-1-0)**

Electrical circuit: D.C circuit: voltage and current sources, mesh current method, nodal voltage method. Delta star and Star-delta transformation, Thevenin's theorem, superposition theorem, Norton's theorem, maximum power transfer theorem

A.C. Circuit: single phase and three phase A.C phasor representation. Electrical Circuit Element's R-L-C, their physical origin based on electromagnetic and electrostatics, R-L, R-C, R-L-C series circuits, sinusoidal steady state: power factor, active and reactive power, parallel and series circuits. Delta and star connections, line and phase quantities, single and three phase power measurement

A.C Fundamentals, Active, Reactive and Apparent power. Basics of transformers, D.C Machines and Induction motor.

Semiconductor devices: construction, working and V-I characteristics of diode, zener diode, LED, photodiodes, SCR, Diac, Triac and their applications.

Transistors: BJT, FET, MOSFET, Construction, working, type of configuration, V-I characteristics, biasing transistor circuits-fixed bias, emitter bias, feedback bias, voltage divider bias, transistor as an amplifier

Operational amplifier: introduction, parameters application-inverting, non-inverting amplifier unity follower, integrator, differentiator, summing circuit. Introduction of logic gates.

### **Text and Reference Books**

1. Basic Electrical Engineering, S N Singh; Prentice Hall International
2. Basic Electrical Engineering, Kuldeep Sahay, New Age International Publishers
3. Fundamentals of Electrical Engineering, B Dwivedi, A Tripathi; Wiley India
4. Electrical Engineering, J. B. Gupta, Kataria and Sons
5. Electrical and Electronics Technology, Edward Hughes; Pearson
6. Robert L. Boylestand / Louis Nashelsky "Electronic Devices and Circuit Theory", Latest Edition, Pearson Education.
7. H S Kalsi, "Electronic Instrumentation", Latest Edition, TMH Publication,.
8. George Kennedy, "Electronic Communication Systems", Latest Edition, TMH,
9. David A. Bell, "Electronic Devices and Circuits", Latest Edition, Oxford University Press.

10. Jacob Millman, C.C. Halkias, Staya brataJit, "Electronic Devices and Circuits", Latest Edition, TMH.
11. David A. Bell, Electronic Instrumentation and Measurements, Latest Edition, Oxford University Press India.

### **CE101: Environment and Ecology (3-0-0)**

Ecosystem: Concept of ecosystem. Structure and function of an ecosystem, Producers, consumers and decomposers. Energy flow in the ecosystem, Ecological succession, Food chains, food webs and ecological pyramids, Introduction, types, characteristic features, structure and function of the following ecosystem: Forest ecosystem. Grassland ecosystem, desert ecosystem, Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries).

Biodiversity and its conservation: Introduction-Definition: Genetic, species and ecosystem diversity, Biogeographical classification of India, Value of diversity: Consumptive use, productive use, social, ethical, aesthetic and option values, Biodiversity at global, national and local levels, India as a mega-diversity nation, Hot space of biodiversity, threats to biodiversity: Habitat loss, poaching of wildlife., man-wildlife conflicts, Endangered and endemic species of India, Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

Environment pollution: Causes, effects and control measures of: (a) Air Pollution, (b) Water pollution, (c) Soil pollution, (d) Marine pollution. (e) Noise pollution. (f) Thermal pollution, (g) nuclear pollution, Solid waste management: causes effects and control measures of urban and industrial wastes, role of individual in prevention of pollution, Pollution case studies, and Disaster management: floods, earthquake, cyclone and landslides.

Solid issues and the environment: From understandable to sustainable development, urban problems related to energy, Water conservation, rain water harvesting. Watershed management, resettlement and rehabilitation of people: its problems and concerns, case studies. Environmental ethics: issues and possible solutions. Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust, case studies, Wasteland reclamation, consumerism and waste products, Environment protection act. Air (prevention and control of pollution) act, Water (prevention and control of pollution) act, Wild life protection act, Forest conservation act. Issues involved in enforcement of environmental legislation, public awareness.

#### **Text and Reference Books**

1. Environment & Ecology by R. K. Agrawal & V .K. Sangal, Krishna's educational publishers
2. Environmental Studies -Benny Joseph-Tata Mcgraw Hill
3. Environmental Studies- D Manjunath, Pearson Education-2006.
4. Environmental studies- R, Rajagopillan -Oxford Publication
5. Text book of Environmental Science & Technology- M. Anji Reddy-US Publication

### **MM101: Material Science (3-0-0)**

Introduction: Types of materials from structure to property, Crystal structure: Bravais lattices , Lattice direction and planes . Crystal Imperfections: point, line and planer defect.

Deformation of material: Recovery recrystallization and grain growth, Mechanical properties of materials: Tensile, Impact, Fatigue and Creep of metals.

Electron theory of Metals: Free electron theory, Zone theory , The dependence of the energies on the wave number, The density of state curves, Conductors and insulators, Semiconductors, Dielectric behavior, Ferroelectricity, Piezoelectricity, Magnetism,

Principles of solidification: Nucleation and growth, Homogeneous and heterogeneous nucleation, Phase Diagrams: Phase rule, isomorphous, eutectic, peritectic, eutectoid and peritectoid

transformation, Fe-cementite diagram; Heat Treatment of Steel: TTT diagram, different heat treatment process: Annealing, normalizing and Hardening, Hardenability.

Selection of Engineering Materials: Common engineering materials including metals and alloys, ceramics composites, polymers.

### **Text and Reference Books**

1. Materials Science and Engineering, by William D. Callister, Jr, (Adopted by R. Balasubramaniam), Wiley India Pvt. Ltd.
2. Elements of Material Science & Engineering by Van Vlack, Pearson
3. Materials Science and Engineering - A First Course by Raghavan, PHI
4. Material Science and Engineering by Smith, Hashemi and Prakash, TMH
5. Introduction to Materials Science for Engineers by Shackelford, Pearson
6. Material Science by Narula , TMH.
7. Material Science for Engineering Students by Fischer, Academic Press
8. Technology of Engineering materials by Philip and Bolton, Butterworth-Heinemann

### **ME103: Engineering Graphics (2-0-2)**

Introduction to basic engineering drawing, instruments, sheet layouts, lines, lettering, dimensioning

Projection of points and lines, Projection of Solids.

Section of solids, Development of surfaces of solids.

Isometric projections

Orthographic projections. Use of CAD software to draw plan, elevation and other views of different objects.

### **Text and Reference Books**

1. Engineering Drawing - N.D. Bhatt & V.M. Panchal, 48th edition, 2005-Charotar Publishing House, Gujarat.
2. Computer Aided Engineering Drawing - S. Trymbaka Murthy, -I.K. International Publishing House Pvt. Ltd., New Delhi, 3rd revised edition- 2006.
3. Engineering Graphics - K.R. Gopalakrishna, 32nd edition, 2005- Subash Publishers Bangalore.
4. Fundamentals of Engineering Drawing with an Introduction to Interactive Computer Graphics for Design and Production-Luzadder Warren J., Duff John M., Eastern Economy Edition, 2005-Prentice-Hall of India Pvt. Ltd., New Delhi.
5. Engineering Drawing – M.B. Shah, B.C.Rana, 2nd Edition

## **THIRD SEMESTER**

### **PR 301: Engineering Mathematics –III (3-0-0)**

Laplace Transform and its properties, Unit step functions, Dirac delta function, , Periodic functions, Inverse Laplace transform, Convolution theorem, Evaluation of integrals by L.T., Solution of Boundary value problems

Fourier Series and its convergence, Fourier coefficients, Dirichlet's Condition, Change of interval, Half-range series, Complex form of Fourier Series

Fourier integral, Formula, Fourier Transform, Fourier sine and cosine transform, Linearity, Scaling, Frequency shifting and time shifting properties, self reciprocity of Fourier transform, Convolution theorem, Application to boundary value problems

Z-Transform and its properties, initial and final value theorem, Convolution theorem, Evaluation of Inverse Z-transform, Difference equation and its application

Line integration, Cauchy theorem, Cauchy Integral formula, Power series, Taylor's and Laurent's series, singularity and residues

Discrete and continuous random variable, cumulative distribution function, Probability mass function, Probability density function, Mathematical expectation, Mean variance, Moment generating function, Binomial Poisson and Normal Distribution.

### **Text and Reference Books**

1. E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.
2. B. V. Ramana, Higher Engineering Mathematics, Tata Mc Graw- Hill Publishing Company Ltd.
3. R.K.Jain & S.R.K. Iyenger, Advance Engineering Mathematics, Narosa Publishing House.
4. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers.
5. Peter V. O' Neil, Advanced Engineering Mathematics, Thomas (Cengage) Learning.
6. Chandrika Prasad, Advanced Mathematics for Engineers, Prasad Mudranalaya
7. A. C. Srivastava & P. K. Srivastava, Engineering Mathematics, Vol. – II, PHI Learning Pvt. Ltd.
8. Rukmangadachari, Engineering Mathematics – II, Pearson Education

### **PR302: Introduction to Soft Skill (2-1-0)**

Speech skills; Rules of Accent, Intonation, Group Discussions and mock interviews (interactive sessions)

Formal Communication: Curriculum Vitae, Minutes, Report Writing

Presentation Skills, Negotiation Skills, Non- verbal Communication and Body Language

Multicultural Communication, Time management, Decision making Emotional Intelligence

### **Text and Reference Books**

1. Rizvi, M. Asraf, Effective Technical Communication. Tata McGraw- Hill: New Delhi
2. Sethij, Lamalesh Sadanand and D.V. Jimdar. A Practical Course in English Pronunciation.
3. Chaturvedi, P.D. and Mukesh Chaturvedi. Bussiness Communication, Concepts, Cases, and Applications. Pearson Education: Delhi.
4. Mishra Sunita and C. Muralikrishtna. Communication Skills for Engineers. Pearson Education:Delhi

### **PR 303 Engineering Thermodynamics (4-0-0)**

Basic concept: Dimensions and units, thermodynamic systems and their properties, zeroth law and temperature equilibrium concept. First law of thermodynamics: Concept of work and heat, open and closed systems, internal energy and enthalpy flow work example. Second law of thermodynamics: Introduction, Kelvin Planks and Clausius statements and their equivalence, reversibility, irreversibility, reversible cycle, Carnot cycle, corollaries of second law, Clausius inequality, entropy as a property, principle of increase of entropy.

Power Cycles: Rankine cycle – Ideal, Reheat and Regenerative Rankine cycles. Gas Power Cycles: Gas Power Cycles; Otto cycle, Diesel cycle, Dual cycle and Brayton cycle. Refrigeration Cycles: Vapor compression refrigeration, Absorption refrigeration and Gas refrigeration Cycles.

Heat Transfer: Modes of heat transfer, conduction – Fourier law, thermal conductivity of solid, liquid and gases, factor influencing thermal conductivity, general 3-dimensional heat conduction equation. One-dimensional steady state conduction through plane walls, cylinder, spheres, flow

through composite walls, cylinder and spheres, critical thickness of insulation, heat conduction with internal heat source through plane wall and cylinders. Two-dimensional steady state conduction through plane wall, one-dimensional unsteady state heat conduction, heat capacity systems. Convection: Free and forced convection, basic concept of hydrodynamics thermal boundary layers, laminar and turbulent boundary layer over a flat plate, equation of motion and energy. Radiation: Thermal radiation, monochromatic and total emissive power, absorptivity, reflectivity and transmissivity, black and gray bodies, Planck law, Wein law, Stefan Boltzman law, Kirchoff's law, heat transfer by radiation between black and gray surfaces.

**Text and Reference Books:**

1. Engineering Thermodynamics, P. K. Nag, Tata McGraw-Hill Education.
2. Thermodynamics: An Engineering Approach, Yunus A. Cengel and Michael A. Boles, Tata McGraw-Hill Education.
3. Heat Transfer, Yunus A. Cengel, Tata McGraw-Hill Education

**PR 304: Quality Assurance and Reliability: (3-1-0)**

Definition of quality, Dimensions of quality, Evolution of quality, Quality cost, Quality assurance, Quality control, Quality planning, Difference between quality control and quality assurance, Quality system, Quality policy

Quality circles, ISO 9000 - ISO 14000 series of quality systems, Quality Awards, Quality audits. Probability distribution: Normal, Exponential, Weibull, Binomial, Poisson, Gamma, Hypergeometric and Chi square distribution

Sampling theory, Operating characteristic curve, AOQ for single sampling plan, Acceptance sampling

Statistical quality control (SQC), Benefits and limitations of SQC, Statistical process control, Control charts for variables - Average chart, Range chart, Standard deviation chart, Control charts for attributes - p chart, np chart, c chart, u chart, U chart, Taguchi techniques,

Reliability: Reliability function, Failure rate, Mean time between failures (MTBF), Mean time to failure (MTTF), Mean time to repair (MTTR), Bathtub hazard rate curve, Useful life availability, maintainability, system effectiveness, Product reliability, Reliability testing, Reliability evaluation, Reliability evaluation of two-state device networks-series, parallel, k-out-of-m systems; Standby redundant systems, Reliability evaluation of three-state device networks-series and parallel, Reliability achievement.

**Text and Reference Books:**

1. Charantimath, Poornima M., Total Quality Management, Pearson
2. Quality control and reliability analysis by Brijendra Singh, Khanna Pub
3. Ramasamy S, Total Quality Management, McGraw-Hill.
4. Mitra A, Fundamental of Quality Control and Improvement, Wiley
5. Mahajan, M., Statistical Quality Control, Dhanpat Rai Publication,
6. Reliability Engineering by E Balagurusamy, Tata McGraw Hill New Delhi
7. The assurance science: A introduction to quality control and reliability by Siegmund Halpern, Prentice hall New Delhi.

**PR 305 Mechanics of Solids (3-1-0)**

Strain Energy: Strain energy due to direct bending. Castigliano's theorem, application to deflection of simply supported beams and cantilever beams due to shear.

Thick cylinders and spheres: Thick cylinders, Radial and hoop stresses. Application of compound stress theories, compound cylinders, thick spherical- shell radial and circumferential stresses. Rotation of rings and discs: Thin disc of uniform thickness, Radial and hoop stresses, Disc with central holes, Disc of uniform strength.

Theories of yielding: Different theories of failure, Comparison of theories of failure, yield loci.

Unsymmetrical bending: Flexural stresses due to unsymmetrical bending of beams

Shear Centre: Shear centre for thin walled open cross flow section, shear flow.

Analysis of strain: Principal strain, Strain Rosette, Mohr's circle of strain & strain Rosette.

Fatigue: Fatigue of metal, Bauschinger's experiment, strain method of obtaining fatigue ranges formula connecting stress range, Maximum stress and ultimate strength S-N curve, Gerber's formula, Goodman's law

Creep: Creep of metals, Mechanisms of creep; Equi-cohesive temperature; Creep curve, Creep rate; Prediction of long term properties from short duration test.

### **Text and Reference Books**

1. Mechanical Metallurgy by George E. Dieter, McGraw Hill Education
2. Mechanics of Materials by Stephen Timoshenko and James M. Gere, CBS Publication.
3. Strength of Materials By Sadhu Singh, Khanna Publication
4. Deformation and Fracture Mechanics of Engineering Materials by Richard W. Hertzberg, Richard P. Vinci, Jason L. Hertzberg, Wiley

### **PR 306 Fluid Mechanics and Machinery (4-0-0)**

Introduction: Concept of continuum; Fluid properties: Viscosity, compressibility, surface tension and capillarity; Types of fluid: real and ideal, Newtonian and Non-Newtonian compressible and incompressible.

Fluid Statics: Fluid pressure and its measurement; manometers: simple and differential types, pressure gauges; hydrostatic force and centre of pressure on plane submerged surfaces. Buoyancy and Floatation: buoyant force and centre of buoyancy, meta-centre and meta-centric height, determination of meta-centric height, conditions of equilibrium of floating and submerged bodies.

Fluid Dynamics: Forces influencing motion of fluid, Euler's equation of motion, Bernoulli's equation, momentum and moment of momentum equations, kinetic energy and momentum correction factors, introduction to Navier-Stokes' Equation.

Introduction: Classification of Fluid Machineries.

Dynamic Action of Fluid Jet: Impact of fluid jet on fixed and moving flat plates, Impact of jet on fixed and moving curved vanes, flow over radial vanes, Jet Propulsion, Euler's fundamental equation, Degree of reaction.

Hydraulic Turbines: Introduction, classification, Impulse Turbine: constructional details, velocity triangles, power and efficiency calculations. Reaction Turbines: constructional details, working principle, velocity triangles, power and efficiency calculations, draft tube, cavitation, governing of turbines, performance characteristic curves.

Positive Displacement Pumps: Reciprocating Pump: working principle, classification, slip, indicator diagram, effect of friction and acceleration, theory of air vessel, performance characteristic curves; gear oil pumps and screw pump.

Rotodynamic Pumps: Introduction, classification, centrifugal pump: main components, working principle, velocity triangles, effect of shape of blade, specific speed, heads, power and efficiency calculations, minimum starting speed, multistage pumps, performance characteristics, comparison with reciprocating pump.

**Text and Reference Books:**

1. Fluid Mechanics by Frank M. White, Mcgraw Hill Education
2. Fluid Mechanics and Hydraulic Machines by R. K. Bansal, Laxmi Publication
3. Engineering Fluid Mechanics by K.L Kumar, S. Chand Publication

**FOURTH SEMESTER****PR 401: Metrology (3-0-0)**

Definitions, precision and accuracy, linearity, repeatability, sensitivity, readability, types and source of errors.

Linear measurement, Vernier calipers, Vernier height master, micrometer, tests for their accuracies.

Limits, fits and gauges, definition and terminology, compound tolerances, tolerance accumulation, fundamental deviation,, calculation of limits, clearance, tolerance etc., types of fits.

Comparator: characteristics, uses and special requirements, sigma mechanical comparators, reed type mechanical comparator, pneumatic comparator, electrical comparator, relative merits and demerits of comparators.

Measurement by light wave interference, flatness testing, fringe patterns, N.P.I. flatness interferometer, Coordinate measuring machine (CMM).

Angular measurement sine centre, sine bar, straightness test by spirit level, and auto collimator.

Measurement and testing of spur gears, terminology of gear tooth, involutes curve, rolling gear test, measurement of tooth thickness by constant chord method, gear tooth Vernier caliper, base tangent method, base pitch measurement, run-out measurement, tooth profile checking.

Measurement of surface finish, terminologies, center line, average root mean square, maximum peak to valley height, surface inspection of comparison methods, roughness measurement by instruments.

Measurement of screw thread, screw terminology, pitch errors in screw thread, measurement of major diameter, minor diameter and effective diameter, two wire method and three wire method.

**Text and Reference Books:**

1. Engineering Metrology, R. K. Jain, Khanna Publishers
2. Engineering Metrology, O. P. Khanna, Khanna Publishers
3. I.C. Gupta, (2003), 'Text Book of Engineering Metrology', Dhanpat Rai Publishing Company.
4. K.J. Hume, 'Engineering Metrology', Macdonald and Co. (publisher) London
5. Czichos (2011), 'The Springer handbook of metrology and Testing'
6. Jay. L. Bucher, 'The Metrology Hand book', American Society for Quality, 2004
7. Smith GT (2002), 'Industrial Metrology',Spinger
8. John W. Greve, Frank W. Wilson, 'Hand book of industrial metrology' PHI – New Delhi
9. D.M. Anthony, 'Engineering Metrology', Pergamon Press.

**PR402: Numerical Methods and Applications (3-1-0)**

Number Systems and Errors: The presentation of integers, the representation of fractions, floating-point arithmetic, loss of significance and error propagation; condition and instability computational methods for error estimation, some comments on convergence of sequences

Interpolation by Polynomial: Polynomial forms, the divided-difference table, interpolation at an increasing number of interpolation points, the error of the interpolating polynomial, interpolation in a function table based on equally spaced points.

The solution of Nonlinear Equations: A survey of iterative methods, programs for some iterative methods, fixed-point iteration, convergence acceleration for fixed-point iteration, convergence of the Newton and secant methods, polynomial equations: real roots, complex roots and Muller's method.

Matrices and Systems of Linear Equations: The solution of linear systems by elimination, the pivoting strategy, error and residual of an approximate solution; norms, backward-error analysis and iterative improvement, determinants, the Eigen value problem

Approximation: Uniform approximation by polynomials, data fitting, orthogonal polynomials, least-squares approximation by polynomials, approximation by trigonometric polynomials, fast Fourier transforms, piecewise-polynomial approximation

Differentiation and integration: Numerical differentiation, numerical integration: some basic rules, Gaussian rules, composite rules, Adaptive quadrature, extrapolation to the limit, Romberg integration

The Solution of Differential Equations: Mathematical preliminaries, simple difference equations, numerical integration by Taylor series, error estimates and convergence of Euler's method, Runge-Kutta methods, step-size control with Runge-Kutta methods, multistep formulas, Predictor-Corrector methods, stability of numerical methods

Introduction to Solutions of P.D.E.: Partial differential equations and their classifications, finite difference representation of first order and second order derivatives, solution procedure of homogeneous parabolic, elliptic and hyperbolic equations

### **Text and Reference Books**

1. Elementary Numerical Analysis-an algorithmic approach, by S.D.Conte & C.D.Boor.
2. Introductory Method of Numerical Analysis by S.S.Sastry( Prentice-Hall of India Pvt.Ltd.)
3. Numerical Methods for Scientific and Engineering Computation, by M.K.Jain, S.R.K.Iyengar & R.K.Jain (Wiley Eastern Ltd.)

### **PR403: Manufacturing Processes-I**

**(4-0-0)**

Introduction to metal casting processes: Casting terms, Sand mould making procedure, Composition of moulding sand and its different properties, Advantages and limitations of casting processes, Application of casting process.

Patterns, Materials, Allowances in patterns, Types of patterns, Pattern color code, Gating and riser design,

Special casting techniques - Shell mould casting, Investment casting, Die casting and its variants, Centrifugal casting and its variants, Continuous casting.

Melting furnaces-cupola, muffle, induction etc., Casting defects.

Foundry automation

Introduction to Metal forming processes: Classification of metal forming processes, Plastic deformation and Yield criteria, Hot and Cold working, Forging, Rolling, Extrusion, Wire drawing, Sheet metal operations.

Classification of joining processes, Types of joints and welding positions, Weld nomenclature, Welding heat sources and their characteristics.

Various welding processes: Electric arc welding, Gas welding, Resistance welding, Solid state welding processes, Electron beam welding and Laser beam welding, Metallurgical characteristics of welded joints, Welding defects, Weld testing and Inspection.

### **Text and Reference Books**

1. R. K. Jain, 'Production Technology : Manufacturing Processes, Technology and Automation 17th Edition
2. Ghosh and Malik, 'Manufacturing Science', TMH
3. P.C. Pandey, Production Engineering Science



4. Kalpakjian, 'Manufacturing Engineering & Technology', Pearson
5. P. N. Rao, 'Manufacturing Technology', MCGRAW HILL INDIA
6. Lindberg, 'Manufacturing Processes', Pearson.
7. Kalpakjian, 'Manufacturing Processes for Engineering materials', Pearson
8. Kaushish, 'Manufacturing Processes' PHI
9. Principles of Foundry Technology, Jain, MCGRAW HILL INDIA

#### **PR404: Theory of Machines**

**(3-1-0)**

Basic kinematics concepts: Links, kinematic pairs, mechanism and inversion. Friction devices: Introduction, belt, chain and, rope drives, transmission of power through friction clutch, brakes. Fundamental law of gearing and gear trains: Classification of gears, basic terminology, geometric and kinematic characteristics of involute and cycloidal tooth profiles, undercutting and interference. Simple, compound and planetary gear train, tooth load and torque. Cams: Classification of cams and follower, radial cam, nomenclature, types of follower motions: uniform, simple harmonic, parallel cycloidal. Generation of cam profile by graphical method, pressure angle, cams with specific contours. Vibration: Basic concept, SHM, degree of freedom, types of damping, equivalent system, free and forced vibration, linear and angular single degree freedom system with and without damping, whirling of shaft, vibration isolation and absorber, elementary treatment of system with two-degree of freedom.

#### **Text and Reference Books**

1. G.H. Martin (1982), 'Kinematics and Dynamics of Machines', 3<sup>rd</sup> edition, McGraw-Hill.
2. A. Ghosh, and A. K. Mallik (2003), 'Theory of Mechanisms and Machines', 2<sup>nd</sup> edition, affiliated East-West Press.
3. T. Bevan (2004), 'Theory of Machines', 3<sup>rd</sup> edition, CBS Publishers.
4. J. J. Vicker, J. E. Shigley, and G. R. Penock (2003), 'Theory of Machines and Mechanisms', 3<sup>rd</sup> edition, Oxford University Press.,
5. J. Hannah, and R. C. Stephens (2004), 'Mechanics of Machines: Elementary Theory and Examples', 4<sup>th</sup> edition., Viva Books.

#### **PR 405: Production Management-I**

**(3-0-0)**

Plant and business organization: Concept, importance and principles of organization, organization chart, Organization manual, Types of organization according to structure along with their advantages, disadvantages and application.

Classification of business organization and ownership along with their advantages, disadvantages and application.

Sources of finance: Need for finance, Types of capital sources, Working capital, Capital structure  
Facility layout and location of plant: Concept and factors governing plant location, location economics, Rural vs. urban plant sites, Process layout, Product layout, Combination layout, Fixed layout, Flow pattern and material handling,

Production planning and control: Introduction, functions of PPC, Design of Production planning and control system.

Sales forecasting: Concept, purpose, techniques, statistical analysis, moving average forecast, exponential smoothing (Smoothing forecast estimation by salesmen etc.).

Inventory control: Introduction, costs, Economic Order Quantity, deterministic and stochastic model, Break Even Analysis.

Materials management: Purchase organization, buying techniques, quality and quantity techniques, accounting, stores and material control, receipts and issue of materials, physical verification of stores.

### **Text and Reference Books**

1. M. Mahajan, 'Production planning and control' Dhanpat Rai Publishers
2. O. P. Khanna. 'Industrial Engineering and Management'.
3. S N Chary (2013) . 'Production and Operation Management', 5th Edition, Tata Mac Graw Hill.
4. J. L. Riggs, 'Production Systems: Planning, Analysis & Control', 4th Edition, John Wiley & Sons.
5. E. S. Buffa and Sarin, 'Modern Production/Operation management', 8<sup>th</sup> Edition, John Wiley & Sons.
6. Paneersalvem, 'Production & Operations Management', 2<sup>nd</sup> edition, PHI.

### **PR 406: Industrial Economics and Accountancy (3-1-0)**

Engineering Economy: Equivalence, time value, present value and annual equivalent cost. Replacement analysis, rate of return evaluation of public activities, generation and evaluation of alternatives in engineering situations, projects, replacement. Depreciation, bath-tub curve, value engineering. Accounting: Financial statements, double entry book keeping, inventory control. Costing: Cost concept, material, labour and overhead costs, overhead allocations and absorption: Introduction to job costing, process costing, marginal costing, standard costing, relevant costs for decision making, cost control and cost reduction, measurement and determinants of market power, market power and public policy.

### **Text and Reference Books**

1. A. Ardalan (1999), 'Economic and Financial Analysis for Engineering and Project Management', CRC Press
2. E. L. Grant, W. Grant, and R. S. Leavenworth (2001), 'Principles of Engineering Economy', 8th Ed., John Wiley & Sons.
3. T. G. Eschenbach (2003), 'Engineering Economy by Applying Theory to Practice (Engineering Technology)', 2<sup>nd</sup> Edition, Oxford University Press.
4. L.T. Blank, and A. J. Tarquin (2003), 'Engineering Economy', McGraw-Hill.
5. J. C. Hartman (2006), 'Engineering Economy and the Decision-Making Process', Prentice-Hall.

## **FIFTH SEMESTER**

### **PR501: Computer Aided Design and Manufacturing (CAD/CAM) (4-0-0)**

Introduction - Concept of CAD/CAM, Computer system, Hardware in computer Aided Design system. Product cycle, Computer aided design system softwares, Transformation, Geometric modelling, Drafting applications, CAD/CAM techniques for finite element data preparation, concept of data structure, Automated material Handling, FMS, CAPP, Computer integrated production planning system, MRP, capacity planning, shop floor control.

### **Text and Reference Books**

1. Computer Graphics, by Hearn & Baker, Prentice Hall of India
2. CAD/CAM, by Groover and Zimmers, Prentice Hall India Ltd.
3. CAD/CAM :Theory and Practice, by Zeid, McGraw Hill
4. CAD/CAM: Computer Aided Design and Manufacturing, by Groover, Pearson India

### **PR502: Machine Design (3-1-0)**

Introduction: Design procedure, Selection of preferred sizes, Aesthetic and ergonomic considerations in design, Manufacturing considerations in machine design, Engineering materials

and their properties, Effect of alloying elements and heat treatment on properties of steels, Materials selection in machine design. IS coding of steel and cast iron, Simple stresses in machine parts, Torsional and bending stresses, Dynamic loads.

Design against fluctuating load: Stress concentration, Endurance limit, Factors affecting endurance limit, Fatigue failure, S-N diagram, Design for reversed stresses and cumulative damage, Fluctuating stresses, Soderberg, Gerber, Goodman and Modified Goodman criteria, Combined stresses

Design of riveted joints, welded joints, bolted joints, cotter joint, knuckle joint. Design of pressure vessels and pipe joints. Design of keys, couplings, shafts, levers, columns, studs and power screw. Design of belt and chain drives, pulleys, springs, clutches and brakes.

#### **Text and Reference Books**

1. Design of Machine Elements, V.B. Bhandari, Tata McGraw Hill Co
2. Machine Design-Sharma and Agrawal, S.K. Kataria & Sons.
3. Machine Design, U C Jindal, Pearson Education.
4. Design of Machine Elements, Sharma and Purohit, PHI.
5. Design of Machine Elements-M.F. Spott, Pearson Education
6. Machine Design-Maleev and Hartman, CBS Publishers
7. Mechanical Engineering Design, 9e – Joseph E. Shigely, McGraw Hill Education.
8. Elements of Machine Component Design, Juvinal & Marshek, John Wiley & Sons

#### **PR503: Manufacturing Processes-II (4-0-0)**

Introduction to Machining and Cutting Tool Geometry: Different conventions or methods of defining tool geometry; Geometry of a single point turning tool; Geometry of milling cutters and twist drill; Conversion of tool angles of a single point turning tool

Mechanism of chip formation: Chip formation mechanism in ductile and brittle materials; Geometry and characteristics of continuous chip formation: chip reduction coefficient and cutting ratio, shear angle, cutting strain, built-up edge formation, classification of chips, shear plane and shear zone theories, orthogonal and oblique cutting, chip tool contact length

Mechanics of chip formation: Development and action of cutting force, Analysis of cutting forces in orthogonal machining using Merchant's Circle Diagram (MCD); Working principle of measurement of cutting forces by dynamometers; Dynamometers for estimating cutting forces

Cutting Temperature: Locations and causes of heat generation in machining; Analytical methods of evaluation of cutting temperature; Measurement of cutting temperature; Role of variation of different geometrical and process parameters on cutting temperature; Control of cutting temperature and cutting fluid application

Tool Life: Major causes and modes of failure of cutting tools; Mechanisms of cutting tool wear; Geometry and measurement of cutting tool wear; Definition and evaluation of tool life; Taylor's tool life equation; Role of different machining parameters on tool life; Assessment and improvement of cutting tool materials

Introduction to Machine Tools: Principle of machine tools, Brief constructional details of lathe, milling machine, drilling machine, grinding machine, Kinematic systems of lathe, milling machine.

#### **Text and Reference Books**

1. Machining and Machine Tools – A. B. Chattopadhyay, Wiley Publishers
2. Metal Cutting – Theory and Practice – Amitabha Bhattacharyya, New Central Book Agency
3. Metal Cutting Principles – Milton C. Shaw, Oxford University Press
4. Manufacturing Science – A. Ghosh, A. K. Mallik, East-West Press Pvt. Ltd

#### NPTEL References:

### **PR 504: Production Management II (3-0-0)**

Value Engineering: Introduction, Objective, Importance of value, Cycles of a product, Value engineering approach, Phases of job plan, Technique of value Engineering, Structure of value Engineering, Organization advantages, Application.

Union and Industrial Relations: Introduction, Trade Unions, Industrial disputes, strikes Lockout, Picketing, Ghero, Settlement of industrial disputes, Collective bargaining handling of worker grievances and procedure, workers participation in management, Union management relations. The Design and scheduling of flow processing system.

Sales and Marketing Management:- Sales organization (functional, area based). Product group organization (functional, abases, product group based, end use based), Selling vs marketing concept, Marketing management and its functions, Marketing research (objective scope) Marketing research techniques, Advertisement, Sales promotion, Channels of distribution packing.

Product development: Basic concepts, Alternative product strategies, Steps in new product development, Product design, Consumer perception and product positioning. Business Process

Re-engineering: Historical background: Nature, significance and rationale of business process reengineering, Fundamental of BPR

#### **Text and Reference Books**

1. S N Chary (2013) 'Production and Operation Management', 5th Edition, Tata Mac Graw Hill.
2. J. L. Riggs, 'Production Systems: Planning, Analysis & Control', 4th Edition, John Wiley & Sons.
3. E. S. Buffa and Sarin, 'Modern Production/Operation management', 8<sup>th</sup> Edition, John Wiley & Sons.
4. Paneersalvem, 'Production & Operations Management', 2<sup>nd</sup> edition, PHI.

### **PR505: Design of Production Tooling (4-0-0)**

Work holding device: Purpose and function of work holder, Principles of jig and fixture design, Method of location, 3-2-1 Method of location, Principles of pin locations, Locating devices, Type of clamping devices, Jig bushes, Types of jigs, Classification of fixtures, Milling fixtures, Turning fixtures, Boring fixtures

Press work die design: Classification of presses, Classification of dies, Centre of pressure, Cutting action in die, Die clearances, Cutting forces in die, Stock stop pilots.

Konckout piercing die design, Blanking die design, Compound die design, Scrap-strip layout for blanking, Evolution of progressive die.

Drives in machine tools, Selection of range of spindle speeds, Setting upper limit and lower limit of centre lathe, Standard value of range ratio, Upper and lower limit of milling machines, Principle of stepped regulation.

Speed loss in G.P., Number of steps in speed range, Number of practical subdivisions for obtaining a desired number of steps, Rules for layout of gear boxes having sliding clusters, Types of structure, Ray diagrams, Decision making for the best ray diagram of a gear box, Determining the number of teeth in gears, Strength of gear teeth, Determination of modules, Design of gear boxes, Mechanical step less drives.

#### **Text and Reference Books**

1. Joshi, P.H. "Jigs and Fixtures", Second Edition, Tata McGraw Hill Publishing Co., Ltd., New

2. Delhi, 2004
3. Donaldson, Lecain and Goold “Tool Design”, III<sup>rd</sup> Edition Tata McGraw Hill, 2000
4. K. Venkataraman, “Design of Jigs Fixtures & Press Tools”, Tata McGraw Hill, New Delhi, 2005.
5. Kempster, “Jigs and Fixture Design”, Hoddes and Stoughton – Third Edition 1974.
6. R.G.W. Pye, Injection Mould Design, SPE Publication, 2000

**PR506: Additive Manufacturing (3-0-0)**

Classification of manufacturing processes, Different manufacturing systems, Introduction to rapid prototyping (RP), Need of RP in context of batch production, FMS and CIM and their application, Basic principles of RP, Steps in RP, Process chain in RP in integrated CAD-CAM environment, Advantages of RP, Classification of different RP techniques – based on raw materials, layering technique (2-D or 3-D) and energy sources : Process technology and comparative study of : Stereolithography (SL) with photo-polymerisation, SL with liquid thermal polymerization, Solid foil polymerization, Selective laser sintering, Selective powder binding, ballistic particle manufacturing – both 2-D and 3-D, Fused deposition modeling, Shape melting, Laminated object manufacturing, Solid ground curing, Repetitive masking and deposition, Beam interference solidification, Holographic interference solidification, Special topic on RP using metallic alloys, Programming in RP, Modeling, Slicing, Internal hatching, Surface skin fills, Support structure.

**Text and Reference Books**

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.
3. Ali K. Kamrani, Emand Abouel 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

**SIXTH SEMESTER**

**PR601: Design for Manufacturing and Assembly (3-0-0)**

Introduction to Design for Manufacturing and Assembly: Engineering design process and its structure, steps in design process, traditional design methods, Introduction to DFMA: History of DFMA, Steps for applying DFMA during product design, Advantages of applying DFMA during product design, Reasons for not implementing DFMA.

Design for manufacturing for metal parts: Recommendations in the Forging Design, Pressed Components Design, Casting Design, Ease of Location and Clamping, Design of Die Casting, Design of Powder Metallurgical Parts

Design for Manual Assembly: Introduction, General Design Guidelines for Manual Assembly, Design Guidelines for Part Handling, Design Guidelines for Insertion and Fastening, Development of a Systematic DFA Analysis Method, DFA Index, Classification System for Manual Handling, Classification System for Manual Insertion and Fastening, Effect of Part Symmetry on Handling Time, Effect of Part Thickness and Size on Handling Time, Effect of Weight on Handling Time, Parts Requiring Two Hands for Manipulation, Threaded Fasteners, Effects of Holding Down, Problems with Manual Assembly Time Standards, Application of the DFA Method.

Product Design for High-Speed Automatic Assembly and Robot Assembly: Introduction, Design of Parts for High-Speed Feeding and Orienting, Additional Feeding Difficulties, High-Speed Automatic Insertion, Analysis of an Assembly, General Rules for Product Design for Automation, Design of Parts for Feeding and Orienting, Product Design for Robot Assembly.

### **Text and Reference Books:**

1. Geoffrey Boothroyd, Peter Dewhurst and Winston Knight (2002) Product Design for Manufacture and Assembly, Second Edition, CRC press, Taylor & Francis, Florida, USA
2. O. Molloy, S. Tilley and E.A. Warman (1998) Design for Manufacturing and assembly, First Edition, Chapman & Hall, London, UK.
3. A.K. Chitale and R.C. Gupta, (1999) Product design and Manufacturing, Prentice Hall of India, New Delhi.
4. Geoffrey Boothroyd (2005) Assembly Automation and Product Design, Second Edition, CRC press, Taylor & Francis, Florida, USA

### **PR602: Metal Forming (3-0-0)**

Elastic & plastic deformation, yield criteria (Mises' and Tresca's). Hot working versus cold working.

Analysis (equilibrium equation method) of forging process for load estimation with sliding friction, sticking friction and mixed condition for slab and disc. Work required for forging, Hand, Power, Drop Forging.

Metal Forming Processes (continued): Analysis of Wire/strip drawing and maximum-reduction, Tube drawing, Extrusion and its application.

Condition for Rolling force and power in rolling. Rolling mills & rolled-sections. Lubrication and defects in metal forming processes.

Sheet Metal working: Presses and their classification, Die & punch assembly and press work methods and processes. Cutting/Punching mechanism, Blanking vs. Piercing. Compound vs. Progressive die. Flat-face vs Inclined-face punch and Load (capacity) needed. Analysis of forming process like cup/deep drawing. Bending & spring-back.

### **Text and Reference Books**

1. Fundamentals of Metal Forming Processes, 2/e, Book by B. L. Juneja
2. Manufacturing Science by Ghosh and Mallik
3. Production Engg. Science by P.C. Pandey

4. Manufacturing Engineering & Technology by Kalpakjian, Pearson
5. Manufacturing Technology by P.N. Rao., TMH
6. Materials and Manufacturing by Paul Degarmo.
7. Manufacturing Processes by Kaushish , PHI
8. Production Technology by R.K. Jain

### **PR603: Operations Research (4-0-0)**

Scope and application of operation research. Linear programming, graphical and simplex method. Special cases in linear programming problems. Duality in linear programming.

Specially structured linear programming problems: Transportation - North west corner method, Least cost method, Penalty method. Methods for optimality check - Modified distribution (MODI) method, Vogel's approximation method (VAM), Assignment models - Hungarian method, Dynamic programming,

Queuing theory( single and double channel). Sequencing model (n jobs – 2 machines, n jobs - 3 machines), CPM and PERT and CPM- crashing networks.

Replacement problems, Inventory models with probabilistic demands and area, quantity constraints, Game theory (competitive strategies), Non-linear programming (Kuhn-Tucker condition), Simulation and Monte-Carlo techniques.

#### **Text and Reference Books**

1. Problem in Operation Research (Principles & Solution), D S Hira, Prem Kumar Gupta)
2. Operations Research, Swarup by Kanti Swarup, P. K. Gupta, Man Mohan
3. Quantitative Techniques in Management, N. D. Vohra

### **PR604: Non Traditional Manufacturing Processes (4-0-0)**

Needs of manufacturing industries and the concept of surface integrity. The role of newer & innovative processes for the solutions

Impact erosion and the evaluation for impregnation of foreign bodies. Theory and application of Abrasive Jet, Water Jet, Abrasive Flow, Ultrasonic, Total Form Machining and Low stress Grinding.

Theory and applications of Chemical Processing: Chemical Machining, etching of semiconductors, coating and Electroless forming and CVD.

Theory and applications of Electrochemical machining and grinding including, Electrochemical sharpening, polishing, honing and deburring, surface treatment, coating and Electroforming.

Thermal energy methods of material processing (machining, welding, cladding, alloying and heat-treatment): Electro-discharge, Laser, Electron beam, Plasma arc, Plasma spray, Ion beam and PVD.

Hybridization of processes for improving process capability and surface integrity. Explanation of some processes like ECDG, ultrasonic and Laser assisted processing, LIGA & SLIGA etc.;

Generic manufacturing and introduction to rapid prototyping.

P-component: Experiments on EDM, ECM, laser etc

#### **Text and Reference Books**

1. Modern Machining Processes by Pandey and Shan Tata McGraw-Hill Education
2. Non-conventional Machining by P.K. Mishra Narosa Publishing House
3. Manufacturing Science by Ghosh and Mallik Prentice Hall PTR
4. Non-traditional manufacturing processes, by Gary F. Benedict CRC Press
5. Non-Traditional Machining Processes by Jagadeesha T, I K International Publishing House

### **PR605: Total Quality Management (3-1-0)**

Introduction: Definition of quality, Dimensions of quality, Evolution of quality, Quality control (QC), Quality assurance (QA), Quality planning (QP), Fundamentals of total quality management (TQM), Some important philosophies and their impact on quality (Deming, Juran, Crosby), Identification and measurement of quality costs, Issues related to products, processes, organization, leadership and commitment for total quality achievement,

TQM Principles and Strategies: Customer satisfaction, Employee involvement, Continuous process improvement, Supplier partnership, Performance measures.

TQM Tools: Business process benchmarking (BPB), Quality function deployment (QFD), Failure mode and effect analysis (FMEA), Six sigma - Basic Concept, Methodology, Process Improvement Model (DMAIC) Steps (Objectives, Tools and Techniques used), Six sigma organization and its Implementation requirements, Introduction to lean manufacturing, JIT, Kaizen, Total productive maintenance

Statistical Process Control Techniques: Definition of statistical quality control (SQC), Benefits and limitations of SQC, Introduction to statistics, Seven quality control tools (old and new), Control charts,

Quality Systems: Need for ISO 9000 and Other Quality Systems, ISO 9000:2000 Quality System – Elements, Implementation of Quality System, Documentation, Quality Auditing, TS 16949, ISO 14000 – Concept, Requirements and Benefits.

#### **Text and Reference Books**

1. Charantimath, Poornima M., Total Quality Management, Pearson
2. Ramasamy S, Total Quality Management, McGraw-Hill.
3. Mitra A, Fundamental of Quality Control and Improvement, Wiley

### **PR606: Professional Elective I (3-0-0)**

#### **Finite Element Method**

Introduction to Finite Element Methods, general descriptions, concept of finite elements: discretization and interpolation function, steps of finite element analysis's procedure.

Calculus of Variation: Function and functionals, Euler Lagrange equation, Boundary conditions, determination of functionals for plane and axisymmetric elastic problems, heat conduction problems, plates and shells problems.

Finite elements: One-two and three-dimensional elements, axi-symmetric elements: generalised: local, global and natural co-ordinate systems.

Iso-parametric, interpolation function, field variable model for displacement and temperature. Direct, variational and Galerikan Methods.

Equation of single elements and assembly of elements and solutions. Application to plane and axi-symmetric elastic problems, heat conduction, plates and shells problems.



### **Text/Reference Books:**

1. Chandrupatla T.R., and Belegundu A.D., Introduction to Finite Elements in Engineering, Pearson Education
2. David V Hutton, Fundamentals of Finite Element Analysis McGraw-Hill Int. Ed.
3. Rao S.S. The Finite Element Method in Engineering, Pergammon Press.
4. Logan D.L., A First course in the Finite Element Method, Third Edition, Thomson Learning,
5. Robert D.Cook., David.S, Malkucs Michael E Plesha , Concepts and Applications of Finite Element Analysis.
6. Reddy J.N, An Introduction to Finite Element Method, McGraw-Hill International Student Edition
7. O.C.Zienkiewicz and R.L.Taylor, The Finite Element Methods, Vol.1. The basic formulation and linear problems, Vol.1, Butterworth Heineman.

### **Digital Manufacturing**

Overview of digital manufacturing processes, What makes a manufacturing process “digital”, The 10 disruptive principles of digital manufacturing processes  
Additive Manufacturing processes – Engineering polymers, metals, ceramics: Stereolithography, Selective Laser Sintering, Fused Deposition Modelling, Polyjet, LENS, Layered object manufacturing, Additive Manufacturing processes for advanced materials: Electronic Materials, Bioprinting, Food Printing, Material properties  
Programmable Assembly, Digital Assembly, Digital Bending  
Fundamentals of geometric representations for digital manufacturing: Solid representations, Boundary representations, Function representations, Voxel representations  
Algorithmic design for digital manufacturing: Parametric Models, Vibrational Geometry, Generative models, Topology optimization, Industrial Safety, Liability and intellectual property, Environmental impact,  
Internet of Things: Advantages and Challenges.

### **Reference and text books**

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.
3. Groover, M.P. and Zimmers, E.W. Jr., CAD/CAM: Computer-aided Design and Manufacturing, Prentice-Hall of India Private Ltd, New Delhi, ISBN 0-87692- 402-10, 1986.

### **Surface Engineering**

Fundamentals of surface engineering: Introduction – Surface dependent properties and failures of engineering components, importance and scope of surface engineering; Surface and surface energy – Structure and types of interfaces, surface energy and related equations; Surface engineering – classification, definition, scope and general principles  
Laser assisted microstructural modification: Surface melting, hardening, shocking and similar processes; Laser assisted compositional modification – surface alloying of steel and non-ferrous metals and alloys, Laser surface cladding  
Surface Coatings: Flame spray; Plasma coating; HVOF, cold spray; Thermal / Electron beam evaporation; Sputter deposition of thin films & coatings by DC, RF, Magnetron and Ion beam; Hybrid / Modified PVD coating processes; Chemical vapor deposition (CVD) and PECVD; Plasma and ion beam assisted surface modification

Characterisation of Coatings: Physical Characterization; Assessment of Coating Hardness; Assessment of Friction and Wear of Coating; Assessment of Surface Roughness and Thickness of Coating; Assessment of Adhesion of Coating

Performance Evaluation of Coated Product: Performance evaluation of TiN Coated Tool and CVD Diamond Coated Tool

### **Text and Reference Books:**

1. Surface Engineering for Wear Resistances – K.G. Budinski, Prentice Hall, Englewood Cliffs, 1988.
2. Handbook of Hard Coatings-Deposition Technologies, Properties and Applications – Edited by Rointan F. Bunshah, Noyes Publications, U.S.A.
3. The Materials Science of Thin Films – M. Ohring, , Academic Press Inc, 2005

### **NPTEL References:**

1. Surface Engineering and Coating Technology by Prof. I. Manna, Department of Metallurgy and Materials Engineering, IIT Kharagpur and Prof. S. K. Ray, Department of Physics & Meteorology, IIT Kharagpur.
2. Technology of Surface Coating by Prof. A. K. Chattopadhyay, Department of Mechanical Engineering, IIT Kharagpur.

## **Production Planning and Control**

Introduction: Definition, Objectives, Functions of production planning and control, Elements of production control, Types of production, Organization of production planning and control department, Internal organization of department, Product design

Production-distribution system design: Plant location, Capacity planning, Multiple plant production facility design.

Aggregate planning and master production scheduling, Aggregation techniques, Aggregate capacity scheduling, Disaggregation of aggregate plan. Analytical and computer integrated solution techniques, Introduction to MRP & ERP, LOB (Line of Balance), Line Balancing, Aggregate planning, Chase planning, Expediting, controlling aspects.

Routing: Definition, Routing procedure, Route sheets, Bill of material, Factors affecting routing procedure, Scheduling and sequencing: Difference with loading, Techniques, Standard sequencing and scheduling methods.

Dispatching: Activities of dispatcher, Dispatching procedure, follow up, definition, types of follow up, Progress chasing and Updating of production schedules, Applications of computer in production planning and control.

Design of production planning and control systems: System design for continuous and intermittent production systems, Integration of master production, Material requirement and Shop scheduling systems.

### **Text and Reference Books**

1. Stevenson William J., Operations Management, McGraw-Hill
2. Mahajan, M., Production Planning and Control, Dhanpar Rai & Co.

## **Concurrent Engineering**

Concurrent engineering tools for collaborative environment, Framework for virtual teams. Multimedia conferencing systems.

Principles of object oriented and distributed databases. Object oriented concurrent programming for design and analysis. Participatory designs. Common product design concepts, design rationale and casual process descriptions.

Product concept development, Analytical Prototyping for kinetic and dynamic validation of constraints in displacements and forces.

Virtual reality tools and techniques for product development and interactive modeling and visualization.

Linking product development to reliability specifications, manufacturing, forecasting, inventory models and market research.

### **Text and Reference Books**

1. Concurrent Engineering, Concepts, implementation and practice, Editors: Syan, Chanan, Menon, U. (Eds.)
2. Concurrent Engineering in Product Design and Development 2003 by I Moustapha

### **Reliability Engineering**

Concepts of Reliability- Definition of Reliability, Failure, Causes of Failures, Life Characteristics Pattern, Measures of Reliability, Reliability Function, Areas of Reliability, Reliability Specifications.

Reliability Data and Analysis- Failure investigation, Data Planning, Data Collection, Preliminary Examination of Failed Part, Data Forms, Motivation and Training, Failure Mechanism, Reliability Analysis

System Reliability Analysis- Series System, Parallel System, Stand by System Redundancy

Simulation and Reliability Prediction- Monte Carlo Method

Maintainability and Availability- Types of Maintenance, Maintainability, Measures of Maintainability, Availability

Life Testing

Quality and Reliability

Measurement and Prediction of Human Reliability

Reliability Management

### **Text and Reference Books:**

1. Reliability Engineering by A. K. Govil, Tata McGraw Hill New Delhi
2. Reliability Engineering by E Balagurusamy, Tata McGraw Hill New Delhi
3. An introduction to Reliability and Maintainability Engineering by Charles E Beling, Tata McGraw Hill New Delhi
4. Quality control and reliability analysis by Brijendra Singh, Khanna Pub

### **Internal Combustion Engine & Gas Turbine**

Introduction, classification, two stroke four stroke (SI and CI) engines, engine parts, engine working principle and valve timing diagram

Engine performance test: purpose and types, measurement of power, Engine system & performance parameters evaluation,

Theory of combustion, Principle of combustion, S.I & C.I. Engine combustion process & parameter & their dependence on engine variables and operating parameters.

Combustion: adiabatic flame temperature, combustion processes & combustion chambers for SI and CI engines, pollutant formation and control, effect of engine variables on combustion processes, knocking in SI & CI engines,

Petroleum based fuels, gasoline & diesel fuel and their properties, blending, knock rating of engine fuels

Carburation: Working principles, chemically correct air fuel ratio and variation, carburetors and modern air fuel systems, compensating devices, venturi and jet dimension calculation,

Injection system, supercharging, engine lubrication and cooling principle,

Simple open gas turbine cycle, effect of operating variables on thermal efficiency, regenerative and reheat cycles, gas turbine applications, closed cycle gas turbine, Gas turbine based-hybrid cycles

### **Text and Reference Books**

1. A textbook of Internal Combustion engines, R.K. Rajput
2. Internal Combustion Engines, Book by V. Ganesan
3. Internal Combustion Engines, Book by M. L. Mathur and R. P. Sharma
4. Gas Turbines, Book by V. Ganesan, TMH

## **SEVENTH SEMESTER**

### **PR701: Automation and Robotics (4-0-0)**

Introduction to Industrial Automation and Control, Architecture of Industrial Automation Systems, Introduction to sensors and measurement systems, Temperature measurement, Pressure and Force measurements, Displacement and speed measurement, Flow measurement techniques, Measurement of level, humidity, pH etc, Signal Conditioning and Processing, Estimation of errors and Calibration, Control of Machine tools : Introduction to CNC Machines, Analysis of a control loop, Introduction to Actuators : Flow Control Valves, Hydraulic Actuator Systems: Pumps and Motors, Proportional and Servo Valves, Pneumatic Control Systems : System Components, Pneumatic Control Systems : Controllers and Integrated Control Systems

Robotic Systems: Fundamentals of robotics and its technology, robot classification based on geometry, devices, control and path movement robot motion analysis, robot selection and its application, economic justification of robots.

Concept of Robotic/Machine vision, Teach pendent, Industrial Applications of Robots for material transfer, machine loading / unloading, welding, assembly and spray painting operations. Anatomy and structural design of robot, Manipulation and geometry, Robot control systems and components, Interlocks and sequence control, Robot and effectors,, Robot drive system, Robot programming

Numerical Control: Conventional numerical control (NC) – basic components of an NC system, applications of NC, economics of NC, and problems with conventional NC. Computer Numerical Control (CNC), Direct Numerical Control (DNC), and combined CNC/DNC systems. NC programming.

### **Text and Reference Books**

1. M.P. Groover, M. Weiss, R.N. Nagel, N.G. Odrey, Industrial Robotics, Technology, Programming and applications, MCGraw hill, New Delhi.
2. M.P. Groover, Automation, Production systems and computer, Integrated manufacturing, Prentise hall of India pvt. Limited, New Delhi.

### **PR702: Supply Chain Management (3-0-0)**

Introduction and overview of supply chain management, Inbound and outbound logistics, Supply chain as a source of competitive advantage. Inbound logistics. Buyer-Vendor co-ordination, Procurement, Vendor development, reduced sourcing and supplier partnership - benefits, risks and critical success factors, multi-level supply control. Outbound logistics: Customer service, physical distribution planning, channel considerations, inventory strategies and management, transportation infrastructure and management, facility location, Materials handling. Strategic

considerations for supply chain: Porter's industry analysis and value-chain models, the concept of total cost of ownership, supply stream strategies, classification and development guidelines, measuring effectiveness of supply management, logistics engineering. Operations Research Models for operational and strategic issues in supply chain management. The Bullwhip Effect and supply-chain management game.

### **Text and Reference Books:**

1. Introduction to Materials Management (7th Edition): J. R. Tony Arnold, Stephen N. Chapman, Lloyd M. Clive
2. Manufacturing Planning and Control for Supply Chain Management: F. Robert Jacobs, William Berry, D. Clay Whybark, Thomas Vollmann

Designing and Managing the Supply Chain 3e with Student CD: David Simchi-Levi, Philip Kaminsky, Edith Simchi-Levi

## **PR703: Professional Elective-II (3-0-0)**

### **Precision Engineering**

Introduction to Precision Engineering: Need for having a high precision, Four classes of achievable machining accuracy, Precision machining, High-precision, Ultra-precision processes and Nanotechnology.

Mechanics of material cutting: Tool signature and Turning operation.

Tool Materials for precision machining: Coated and Laminated carbides, Ceramics, Diamond, Cubic Boron Nitride.

Ultra-precision machine elements: Guide-ways, Drive-system, Friction drives, Linear motor drive, Spindle drive.

Hydrodynamic and hydrostatic bearings: Principle of rolling element bearings, Design and selection, Bearing life, Construction of lubricated sliding bearings, Principle of hydrodynamic bearings, Hydrodynamic Thrust Bearings. Design of Hydrostatic Bearings, Hybrid Fluid Bearings.

Gas Lubricated Bearings: Aerostatic Bearings, Operation of Aerostatic Bearing Systems, Aerostatic Spindles, Hybrid Gas Bearings.

Micro-electro-Mechanical Systems: Characteristics and Principles, Materials and Design, Application of MEMS, Fabrication and Micro-manufacturing Processes, Clean Rooms, Design and Construction of Clean Rooms.

### **Text and Reference Books**

1. Precision Engineering – V.C. Venkatesh, Tata McGraw Hill
2. Manufacturing Engineering and Technology – S. Kalpakjian, 3<sup>rd</sup> Ed. Addison-Wesley Publishing Co
3. Principles of Precision Engineering – H. Nakazawa, Oxford University Press

### **Lean Manufacturing**

Introduction: SEVEN forms of waste and their description, Historical evolution of lean manufacturing, Global competition, Customer requirements, Requirements of other stake holders, Meaning of Lean Manufacturing System (LMS), Meaning of Value and waste, Need for LMS, Symptoms of underperforming organizations, Meeting the customer requirement, Elements of LMS. Traditional Vs lean manufacturing.

Standard work : Communication of standard work to employees, Standard work and flexibility, Visual controls, Quality at the source, 5S principles, Continuous improvement/Kaizen, Poke

Yoke, Overall equipment effectiveness, Preventative maintenance, Total quality management vs total productive maintenance, Changeover/setup time, Batch size reduction, Production levelling. Value Stream Mapping- The as-is diagram-the future state map-application to the factory simulation scenario, Case studies, Elements of JIT, Value creation and waste elimination, Main kinds of waste pull production, Different models of pull production, Uniform production rate - pull versus push method, Kanban system, Cause and effect diagram, Pareto chart, Radar chart, DFMA, Visual workplace. Optimized production technology, Team establishment, transformation process, Project Management, Lean implementation, Reconciling lean with other systems, Lean six sigma, Lean and ERP, Lean with ISO 9001:2000.

### **Text and Reference Books**

1. N. Goplakrishnan, Simplified Lean Manufacture, PHI, 2010
2. Pascal Dennis, Lean Production Simplified, Productivity Press, 2007

### **Production Design and Process Planning**

Introduction: Four plane concept of manufacturing – planning, control, material flow, and manufacturing process. Control loop of a manufacturing system. Basic functions of a manufacturing facility for small- and medium-size production runs. Functions of a computer in a manufacturing organization. Concurrent Engineering: Sequential versus concurrent engineering, mathematical model for interactions between design and manufacturing, benefits of CE, characterization of CE environment, framework for integration of life-cycle phases in CE, CE techniques, difficulties associated with CE, examples.

Automated Material Handling and Storage Systems: Principles of MH, MH equipment, types and components of AGVS, automated storage and retrieval systems, distributed computer control architecture for AGVS and AS/RS, conveyors.

Process Planning: Manufacturing environment for process planning. Generative process planning, variant process planning, and CAPP system. Computer-aided generation of process plans. Group Technology, CMS, and MRP: Classification methods – OPITZ , CODE and MICLASS systems. Master production schedule. Material Requirements Planning (MRP). Manufacturing Resources Planning (MRP-II)–capacity requirement planning, order release planning, and operations sequencing. Group scheduling in MRP-II environment.

Flexible Manufacturing Systems: Types of flexibility, key characteristics, basic features of physical components of FMS, control components of FMS, operational problems and layout considerations, simulation modeling and FMS benefits.

### **Text and References Book**

1. Groover, M.P. and Zimmers, E.W. Jr., CAD/CAM: Computer-aided Design and Manufacturing, Prentice-Hall of India Private Ltd, New Delhi, ISBN 0-87692- 402-10, 1986.
2. Halevi, G., The Role of Computers in Manufacturing Processes, John Wiley.
3. Orlicky, J., Material Requirements Planning, McGraw-Hill.
4. Koren, Y., Computer Control of Manufacturing Systems, McGraw-Hill.
5. Vail, P.S., Computer Integrated Manufacturing, PWS-KENT Publishing Co.
6. Rembold,U., Blume, C. and Dillmann, R., Computer Integrated Manufacturing
7. Technology and Systems, Marcel Dekker. Hyde, W.F., Improving Productivity by Classification, Coding, and Database Standardization, Marcel Dekker.
8. Noori, H., Managing the Dynamics of New Technology: Issues in Manufacturing Management, Prentice-Hall.

### **Organization Behavior and Industrial Psychology**

Personality Self-awareness; Perception and Attribution; Learning; Values and Attitudes, Motivation; Groups, Group Dynamics, Teams; Skills for Managing Teams – Communication, Conflict, Power and Influence; Leadership

What is an Organization; Determinants and Parameters of Organizational Design; Organization and Environment; Organizational Strategy; Power and Conflicts in organization; Organization Decision Making and Strategy-formulation; Organizational Culture; Organizational Failure and Pathology; Organizational Change and Development; Organizational Learning and Transformation

Cross Cultural Management

### **Text and References Books**

1. Koontz, H. and Wehrich , H., Management-A Global Perspective, 12., TMH
2. Robbins S.P, Seema Sanghi, Organizational Behavior, 11th ed, Pearson Education.
3. Luthans, Fred, Organizational Behavior, McGraw Hill 2008
4. Udai Pareek, Understanding Organizational Behavior, Oxford University Press
5. Organizational Behavior – by L. M. Prasad – S. Chand Publications
6. Organizational Behavior – by Suja Nair – S. Chand Publications

### **PR704: Professional Elective-III (3-0-0)**

#### **Theory of Abrasive Machining**

Abrasive machining processes - Brief introduction to grinding, honing, lapping, superfinishing, polishing, buffing, abrasive water jet machining, ultrasonic machining

Grinding - purpose of grinding; similarity between grinding and machining; identification of process parameters in grinding; Various grinding processes – finish grinding; grinding for bulk material removal; creep feed grinding; fast feed grinding.

Grinding Wheels – specifications; grit materials; grit shape and size; bond; structure; concentration; hardness; super-abrasive wheels; monolayer wheels.

Grinding Geometry and Kinematics – contact length; measurement of contact length; grinding path; active grits; measurement of active grits; maximum grit depth of cut for regular as well as irregular wheel topography.

Wheel Conditioning – truing and dressing techniques and parameters; effect of dressing on grinding wheel parameters; dressing of super-abrasive wheels; characterization of wheel topography.

Grinding Mechanism and Mechanics – grinding chips and their analysis; mechanism of chip formation in grinding - shearing, rubbing and ploughing, other sources of energy consumption in grinding; mechanism in superabrasive grinding; grinding force and specific energy modelling; effect of parameters on forces and specific energy.

Temperature in Grinding – measurement of grinding temperature; Thermal modelling of grinding process; effect of grinding parameters on temperature; effect of temperature of job quality; temperature control techniques; grinding fluids and lubrication.

Surface Integrity – understanding surface integrity; thermal damages in grinding - burning, oxidation, tempering; residual stresses – effect of residual stresses on job quality; measurement of residual stresses; introduction to X-ray diffractometry; XRD measurement of residual stress; application of Barkhausen Noise Technique in grinding

Grinding Wheel Wear – measurement techniques; wear mechanisms; grinding chemistry; grinding fluids and lubrication.

#### **Text and Reference Books:**

1. Changsheng Guo, Stephen Malkin, Grinding Technology: Theory and Applications of Machining with Abrasives, Industrial Press Inc.,

## **Product Design and Development**

**Product Development Process:** Background for design, design theory, design materials, human factors in design applied ergonomics, product development processes and organization, identifying customer needs, establishing product specifications, concept generation and selecting product architecture.

**Product Design Methods:** Generating concepts, selection of a concept, Testing of concept, product architecture, Creative and rational clarifying objectives-the objective trees methods, establishing functions the function analysis methods, setting requirement-requirements specification methods determining characteristics - the QFD method, generating alternatives-the morphological chart method, evaluating alternatives-the Weighted objectives methods, improving details-the value engineering method and design strategies.

**Design for Manufacture:** Estimating manufacturing costs, reducing component, assembly and support cost design for assembly, design for disassembly, design for environment, design for graphics and packaging, effective prototyping-principle and planning.

**Industrial Design:** Its need-Ergonomic needs, Aesthetic needs, impact, accessing the quality, steps involved In Industrial design process, Management of Technology & user driven products. Patents, Product Development & Project Management Legal issues in product design, trademarks, trade-secret, copy rights, patents-types, steps for disclosure, design resources, economics-quantitative & qualitative analysis, management of product development projects, Design Structure Matrix, Gantt Chart, Project schedule, budget, risk plan, accelerating project, execution, assessing and correction, Intellectual property rights.

### **Text and Reference Books:**

1. Product Design & Development-Karl. T. Ulrich and Steven D. Eppinger- TMH, Delhi.
2. Product Design-Kevin Otto and Kristin Wood-Pearson Education.
3. Product Development-Chitale & Gupta-Tata McGraw Hill.
4. Product Design and Manufacturing-Chitale & Gupta-PHI, Delhi.
5. Product Design: Creativity, Concepts and Usability-Kumar-PHI, Delhi
6. Concurrent Engineering in Product Design and Development-Imad Moustapha-New Age.
7. Operations Management-Monks, J.G-McGraw Hill.
8. Product Design and Development-Ulrich & Eppinger-TMH Delhi.
9. Facility Layout and Location-Francis, R.L., and White, J. A.- Prentice Hall of India

## **Project Management**

**Introduction to Project Management and Project Initiation:** Definition, characteristics, types of project management, Major factors affecting project management, concept of sustainable development in projects. Basic understanding of the project life cycle, project selection, idea generation, tools for idea generation, project selection models; project management soft skills, negotiation, scope for change and conflict management. Organization and project Management. Project controlling, its activities and types of control, Project review and auditing.

**Project Analysis:** Market and demand analysis: Market survey, demand forecasting and its uncertainties.

**Technical Analysis:** Product mix, plant capacity, raw materials, location, machinery and equipment.

**Financial Analysis:** Cost of project, cost of production, break even analysis, means of project financing, taxation in projects finance, and role of financial institutions in project finance. Project



Appraisal techniques, like net present value, internal rate of return, benefit cost ratio, social cost analysis

Networking and scheduling in Project Management, CPM and PERT analysis; float times, crashing activities, contraction of network for cost optimization, updating; cost analysis for resource allocation.

### **Text and Reference Books**

1. Chandra, P. (2011) Project Management, TMH, New Delhi.
2. Nagarajan, K. (2010) Project Management, New Age Publishing House, New Delhi.
3. Wysocki, Robert K., Bick Robert and Crane David B. (2000). Effective Project Management. John Wiley and Sons, USA.

### **Advanced Welding Processes**

Introduction: An introduction to welding processes, Welding as compared with other fabrication processes, Importance and application of welding, classification of welding processes, Health & safety measures in welding, areas for development, process application trends.

Physics of Welding Arc: Welding arc, arc initiation, physics of welding Arc, Basic characteristics of power sources for various arc welding processes, voltage distribution along the arc, arc characteristics, arc efficiency, Effect of shielding gas on arc, isotherms of arcs and arc blow.

Welding Processes: Manual Metal Arc Welding (MMAW), TIG, MIG, Plasma Arc, Submerged Arc Welding, Electroslag and Electroslag, Flux Cored Arc Welding, Resistance welding, Friction welding, Brazing, Soldering and Braze welding processes, Laser beam welding, Electron beam welding, Ultrasonic welding, Explosive welding, Friction Stir Welding, Underwater welding & Microwave welding, Plastic welding, Narrow-gap welding techniques.

Heat Flow Welding: Calculation of peak temperature; Width of Heat Affected Zone (HAZ); cooling rate and solidification rates; weld thermal cycles; residual stresses and their measurement; weld distortion and its prevention; monitoring and control of welding .

Repair & Maintenance Welding: Hardfacing, Cladding, Surfacing, Metallizing processes and Reclamation welding.

Weldability: Effects of alloying elements on weldability, welding of plain carbon steel, Cast Iron and aluminium. Micro & Macro structures in welding.

Welding automation and robotics: Automation options, Simple mechanization, Dedicated and special-purpose automation, Robotic welding, Modular automation, Programmable control, Remote-control slave and automated systems, Advances in welding automation, Evaluation of and justification for automated welding.

### **Text and Reference Books**

1. Advanced Welding Processes, by J.Norrish, Woodhead Publishing Series in Welding and Other Joining Technologies, 1st Edition.
2. Welding and Welding Technology, by- Richard L. Little, McGraw Hill Education.
3. Welding Principles and Practices, by- Edwards R. Bohnart, McGraw Hill Education.
4. Welding Handbooks (Vol. I & II).

## **EIGHTH SEMESTER**

**PR 801: Work System Design and Ergonomics**

**(4-0-0)**

Productivity and its scope, Factors affecting Productivity, Productivity improvement techniques, Productivity in the individual enterprise.

Method study and Tools for Method study, Micro motion study, Time study, Performance rating and allowances, Standard time, Predetermined Motion Time system, Job Evaluation and Merit rating, Work sampling, Wage and Incentive, Work study and Training Programs.

Ergonomic and Human factors: Principles of motion economy, Fatigue and working condition, Design of work place and tools and equipment, Effect of working environment..

Introduction: The focus of ergonomics, Ergonomics and its areas of application in the work system attempts to 'humanize' work, modern ergonomics, effectiveness and cost effectiveness, future directions for ergonomics

Anatomy, posture and body mechanics, Some basic body mechanics, Postural stability and postural adaptation, Low back pain, Risk factors for musculoskeletal disorders in the workplace, Behavioral aspects of posture, Effectiveness and cost-effectiveness

Anthropometric principles in workspace and equipment design, Designing for a population of users, Sources of human variability, Anthropometry and its uses in ergonomics, Principles of applied anthropometry in ergonomics, Application of anthropometry in design, Design for everyone, Anthropometry and personal space

Static work: Design for standing and seated workers, Fundamental aspects of standing and sitting, An ergonomic approach to workstation design, Design for standing workers, Design for seated workers, Work surface design, Visual display units, Guidelines for the design of static work, Effectiveness and cost-effectiveness

Work capacity, stress and fatigue

Stress and fatigue, Muscles, structure, function and capacity, The cardiovascular system, The respiratory system, Physical work capacity, Factors affecting work capacity, Effectiveness and cost-effectiveness

Heat, cold and the design of the physical environment-Fundamentals of human thermoregulation, Work in hot climates, Work in cold climates, Protection against extreme climates; Vision, light and lighting-Lighting design considerations, Visual fatigue, eye strain and near work; Hearing, sound, noise and vibration; Human information processing, skill and performance, Cognitive systems;

Displays, controls and virtual environments; Human-computer interaction, memory and language; Human-machine interaction, human error and safety; System design: organizational and social aspects.

### **Text and Reference Books**

1. Introduction to Ergonomics, Third Edition by R.S. Bridger
2. Human Factors in Engineering and Design, Mark S. Sanders, Ernest J. McCormick, McGraw-Hill, Inc.
3. Ergonomics of Work Systems, Stephen M. Popkin , Heidi D. Howarth, Donald I. Tepas, Wiley.
4. The Human Factor, 1st Edition by Kim Vincente

### **PR 802: Professional Elective IV (3-0-0)**

#### **Manufacturing of Composite Materials**

Introduction to Composites: Fundamentals of composites, need for composites, enhancement of properties, classification of composites – Matrix-Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC), Reinforcement, particle reinforced composites, Fibre reinforced composites. Applications of various types of composites. Fiber production techniques for glass, carbon and ceramic fibers.

**Polymer Matrix Composites:** Polymer resins, thermosetting resins, thermoplastic resins, reinforcement fibres, rovings, woven fabrics, non woven random mats, various types of fibres. PMC processes, hand lay up processes, spray up processes, compression moulding, reinforced reaction injection moulding, resin transfer moulding, Pultrusion, Filament winding, Injection moulding. Fibre reinforced plastics (FRP), Glass Fibre Reinforced Plastics (GFRP). Laminates-Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. applications of PMC in aerospace, automotive industries

**Metal Matrix Composites:** Characteristics of MMC, various types of metal matrix composites alloy vs. MMC, advantages of MMC, limitations of MMC, Reinforcements – particles, fibres. Effect of reinforcement, volume fraction, rule of mixtures. Processing of MMC, powder metallurgy process, diffusion bonding, stir casting, squeeze casting, a spray process, Liquid infiltration In-situ reactions, Interface measurement of interface properties, applications of MMC in aerospace, automotive industries

**Ceramic Matrix Composites and Special Composites :** Engineering ceramic materials, properties, advantages, limitations, monolithic ceramics, need for CMC, ceramic matrix, various types of ceramic matrix composites, oxide ceramics, non oxide ceramics, aluminium oxide, silicon nitride, reinforcements particles, fibres, whiskers. Sintering, Hot pressing, Cold isostatic pressing (CIPing), Hot isostatic pressing (HIPing). Applications of CMC in aerospace, automotive industries, Carbon /carbon composites, advantages of carbon matrix, limitations of carbon matrix carbon fibre, chemical vapour deposition of carbon on carbon fibre perform. Sol-gel technique.

### **Text and Reference Books**

1. Composite materials, K.K. Chawala, 2nd ed., (1987) Springer-Verlag, New York.
2. Nanocomposite Science and Technology, P. M. Ajayan, L. S. Schadler, P. V. Braun, (2003), Wiley-VCH Verlag GmbH Co. KGaA, Weinheim.
3. Ceramic matrix composites, K.K. Chawala, 1st ed., (1993) Chapman & Hall, London.
4. Advances in composite materials, G. Piatti, (1978) Applied Science Publishers Ltd., London.
5. Human Factors in Engineering and Design, Mark S. Sanders, Ernest J. McCormick, McGraw-Hill, Inc.
6. Ergonomics of Work Systems, Stephen M. Popkin, Heidi D. Howarth, Donald I. Tepas, Wiley

### **Energy Conservation and Management**

**Energy Scenario:** Commercial and Non-commercial energy, primary energy resources, commercial energy production, final energy consumption, Indian energy scenario, Sectoral energy consumption (domestic, industrial and other sectors), energy needs of growing economy, energy intensity, long term energy scenario, energy pricing, Energy security, energy conservation and its importance, energy strategy for the future, Energy Conservation Act 2001 and its features.

**Basics of Energy its various forms and conservation :** Electricity basics – Direct Current and Alternating Currents, electricity tariff, Thermal Basics-fuels, thermal energy contents of fuel, temperature and pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity and heat transfer.

**Evaluation of thermal performance – calculation of heat loss – heat gain, estimation of annual heating & cooling loads, factors that influence thermal performance, analysis of existing buildings setting up an energy management programme and use management – electricity saving techniques**

**Energy Management & Audit:** Definition, energy audit, need, types of energy audit. Energy management (audit) approach-understanding energy costs, Bench marking, energy performance,

matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements, fuel and energy substitution, energy audit instruments and metering  
Financial Management :Investment-need, appraisal and criteria, financial analysis techniques simple payback period, return on investment, net present value, internal rate of return, cash flows, risk and sensitivity analysis; financing options, energy performance contracts and role of Energy Service Companies (ESCOs).

### **Text and Reference Books**

1. W. F. Kenny, Energy Conservation In Process Industry.
2. Amlan Chakrabarti, Energy Engineering and Management, Prentice hall India 2011
3. CB Smith, Energy Management Principles , Pergamon Press, New York
4. Hand outs New Delhi, Bureau of energy efficiency
5. W. C. Turner, John Wiley and sons, Energy Management Hand Book.

### **Tribology**

Introduction to Tribology; Interdisciplinary approach and economic benefits

Friction: Causes of friction - Adhesion theory, Abrasive theory, Junction growth theory, Laws of rolling friction, Friction Instability

Wear: Wear Mechanisms - Adhesive wear, Abrasive wear, Corrosive wear, Fretting wear, Wear Analysis

Lubrication and Lubricants: Importance of lubrication, Boundary lubrication, Mixed lubrication, Full fluid film lubrication-hydrodynamic, Elastohydrodynamic lubrication, Types and properties of lubricants, Lubricant additives.

Fluid Film Lubrication: Fluid mechanics concepts, Equation of Continuity and Motion, Generalised Reynolds equation with Compressible and Incompressible lubricants, Solution of Reynolds equation, Calculation of flow rate; Thermal equilibrium

Applications of Tribology: Rolling Element Bearings; Bearing Clearance and Bearing Lubrication; Friction and Lubrication of Gears; Surface Fatigue of Spur Gears; Journal Bearings; Hydrostatic bearings; Hydrodynamic Journal Bearings

### **Text and Reference Books:**

1. Tribology, Friction and Wear of Engineering Materials – I. M. Hutchings, Butterworth Heinemann Publications
2. Introduction to Tribology – Bharat Bhushan, Wiley Publications
3. Engineering Tribology – Prasanta Sahoo, PHI Publications

### **Quantity Production Methods**

Classification of production. Industrial and economical aspects of production in large quantity. Various methods of quantity production, production of common engineering objects like rods, bars, rails, tubes, threaded objects, gears, bearings, cams, cutting tools etc. Purpose, design and use of jigs and fixtures. Role of automation in quantity production. Scheduling, tool layout and cam layout for semi-automatic and automatic machine tools. Large quantity production by special purpose and transfer machines. Quantity production of small items like washers, seals laminates, cups, strong and soft tubes, coins etc by shearing, forming and embossing in press tools. Industrial methods of manufacturing of pins, needles, wires, rims and similar products. Large scale production of various objects made of polymer, ceramics and composites. Quantity production by processes like spinning, bulging, hydro-forming, magneto-forming and explosion forming. Group technology. Selection of processes, tools and systems and process planning for

feasible and economic production. Flexible automation and computer control in manufacturing. Assessment and control of productivity, quality and economy in quantity production.

### **Text and Reference Books**

1. Manufacturing Science by Ghosh and Mallik, East west press.
2. M.P. Groover, Automation, Production systems and computer, Integrated manufacturing, Prentice hall of India pvt. Limited, New Delhi.
3. Production Technology: Manufacturing Processes, Technology and Automation by R. K. Jain

Materials and Processes in Manufacturing by E. Paul DeGarmo, Wiley

### **Entrepreneurship Management**

Introduction to Entrepreneurship: Meaning and concept of entrepreneurship, the history of entrepreneurship development, role of entrepreneurship in economic development, agencies in entrepreneurship management and future of entrepreneurship.

The Entrepreneur: Meaning of entrepreneur, the skills required to be an entrepreneur, the entrepreneurial decision process, and role models, mentors and support system.

Business Opportunity Identification: Business ideas, methods of generating ideas, and opportunity recognition

Preparing a Business Plan: Meaning and significance of a business plan, components of a business plan, and feasibility study

Financing the New Venture: Importance of new venture financing, types of ownership securities, venture capital, types of debt securities, determining ideal debt-equity mix, and financial institutions and banks

Launching the New Venture: Choosing the legal form of new venture, protection of intellectual property, and marketing the new venture

Managing Growth in New Venture: Characteristics of high growth new ventures, strategies for growth, and building the new venture capital

Harvesting Rewards: Exit strategies for entrepreneurs, bankruptcy, and succession and harvesting strategy.

### **Text and Reference Books:**

1. Small scale industries and entrepreneurship, Dr. Vasant Desai, Himalayan Publishing House
2. Management of small scale industries, Dr. Vasant Desai, Himalayan Publishing House
3. Management of small scale industries, J.C. Saboo Megha Biyani, Himalayan Publishing House
4. Dynamics of entrepreneurial development and Management, Dr. Vasant Desai, Himalayan Publishing
5. Entrepreneurship development, Moharanas and Dash C.R., RBSA Publishing, Jaipure
6. Beyond entrepreneurship, Collins and Lazier W, Prentice Hall, New Jersey, 1992
7. Entrepreneurship, Hisrich Peters Sphephard, Tata McGraw Hill
8. Fundamentals of entrepreneurship, S.K. Mohanty, Prentice Hall of India
9. A Guide to Entrepreneurship, David Oates, Jaico Publishing House, Mumbai, Edn 2009

### **Knowledge Management**

Introduction: An Introduction to Knowledge Management - The foundations of knowledge management- including cultural issues- technology applications organizational concepts and processes- management aspects- and decision support systems. The Evolution of Knowledge management: From Information Management to Knowledge Management - Key Challenges Facing the Evolution of Knowledge Management - Ethics for Knowledge Management  
Creating the Culture of Learning and Knowledge Sharing: Organization and Knowledge Management Building the Learning Organization. Knowledge Markets: Cooperation among Distributed Technical Specialists – Tacit Knowledge and Quality Assurance.  
Knowledge Management the Tools: Telecommunications and Networks in Knowledge Management - Internet Search Engines and Knowledge Management - Information Technology in Support of Knowledge Management -Knowledge Management and Vocabulary Control - Information Mapping in Information Retrieval -Information Coding in the Internet Environment - Repackaging Information.  
Knowledge Management Application: Components of a Knowledge Strategy - Case Studies (From Library to Knowledge Center, Knowledge Management in the Health Sciences, Knowledge Management in Developing Countries).

### **Text and Reference Books:**

1. Srikantaiah.T. K., Koenig, M., “Knowledge Management for the Information Professional”Information Today, Inc., 2000
2. Nonaka, I., Takeuchi, H., “The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation”, Oxford University Press, 1995.
3. Kimiz Dalkir, Jay Liebowitz, “Knowledge Management in theory & practices”, 2011, 2<sup>nd</sup> edition.
4. Donald Hislop, “ Knowledge Management in Organizations -A critical introduction”, 3rd edition, Oxford University Press.

### **Human Resource Management**

Introduction: Concept of Human Resources, Evolution of HRM, Nature and Significance of HRM, Challenges in HRM, Strategic Human Resource Management  
Procurement of Human Resources: Manpower Planning, Recruitment and Selection, Orientation and Socialisation, Transfer, Promotion, Separation  
Training, Appraisal and Human Resource Development: Training, Management Development, Performance Appraisal, Concept of HRD, OCTAPACE Culture, Morale & Job Satisfaction, Stress, Human Resource Audit  
Job Design and Compensation: Job Analysis, Job Enlargement, Job Enrichment, Job Evaluation, Wage and Salary Administration, Methods of Wage Payment, Incentive Plans  
Employee Welfare and Industrial Relations: Employees Safety and Concept of Labour Welfare, Trade Unionism, Collective Bargaining, Workers’ Participation in Management, Industrial Disputes and Settlement Machinery, Discipline and Grievance Procedure  
Social Security and Industrial Law: Concept of Social Security, The Workmen’s Compensation Act, 1923; The Maternity Benefit Act, 1961; The Employees’ State Insurance Act, 1948; The Payment of Gratuity Act, 1972.

### **Text and Reference Books:**

1. Human Resource Management : Stephen P. Robbins
2. Human Resource Management : Ian Beardwell
3. Human Resource and Personnel management : K. Aswathappa
4. Personnel Management and Industrial Relations: Dale Yoder

### **Industrial Relation and Safety**

Industrial Relations: Concept, Evolution and Dominant aspect of Industrial Relations, Industrial Disputes and Strikes, Collective Bargaining, Worker's Participation in Management, Trade Unionism

Industrial Safety: Concept, scope and nature of Employees' Health and Safety, Health and Safety Management Systems, Industrial Accidents, Safety Education, Works Place Hazards and Risk Control, Violence at work, Movement of people in the work place, Working at height.

Employees' Welfare and Social Security: Concept and Scope of Employees' Welfare, Agencies of Labour Welfare, Types of Welfare Services, Social Security in India

Labour Legislations and ILO: Principles and Types of Labour Legislations, The Factories Act, 1948; The Equal Remuneration Act, 1972; The Trade Unions Act, 1926; The Workmen's Compensation Act, 1923; The Maternity Benefit Act, 1961; The Employees' State Insurance Act, 1948; International Standards of Labour and Their Influence on Indian Labour Legislation.

**Text and Reference Books:**

1. Industrial Relations and Labour Laws : S. C Srivastava
2. Impact of ILO standards on Indian Labour Laws : Dr. N Maheswara Swamy
3. Labour Laws One Should Know: Ajay Garg
4. International Health and Safety at Work : Hughes and Ferrett