PRODUCTION AND INDUSTRIAL ENGINEERING

Course Name	**:**	**INTRODUCTION TO PRODUCTION AND INDUSTRIAL ENGINEERING**
Course Code	**:**	**PEN 101**
Credits	**:**	**2**
L T P	**:**	**2-0-0**

Course Objectives:
To acquaint students with the evolution, scope and basics of Production and Industrial Engineering.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**HISTORY AND EVOLUTION:** Definition, concept and scope of Production and Industrial Engineering, evolution of Production and Industrial Engineering.	4
2	**BASICS:** Concept of manufacturing systems, design of manufacturing systems, operations and management of manufacturing systems.	4
3	**INTRODUCTION TO PRODUCTION ENGINEERING:** Principles of good product design, tolerances and product life cycle, Machining, Metal casting, Metal forming, Joining and welding processes.	6
4	**INTRODUCTION TO INDUSTRIAL ENGINEERING:** Product economy and production system, Concept of quality and cost, Logistics, Production planning and inventory control, Operations research, Quality control.	7
5	**INTELLECTUAL PROPERTY RIGHTS:** Concept, scope and challenges	3
6	**FUTURE TRENDS IN PRODUCTION AND INDUSTRIAL ENGINEERING:** New developments, applications and case studies.	2
7	**LABORATORY EXPOSURE IN THE FOLLOWING AREAS:** Understanding the concepts of: Turning, EDM, Welding, PLC, Surface roughness testing and Work study.	2

Course Outcomes:	
1	Students will be able to relate the evolution of Production & Industrial Engineering to societal and other needs.
2	Students will be able to identify the basic processes of Production & Industrial Engineering in industry.
3	Students would be able to come up with innovative conceptual solutions in Production & Industrial Engineering.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Manufacturing Engineering and Technology", Serope Kalpakjian and Steven Schmid, Pearson Education, 7th edition.	2013
2	"Materials and Processes In Manufacturing", DeGarmo, , John Wiley & Sons	2011
3	"Engineering fundamentals and problem solving", Eide, Jenison, Mashaw, Northrop, John Wiley and Sons,	2002.
4	"Industrial Engineering and management- a new perspective", Hicks, P.E., McGraw Hill Inc,	1994.
5	"W.C. Introduction to Industrial and Systems Engineering", Turner, Prentice Hall,	1992.

Course Name	**:**	**INTRODUCTION TO MANUFACTURING**
Course Code	**:**	**PEN 102**
Credits	**:**	**4**
L T P	**:**	**2-0-4**

Course Objectives:
At the end of the course the students should be able to describe the properties of engineering materials and different manufacturing processes. The students should be able to select appropriate manufacturing process and manufacture a job in the different shops.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** Introduction to manufacturing, classification of manufacturing processes, classification of engineering materials, comparison of material properties of metals, ceramics and plastics, crystal structures, strain hardening effects, stress-strain curves. Safety measures in workshop.	**3**
2	**MATERIALS AND HEAT TREATMENT** Objective of heat treatment, classification of heat treatment, annealing, normalizing, hardening & tempering, case hardening, carburizing, nitriding, flame hardening, induction hardening, applications of heat treatment.	**4**
3	**FOUNDRY** Pattern, properties of pattern material, types of pattern, cores. Types of sand, moulding sand ingredients. Types of moulding processes. Types of casting processes: sand casting, shell casting, investment casting and centrifugal casting. Casting defects & remedies.	**4**
4	**FORMING** Metal forming, types and applications, hot & cold working, forging, drawing, rolling and sheet metal operations.	**3**
5	**MACHINING** Metal removal processes, machines, single-point tool, cutting tool geometry, lathe - types, elements and main parts of lathe, drilling, milling and grinding machines. Applications.	**3**
6	**FINISHING** Surface finishing processes, principle and applications, lapping, honing, super finishing, polishing, buffing, electroplating, galvanizing.	**2**
7	**WELDING** Classification of welding processes, mechanism of arc formation, arc welding processes, gas welding, and resistance welding, principles and applications, welding defects, causes and remedies. Soldering and brazing.	**3**
8	**PLASTICS MANUFACTURING** Types and properties of plastics, thermosetting and thermoplastic resins, elastomers. Fabrications of plastics, injection moulding, blow moulding, extrusion moulding etc.	**2**
9	**MODERN MANUFACTURING PROCESSES** Introduction, classification of modern machining processes, electric discharge machining (EDM), electro chemical machining (ECM), laser beam machining (LBM), Rapid Prototyping Techniques	**2**
10	**CASE STUDIES** Considerations of selecting manufacturing processes for industrial product like compact disc, PCB and emerging applications.	**2**

List of Experiments:		**Number of Turns**
1	To prepare half lap T & L joint in the carpentry shop.	**1**
2	To prepare the pattern of half nut in carpentry shop.	**1**
3	To prepare cube from a piece of round bar in forging shop.	**1**

4	To study the lathe, milling, planer, and shaper operations.	**1**
5	To manufacture a multi-operational job on lathe/milling in the machining shop.	**1**
6	To prepare series and parallel wiring connections in the electrical shops.	**1**
7	To prepare the butt joint by SMAW in welding shop.	**1**
8	To prepare the mould of a given pattern in foundry shop.	**1**
9	To cast the prepared mould in foundry shop.	**1**
10	To prepare a square job in the fitting shop.	**1**

Course Outcomes:	
1	Compare the properties of the engineering materials.
2	Select the appropriate manufacturing process for a given job.
3	Manufacture the jobs in the different shops.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Fundamentals of Modern Manufacturing, Materials, Processes, and Systems", Mikell P. Groover, John Wiley & Sons.	2014
2	"Materials and Processes In Manufacturing", DeGarmo, John Wiley & Sons	2011
3	"Manufacturing Engineering and Technology", Serope Kalpakjian and Steven Schmid, Pearson Publications.	2009
4	"Foundry, Forming and Welding", P.N. Rao, Tata M/C Graw Hill Publication.	2007
5	"A Textbook of Production Technology: Manufacturing Processes", P. C. Sharma, S. Chand & Company Ltd.	2004

Course Name	**:**	**KINEMATICS AND DYNAMICS**
Course Code	**:**	**PEN 201**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:
At the end of the course the students should be able to describe the various machine elements, identify basic drives, moving elements and realize its functioning.

Total No. of Lectures – 42

Lecture wise breakup		**Number of**
1	**VELOCITY ANDACCELERATION** Basic concept of machines, link, kinematics pair, kinematics chain, mechanism inversions for kinematics chains, slider crank chains and its inversions. Quick return motion (Crank and Slotted lever type and whitworth type), Instantaneous center of rotation of body, velocity of rubbing in pin joints, coriolis component of acceleration and advanced problems on velocity and acceleration (with analytical method), numerical problems	**5**
2	**FRICTION:** Types and laws of friction, inclined plane, efficiency of inclined plane, square and V threads, screw jack. Disc & cone clutch. Friction circle. Friction axis of link, numerical problems.	**5**
3	**TOOTHER GEARING:** Condition for smooth transmission of motion, nomenclature of involute teeth, involute rack, path of contact and arc of contact, interference minimum number of teeth, method of removing interference, helical and spiral gears, bevel gears, worm and worm wheel, their speed ratio, numerical problems.	**5**

4	**BELTS ROPES AND CHAINS:** Materials, types of drives, idle pulley, intermediate or counter shaft pulley, angle and right angle drive, quarter turn drive, velocity ratio, laws of velocity ratio, crowning of pulleys, loose and fast pulleys, belt length, stepped cone pulley belts, ratio of tension on tight and slack side of belt, HP transmitted, angle of contact, centrifugal tension, initial tension, rope guide, chain guide, types of chain, length of chain, numerical problems.	**6**
5	**GEAR TRAINS:** Simple compound and epi-cyclic gear trains, estimation of their velocity ratio, numerical Problems	**4**
6	**FLYWHEEL AND TURNING MOMENT DIAGRAM:** Fluctuation of speed and energy, coefficient of Fluctuation of speed and energy, simple problems on flywheel of a shearing machine.	**4**
7	**CAMS:** Displacement, velocity and acceleration diagrams, profile of cams, determination of maximum velocity and acceleration of follower, types of Cams, advance problems of cams with reciprocating and oscillating followers.	**4**
8	**BALANCING:** Balancing of rotating masses, primary secondary balancing of reciprocating masses, balancing machines.	**4**
9	**GOVERNORS:** Types of governors, terms used in governors, watt, porter, proell and hartnell governor, effort and power of governor, stability. Sensitiveness, hunting & isochronous, controlling force curve	**5**

List of Experiments:		**Number of hours**
1	To perform motion analysis of slider crank mechanism	**2**
2	To study various inversions of kinematic chains	**2**
3	To determine the moment of inertia of flywheel	**2**
4	Exercise on balancing	**2**
5	Exercise on determining characteristics curves for some governors like Watt, Porter or Proell	**2**

Course Outcomes:	
1	Identify the methods and machines for determination of mechanical tests.
2	Calculate the moment of inertia for a given example.
3	Identify the working of governors and plot its characteristic curves.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1.	"Theory of Machines and mechanisms", P L Ballaney, Khanna Publications	2014
2.	"Theory of Machines",S S Rattan, Tata McGraw Hill	2009
3.	"Theory of Machines and Mechanisms", Joseph Edward Shiegley& John Joseph Uicker, McGraw Hill Book Company	1988

Course Name	**:**	**INDUSTRIAL METROLOGY**
Course Code	**:**	**PEN 202**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:

At the end of the course the students should be able to describe the needs for standards and measuring devices and identify various instruments, their working principles and applications**.**

Total No. of Lectures – 42

Lecture wise breakup		**Number of**
1	**STANDARDS OF MEASUREMENT** Need of standards, classification: primary, secondary and tertiary standards, traceability of standards, length standards: line and end standards, derivation of end standard from line standards. Slip gauges and their calibration, wavelength standards. Angle standards: angle slip gauges, precision polygons and divided circles.	**6**
2	**LIMITS, FITS AND TOLERANCES** Concept of interchangeability, types of interchangeability, need for standard systems of limits, fits and tolerances, BIS; 919; 1963 standard system, selection of limits and fits exercises on limits, fits and tolerances, design principles for limit gauges. Taylor's principle, types of limit gauges, tolerances on limit gauges.	**6**
3	**MEASURING AND GAUGING INSTRUMENTS** Design principles of measuring instruments; kinematics design, principle of alignment. pivots and bearings, sources of error in measurement, calibration of measuring instruments: mechanical linear and angle measuring instruments. vernier calipers, micro - meters, dial	**8**
	gauges, bevel protectors, sine bar spirit level, optical instruments; autocollimator, tool room microscope, length measuring machines, comparators; magnification principles, types of comparators, mechanical, optical, pneumatic, electrical and electronic comparators.	
4	**GEOMETRICAL METROLOGY** Concept of form errors, straightness, flatness, roundness, squareness and concentricity errors and their measurements.	**6**
5	**SCREW THREAD AND GEAR METROLOGY** Elements of screw thread metrology, measurement of major, minor and effective diameters of external and internal screw threads, measurement of pitch and screw thread angle, effect of pitch error, elements of gear metrology, measurement of gear tooth thickness, gear profile, gear concentricity, pitch and run-out for involute gears, gear rolling test.	**6**
6	**MEASUREMENT OF SURFACE FINISH** Concept of macro and micro errors, scales; surface roughness measures, datum for surface roughness measurement; M and E system, measurement of surface roughness, stylus methods using mechanical, optical and electrical magnification	**10**

List of Experiments:		**Turns**
1	Measurement of angle and width of"V" block	**1**
2	Measurement of angle using sine bar and measurement of cylinder using bore gauge	**2**
3	Measurement of screw thread element using tool makers microscope & optical projector	**2**
4	Measurement of gear tooth thickness using gear vernier caliper	**1**
5	Measurement of effective diameter of external screw thread using three wire method	**1**
6	Measurement of straightness error using auto collimator	**1**
7	Measurement of dimensions and profiles using universal microscope	**1**
8	Measurement of surface roughness using talysurf	**1**
9	Designing and conducting process capability for a given machine/ process	**2**
10	Designing a sampling plan for a given application	**1**

Course Outcomes: By the end of this course, the students will be able to:	
1	Identify the standards used for measuring devices used in metrology.
2	Design limit gauges for a given operation in a job.
3	Identify the various form errors in a part.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Metrology Handbook manual" - Mitutoyo, Japan	2015
2	Ëngineering Metrology", Mahajan	2012
3	"Handbook of Industrial Metrology – A S T M E", Prentise Hall of India Ltd.	2011
4	"Text book of Engineering Metrology", I C Gupta, Dhanpat Rai	2010

Course Name	**:**	**METALLURGY AND CASTING TECHNOLOGY**
Course Code	**:**	**PEN 203**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:
The student shall be exposed to the basic manufacturing techniques such as casting, metal forming, welding and powder metallurgy along with some lab exposure

Lecture wise breakup		**Lectures**
1	**METALLURGY:** Iron carbon diagram, solidification of pure metals and alloys, nucleation and growth in alloys, solidification of actual castings, progressive and directional solidification. Principles of Phase transformations, Phase rule, Equilibrium diagrams, Recovery, recrystallization and grain growth.	**8**
2	**HEAT TREATMENT:** Basic principles involved in heat treatment of plain carbon steels & alloy steels, Principles &applications of: Annealing, Normalizing, Hardening, Tempering, Surface hardening of Steels, Principles of Induction & Oxyacetylene flame hardening. Procedure for Carburizing, Nitriding & Cyaniding, Harden-ability: Jominey end quench test method.	**8**
3	**INTRODUCTION TO METAL CASTING:** Types of pattern, pattern allowances, pattern design, recent development in pattern design, types of sand, properties of moulding sand, testing of sand.	**6**
4	**GATING SYSTEM AND RISERING** Gating systems and their characteristics, various parts of gating system, Various types of gates, various types of risers, function of riser, riser design.	**3**
5	**MELTING:** Various types of melting furnaces, selection of melting furnace.	**4**
6	**MOULDING/CASTING PROCESS** Sand moulding machine moulding, shell moulding process, investment casting process, centrifugal casting process.	**3**
7	**CASTING DEFECTS** Various casting defects, causes and remedies of the casting defects	**4**
8	**POWDER METALLURGY:** Characteristics of metal powders and production methods, Mixing and blending, compacting, sintering and finishing, process principles, Defects and limitations and industrial applications	**6**

Total No. of Lectures – 42

List of Experiments:		**Number of Turns**
1	Exercise on mould preparation and testing its strength on a sample	**2**
2	Determination of permeability and green strength of moulding sand.	**2**
3	Determination of clay content in a given sample	**2**
4	Determination of grain fineness number for a given sand mix	**2**
5	Exercise on preparing a casting, using furnace melting	**2**
6	Prepare a sample for the purpose of viewing the micro structure of mild steel and cast iron	**2**

Course Outcomes:	
1	To select the heat treatment process
2	To select the casting process
3	Able to design a pattern for the casting
4	Able to prepare a job by casting process

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Principle of introduction to physical metallurgy", Avner, McGraw Hill.	2012
2	"Elements of Metal Casting", Richard W. Hein, Carl R. Loper and Philip C. Rosenthal, Tata McGraw Hill Education	2008
3	"Foundry, forming and Welding", P.N. Rao: Tata M/C Graw Hill Publication.	2001

Course Name	**:**	**MACHINE DRAWING**
Course Code	**:**	**PEN 204**
Credits	**:**	**4**
L T P	**:**	**2-0-4**

Course Objectives:
At the end of the course the students should be able to describe the terminologies in machine drawing, get exposed to international standards, symbols, requirements and applications of dimensioning.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**BASICS OF MACHINE DRAWING** Review of ISI Standard SP 46: Types of Lines, Review of orthographic projection. Dimensioning.	**6**
2	**DIMENSIONING AND ORTHOGRAPHIC PROJECTIONS** Dimensioning, Review of orthographic projection.	**4**
3	**SYMBOLS AND REPRESENTATIONS** Representation of machining symbols and welding symbols and joints, types of rivets & joints, Types of bolts, nuts & their locking devices, other fasteners. Shaft Couplings	**4**
4	**LIMITS AND TOLERANCES:** Limits, fit, tolerances, surface roughness, General Tolerances; Surface quality symbols, terminology and representation on drawings, correlation of tolerance and surface quality with manufacturing techniques. Basic calculations and their drawing representations.	**4**
5	**SCREW THREADS** Different conventions used on technical drawings, Types of threads, representation of screw and other threads.	**8**
6	**ASSEMBLY DRAWINGS** Review of sheet preparation, boundary lines, Title block, Bill of Material, Assembly Drawings of various machine sub-assemblies and assemblies from detailed drawings, sketch of actual machine component.	**2**

List of Experiments:		**Number of Turns**
1	Fasteners	**1**
2	Journal Bearing	**1**
3	Lathe Tool Post	**1**
4	Shaper Tool Post	**1**
5	Bench Vice	**1**
6	Lathe Tail Stock	**1**
7	Crane Hook	**1**
8	Gib and Cotter Joint	**1**
9	Knuckle Joint	**1**
10	Coupling	**1**
11	Screw Jack	**1**
12	Swivel Bearing	**1**

Course Outcomes:	
1	Understand and interpret various symbols in machine drawings.
2	Draw basic machine elements such as fasteners, bearings, lathe tool post etc.
3	Read and interpret assembly drawings.

Suggested Books:		
Sr.	**Name of Book/ Authors/ Publisher**	**Year of**

No.		Publication/ Reprint
1	"A First Year Engineering Drawing", AC Parkinson, Pitman	2009
2	"Machine Drawing", N D Bhatt, Charotar Publishing House Pvt. Limited,	2008
3	"Machine Drawing", P S Gill, Katson Publishing	2009
4	"Mechanical Engineering Design", Shigley J E, McGraw Hill, eighth ed.	2008

Course Name	**:**	**TECHNICAL COMMUNICATIONS**
Course Code	**:**	**PEN 205**
Credits	**:**	**2**
L T P	**:**	**2-0-0**

Course Objectives:
At the end of the course the students should be able to effectively communicate keeping in mind that, in their career, they may be involved with designing, service, management, sales, customer liaison, or any/all of such activities.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	Overview of research writing, editing and design principles of technical and professional communication.	**3**
2	Information gathering, organizing and presenting effectively according to the audience and Purpose	**3**
3	Technical documentation, including such items as proposals, requirements, recommendation reports and business correspondence.	**5**
4	Lessons on: Oral reports and public speaking.	**3**
5	Lessons on: Teamwork, participation in group discussion and interviews.	**3**
6	Use of visuals and audio to communicate material effectively.	**3**
7	Research techniques using the library and the Internet modes.	**3**
8	Case studies and seminar with an aim to improve the communication skills.	**5**

Course Outcomes: By the end of this course, the students will be able to:	
1	Participate and demonstrate effective technical communication through seminars.
2	Participate and demonstrate effective technical communication through speech to a variety of audience
3	Participate and demonstrate effective communication through written reports and team work management.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Fundamental of Technical Communication", Meenakshi Raman and Sangeeta Sharma,Oxford University Press, India	2014
2	"Effective Technical Communication-A guide for Scientists and Engineers", Barun K. Mitra, Oxford University Press, India	2006
3	**"** Guide to Writing as an Engineer", David F. Beer and David McMurrey**,** 2nd ed., Wiley	2004
4	"Pocket Style Manual", Diane Hacker, Bedford/St. Martin's, ISBN: 0312406843.	2003

Course Name	**:**	**ENGINEERING ANALYSIS AND DESIGN**
Course Code	**:**	**PEN 206**
Credits	**:**	**4**
L-T-P	**:**	**3-1-0**

Course Objective:

The objective of the subject is to uphold a steadiness between theory, numerical computation and practical solutions to engineering systems.

	Lecture wise breakup	No. of Lecture
1	**Introduction:** Introduction, the design process, Engineering design versus analysis, conventional versus optimum design process, basic terminology and notation. Design variables, cost function, design constraints and general mathematical models for optimum design and case studies.	**6**
2	**Engineering Analysis**: Role of analysis, the design spiral, Computer Aided engineering analysis: visualization, analysis and redesign, Statistical Considerations, safety and reliability. Case studies on common Engineering designs and mechanisms such as: Clutch assembly, Sewing machine, Bore well, Single point cutting point, Riser design, Design of Key and Concept of hydraulics in design.	**10**
3	**Reverse Engineering:** Introduction, Steps, Rapid prototyping, Rapid manufacturing and applications. Design for manufacturing and assembly (DFMA). Case studies on DFMA.	**6**
4	**Learning from Failure**: Various failure case studies, Failure of machine components, Failure modes and effect analysis (FMEA) and case studies.	**4**
5	**Aesthetics in Engineering Design**: Concept of visual design, Written, Oral and poster presentations and case studies.	**6**
6	**Design of Experiments and Optimization:** Strategy of experimentation, basic principles, guidelines for designing experiments, sampling and sampling distribution. Design of experiments with a single factor and multi factor design, analysis of variance (ANOVA) and introduction to factorial design.	**6**
7	**Taguchi Methodology:** Design of experiments - The Taguchi Approach, Taguchi philosophy, Concept of the loss function, Experiment design strategy, Areas of application, Quality characteristic, Taguchi quality strategy, Selecting design parameters for reduced variation, Signal to Noise ratio (S/N ratio), Analysis of variance (ANOVA), confirmation experimentation, F-test.	**8**
8	**Finite Elements in Engineering:** Introduction, Stress strain relationship, temperature effects, potential energy and Equilibrium. Von Mises stress. Finite element modeling (One dimension only) coordinate and shape functions and potential energy approach. .	**6**
9	**Engineering Ethics and team work:** Engineering ethics, Intellectual property rights, Case studies and presentations.	**4**

Course Outcomes: Upon successful completion of this course, the student will be able to:	
1	Understand basic theoretical principles in engineering design and optimization;
2	Understand a wide range of engineering related designs and mechanisms.
3	Apply "Design of Experiment technique" to some engineering problems.

Suggested Books:		
Sl. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication**
1	A primer on Taguchi Methodology- Ranjit K Roy	2011
2	Optimization for Engineering Design- Kalyanmoy Deb, PHI	2010
3	Product Design and Manufacturing , AK Chitale and Gupta R C., PHI (6th Edn.)	2011
4	Introduction to Finite elements in engineering, Chandrupatla & Belegundu, Prentise Hall	2006
5	Design and Analysis of Experiments- Douglas C Montgomery- WILEY	2005

Course Name	**:**	**FORMING AND WELDING**
Course Code	**:**	**PEN 207**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:
At the end of the course the students should be able to describe various requirements and applications of heat treatment, classify and identify the different welding processes.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**METAL FORMING:** Introduction, classification, effect of forming parameters, hot and cold working processes, true strain curves, determination of flow stress, Tresca and Von Misces criteria, metal forming lubrication, lubrication mechanism, boundary mixed and hydrodynamic lubrication.	**10**
2	**ROLLING:** Classification of rolling processes, rolling mills, products, variables, rolling defects and controls. Defects & Remedies.	**3**
3	**DRAWING:** Drawing of rods, wires, tubes, variables in drawing and operations, analysis of drawing forces. Defects & Remedies.	**3**
4	**FORGING:** Open and closed forging, Hammer, Press and Drop forging, analysis of forging forces, sticking and sliding friction. Defects & Remedies.	**3**
5	**EXTRUSION:** Classification of extrusion processes, equipment and variables used in extrusion. Defects & Remedies.	**3**
6	**WELDING:** Classification of welding processes, physics of arc, arc blow, welding symbol, types of V-I characteristics, different types of power sources**,** Classification and selection of welding electrodes, welding fluxes,	**6**
7	**METAL TRANSFER:** Forces affecting metal transfer, classification of modes of metal transfer, parameter effecting metal transfer.	**2**
8	**WELDING PROCESSES:** Principle, advantages disadvantages and applications of Gas welding, SMAW, MIG, TIG, SAW, Electro-slag, Plasma, EBW and LBW process. Welding defects, brazing and soldering, thermal spraying. Heat affected zones. Introduction to Non-Fusion welding processes: resistance welding, solid state welding.	**6**
9	**TESTING AND CHARACTERIZATION OF MATERIALS:** Destructive and non-destructive testing of materials: tensile, bend and impact testing of weldment and on weld metal, dye penetrant, magnetic particle testing.	**6**

List of Experiments:		**Number of Turns**
1	Fabrication exercise by using MMA welding machine	**2**
2	Practical exercise on brazing	**2**
3	Practical exercise on MIG/ TIG welding	**2**
4	Practical exercise on SAW	**2**
5	Study of friction welding process	**2**
6	Wire drawing exercise on the draw bench	**2**
7	Practical exercise on ultrasonic welding process	**2**

Course Outcomes: By the end of this course, the students will be able to:	
1	To select and compare the various forming process.
2	To select and compare the various welding process.
3	Should be able to fabricate a welding job.
4	Able to learn the specific welding applications and innovations.
5	Choose different heat treatment processes for a given requirement
6	Classify and choose a particular welding process for a given requirement

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"A text book of Production Engineering" , PC Sharma Publisher S Chand	2014
2	"Welding Engineering and Technology", RS Parmar, Khanna Publisher	2013
3	"AWS handbooks", 9th Edition, Volume-2	2011

Course Name	**:**	**DESIGN OF MACHINE ELEMENTS**
Course Code	**:**	**PEN 208**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of the course the students should be able to describe the basics of machine elements, its design; identify various fasteners, drives and their design criterion.

Total No. of lectures: 42

Lecture wise breakup		**No. of Lectures**
1	**FUNDAMENTALS OF DESIGN :** Scope and Meaning of design with special reference to machine design. Concept of tearing, bearing, shearing, crushing, bending etc. Selection of materials, Behavior of materials. Fabrication characteristics of materials. Stress concentration, factor of safety under different loading conditions, stress concentration factors. Design stress for variables and repeated loads. Endurance limit, Fits and tolerance and finish.	**5**
2	**FASTNERS:** Cotters and cotters joints, pin fasteners, knuckle joints, Welded joints and rivet connection, eccentrically loaded	
3	**DESIGN OF BELT DRIVE:** Selection of a belt drive, types of belts, working stresses in belts, coefficient of friction between belt and pulley, belt joints, velocity ratio of a belt drive, slip & creep of the belt, length of an open belt drive, length of a cross belt drive. Power transmitted by a belt. V-belt, types of V-belts and pulleys, ratio of driving tensions for v-belt, v-flat drives	
4	**DESIGN OF GEAR DRIVE:** Factors influencing the choice of a gear, condition for constant velocity ratio of gears–law of gearing, forms of teeth, cycloidal teeth, involute teeth, interference in involute gears, minimum number of teeth to avoid interference. Design considerations for a gear drive, beam strength of gear teeth, permissible working stress for gear teeth, dynamic tooth load, static tooth load, wear tooth load, causes of gear tooth failure, design procedure for spur gears and helical gear.	

5	**DESIGN OF SPRINGS:** Types of springs, material for helical springs, compression spring terminology, end connections for tension & compression helical springs, stresses in helical springs of circular wire, deflection of helical springs of circular wire, eccentric loading of springs, buckling of compression springs, surge in springs, energy stored in helical springs of circular wire, helical springs subjected to fatigue loading, springs in series, springs in parallel, concentric or composite springs, helical torsion springs, flat spiral springs, leaf springs, construction of leaf springs,	**6**
6	**DESIGN OF A SLIDING AND ROLLING TYPE OF BEARINGS:** Types of sliding contact bearings, hydrodynamic lubricated bearings, wedge film journal bearings, squeeze film journal bearings, lubricants, bearing characteristic number and bearing modulus for journal bearings, critical pressure of the journal bearing, sommerfeld number. Design procedure for journal bearings, solid journal bearing, bushed bearing, split bearing or plummer block, design of bearing caps and bolts. thrust bearings, foot-step or pivot bearings, collar bearing Types of rolling contact bearings, radial ball bearings, designation of ball bearings, thrust ball bearings. Basic static load rating of rolling contact bearings, static equivalent load for rolling contact bearings.	**6**
7	**SHAFTS, KEYS AND COUPLINGS :** Types of shafts, standard sizes of transmission shafts, stresses in shafts, maximum permissible working stresses for transmission shafts, design of shafts, shafts subjected to twisting moment & bending moment, shafts subjected to axial load in addition to combined torsion and bending loads, design of shafts on the basis of rigidity. Types of keys, strength of a sunk key, effect of keyways, types of shaft couplings, design of flange coupling, flexible coupling, bushed pin flexible coupling, oldham coupling, universal coupling	**6**

Course Outcomes: By the end of this course, the students will be able to:	
1	Classify different machine elements and understand their failure modes.
2	Identify and apply the required criterion for designing different machine elements
3	Design some basic machine elements like shafts and bearings.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Machine Design", P C Sharma and D K Aggarwal, SK Kataria and Sons, 11th edition	2011
2	"Hartman & Maleev's Machine Design", O.P. Groover, CBS	2011
3	"Manual of Machine Design", Frank Castle, Amazon Books	2009
4	"Mechanical Engineering Design", by Shigley J E , McGraw Hill, eighth ed.	2008

Course Name	**:**	**TOOL DESIGN**
Course Code	**:**	**PEN 209**
Credits	**:**	**4**
L T P	**:**	**2-0-4**

Course Objectives:

At the end of the course the students should be able to describe the basics of jigs and fixtures, understand their designing aspects and economics.

Lecture wise breakup		**Number of**
1	**INTRODUCTION:** Principle of jigs & fixture design, location devices, Design principle common to jigs and fixtures, difference between jigs and fixtures, drawing and design of various clamping device.	**6**
2	**DRILLING JIGS:** Box type, leaf type, Indexing type, trunion type etc.	**3**

3	**FIXTURES:** Milling: String Fixtures, Indexing Fixtures & Mill fixtures etc. Grinding: For Cylindrical grinding, surface grinding Assembly and welding fixtures, lathe fixture for Automobile components and frames, machines etc.	**7**
4	**ECONOMICS:** Economics of jigs and fixtures, selection of particular types of jigs and fixture.	**3**
5	**PRESS TOOL:** Types of presses and selection, press accessories and attachments, Terminology of shearing dies, analysis process, shearing clearance, shearing with inclined edges, strip layouts, various die materials, various die clearance and allowances. Drawing Dies, Bending Dies, Compound Dies, Combination Dies and Progressive Dies. Development of blanks and scrap strip layouts, Die materials, Selection between dies Die clearances and Allowances	**11**
6	**DIE DESIGN:** Design of blanking, progressive, bending and forming die.	**2**

List of Experiments: At least eight different types of Jigs and the Fixture are to be designed and drawn and at least two different types of dies are to be designed and drawn.		**Number of Turns**
1	Drilling jig (Box type, Leaf type, indexing type, trunion type etc.)	**3**
2	Milling Fixture (String fixture, Indexing fixture and mill fixture etc.)	**2**
3	Lathe fixture (to machine a component)	**2**
4	Assembly and welding fixture (for automobile components and frames, machines etc.)	**2**
5	Drawing Dies, Bending Dies,	**2**
6	Compound Dies, Combination Dies and Progressive Dies.	**2**

Course Outcomes:	
1	Differentiate between a jig and a fixture
2	Design a simple jig for a given application
3	Design and draw a simple fixture for a given application

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Tool Design", Donoldson, Tata McGraw Hill	2012
2	"Jigs & Fixtures: Non standard clamping devices", Grant, Tata McGraw Hill, Ind. Press Inc., NewYork	2010
3	"Jigs and Fixtures", P H Joshi, Tata McGraw Hill Edition	2010

Course Name	**:**	**INDUSTRIAL ENGINEERING – I**
Course Code	**:**	**PEN 210**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:

At the end of the course the students should be able to describe productivity and its improvement techniques, identify the methods in work study, work measurement and ergonomic aspects in work study.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION:** Definition and scope of Industrial engineering role of an industrial engineer in industry, functions of industrial engineering department and its organization, qualities of an industrial engineer	**6**
2	**PRODUCTIVITY AND WORK STUDY:** Productivity concept and definition: Introduction, definitions of productivity, Productivity measurement at national, industrial and enterprise level, Benefits of higher productivity. Productivity in the individual enterprise: Introduction, Productivity measurement approaches at the enterprise level, Productivity of materials, Productivity of land, buildings, machines and manpower, Factors contributing to productivity improvement Techniques for productivity improvement: Introduction, Work content and ineffective time, Improving productivity for reducing work content, Improving productivity by reducing ineffective time, Management of productivity	**8**
3	**WORK STUDY:** Introduction, basic procedure, prerequisites of conducting a work study. The human factor in application of work study: Introduction, management and supervisor; their role in work study, the works study man. The influence of working conditions on work study: Introduction, factors affecting working conditions, occupational safety and health, fire prevention and protection, layout and housekeeping, lightning and climate conditioning, noise and vibrations, ergonomics, arrangement of working time, conclusion	**8**
4	**METHOD STUDY:** Introduction to method study and the selection of job: Introduction, definition and objective of method study, procedure of method study. Flow and handling of materials: Introduction, plant layout, developing the new layout, the handling of materials Tools for recording the movement of worker: Introduction, string diagram, flow process chart; man type, travel chart, multiple activity chart. Introduction, the principles of motion economy, classification of movements, further notes on workplace layout, notes on the design of jigs, tools and fixtures, machine controls and displays of dials, the two handed process chart, Simo chart.	**8**
5	**WORK MEASUREMENT:** Purpose of work measurement, the basic procedure, the techniques of work measurements, Work sampling: Introduction, basic concept and procedure, Time study: rating: Introduction, the quality worker, the average worker, standard rating and standard performance. Predetermined time standards (PTS): Introduction, definition, advantages of PTS system, Criticisms of PTS system, different forms of PTS system, use of PTS system, and application of PTS system.	**8**
6	**WORK DESIGN:** Concept of job enlargement, job enrichment and job rotation, effective job design consideration technological and behavioral factors	**2**
7	**ERGONOMICS:** Introduction to ergonomics, consideration in designing man machine systems with special reference to design of displays and control	**2**

List of Experiments:		Number of Turns
1	To study various plant layouts and suggest improvements in existing Metal cutting laboratory /Workshops layout	2
2	Draw flow process chart for nut/bolt and washer assembly	2
3	Draw a two handed process chart for a simple process of a job preparation on a lathe	2
4	Draw string diagram for Manufacturing/Service Organization and revise the location of machine/service facility in case of improvement.	2
5	Perform time study using stop watch for End milling operation on milling machine	3
6	Ergonomic evaluation for welding processes.	3

Course Outcomes: By the end of this course, the students will be able to:	
1	Productivity and Partial Productivity calculation for an organization.
2	Design a method for manufacturing for a new Process and Modify the existing Process,
3	Draw the flow process charts for a given process
4	Apply work measurement techniques for a given job
5	Identify and perform time study for simple applications.
6	Apply ergonomic concepts in work environment.

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	"Work study", ILO, Second Edition, Oxford and IBH Publishing	2010
	"Industrial Engineering and management", O.P. Khanna, Dhanpat Rai Publisher.	2010
2	"Industrial Engineering and Production management", Martand Telsang, S. Chand Publisher.	2006

Course Name	**:**	**MACHINING TECHNOLOGY**
Course Code	**:**	**PEN 211**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:

The students will be able to study and understand the basic elements, classification and applications of some important conventional machines like lathes, shapers, milling, drilling and grinding and understand the principles of some non-conventional machining technologies.

Total No. of Lectures – 42

Lecture wise breakup		Number of Lectures
1	**INTRODUCTION** Classification of M/c Processes, Kinds of Motions in M/c tools, Tool materials & Cutting fluids	4
2	**LATHE & LATHE OPERATIONS:** Classification of lathes & Capstan turrets, Geometry of a single Pt tool, Speed, Feed & Depth of Cut, Turning, facing, taper turning, parting, chamfering & threading.	6
3	**DRILLING MACHINES :** Classifications, Nomenclature of a Drill, Drilling operations such as boring, reaming, tapping.., Speed, feed & M/c time calculations	4
4	**MILLING M/C :** Classifications, Specs, Indexing devices, Up Milling & Down Milling, Milling	4

	Attachments, Cutter geometry, Speed, feed & M/c time calculations.	
5	**GRINDING MACHINES** Classifications & Applications. Surface, Internal & Centre-less grinding, Wheel Selection, Standards, M/c times. Dressing& truing of Grinding wheels	**3**
6	**SHAPING, PLANING AND BROACHING** Types & classification of Shapers, Planers, Specifications, QRM, Speed, Feed & Machining time calculations. Job holding devices & applications. Broaching Tools, parameters	**2**
7	**THORY OF METAL CUTTING** Types of Chips, Mechanics of Chip Formation, Relevance of Shear Angle, Merchant Circle, Lee & Shafer's theory, Forces in Turning, Drilling & Milling, Mechanisms of tool failures, Tool life, Mach inability, Cutting fluids in machining.	**4**
8	**NON CONVENTIONAL MACHINING PROCESSES** Abrasive jet M/c. Ultrasonic Machining, Electro-Chemical M/c Electric Discharge m/c, Electron beam M/c, Laser Beam M/c, Plasma Arc Machining Electro-Chemical Grinding, Chemical M/c, Abrasive Flow Machining	**5**
9	**HIGH VELOCITY METAL FORMING** Electro-hydraulic Forming, Mechanical High Velocity Forming, Magnetic pulse Forming & Explosive forming	**4**
10	**GEAR MANUFACTURING PROCESSES** Introduction & Methods used. Production of Spur, Bevel & Worm gears. Casting, Powder Metallurgy, Molding & Rolling Gear Hobbing & Gear Shaping Processes Bevel Gear Generator & Gear Finishing Operations. Gear Shaving, Gear Burnishing & Gear Grinding Operations	**6**

List of Experiments:		**Number of Turns**
1	Job preparation through hacksaw cutting and centering	**1**
2	Exercise on lathe involving turning, tapering and threading	**2**
3	Exercise on drilling machine	**2**
4	Exercise on milling machine	**2**
5	Exercise on gear cutting	**2**
6	Exercise on grinding machine	**2**
7	Exercise on shaping machine	**2**

Course Outcomes:	
1	Choose specific machines for a particular job
2	Understand the basic mechanisms like quick return mechanism in shaper and half lever mechanism in lathe
3	Understand the principles of metal cutting and find out the machining times for a given data.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Materials and Processes In Manufacturing", John Wiley & Sons, DeGarmo	2011
2	"Fundamentals of Metal Cutting & Machine Tools", B L Juneja& G S Sekhon, New Age International Publication.	2010
3	"Modern Machining Process", P C Pandey & H S Shan, Tata McGraw Hill	2008
4	"Production Technology", PC Sharma, S Chand Publications	2007
5	"Introduction to Machining Science", Lal, G. K., New Age Publications	2007
6	"Manufacturing Science", Ghosh, A., & Mallik, A.K., East West Press Pvt. Ltd.	1999

Course Name	**:**	**COMPUTER INTEGRATED MANUFACTURING**
Course Code	**:**	**PEN 301**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of the course the students should be able to describe geometric transformations and modeling along with identifying the concepts of process planning, material handling and cellular manufacturing.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**COMPUTER AIDED DESIGN:** The Product Design Process, CAD System Input – Output Devices, Selection of CAD/CAM Systems	**2**
2	**COMPUTER GRAPHICS AND TRANSFORMATION:** Geometric Transformations, Homogeneous Representation, Composition of Transformations	**6**
3	**GEOMETRIC MODELING:** Geometric Modeling Approaches, Wireframe Modeling, Surface Modeling, Solid Modeling, Parametric and Variation Design, Rapid Prototyping	**6**
4	**COMPUTER AIDED ENGINEERING ANALYSIS:** Finite Element Modeling, Design Optimization, Commercial Packages to Support Product Modeling and Analysis	**4**
5	**PROCESS PLANNING AND CONCURRENT ENGINEERING:** Process Planning, Computer Aided Process Planning, Concurrent Engineering and Design for Manufacturing, Advanced Manufacturing Planning	**4**
6	**MATERIAL HANDLING AND IDENTIFICATION TECHNOLOGIES:** introduction to Material Handling, Material transport Equipment, Storage System Performance and Location Strategies, Conventional Storage Methods and Equipment Automated Storage Systems, Automatic Identification and Data Capture, Bar Code Technology, Radio Frequency Identification, Other AIDC Technologies	**4**
7	**CELLULAR MANUFACTURING:** Part Families, Parts Classification and Coding, Production Flow Analysis Cellular Manufacturing, Applications of Group Technology	**4**
8	**FLEXIBLE MANUFACTURING SYSTEMS:** FMS Components, FMS Applications and Benefits, FMS Planning and Implementation Issues.	**4**
9	**INSPECTION TECHNOLOGIES:** Inspection Metrology, Conventional Measuring and Gaging Techniques, Coordinate Measuring Machines, Surface Measurement, Machine Vision, Other Optical Inspection Methods, Noncontact Non-optical Inspection techniques	**4**
10	**PRODUCTION PLANNING AND CONTROL SYSTEMS:** Aggregate Production Planning and Master Production Schedule, Material Requirements Planning, Capacity Planning, Shop Floor Control, Inventory Control, Extensions of MRP	**4**

Course Outcomes: By the end of the course, the students will be able to:	
1	Identify and differentiate the different components involved in CAD
2	Perform simple geometric transformations
3	Describe the importance of flexible and cellular manufacturing systems and its advantages in industries.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Systems Approach to Computer Integrated Design and Manufacturing", Nanua Singh, John Wiley Sons	1995
2	"Automation Production Systems and CIM", Groover, Prentice Hall	2007
3	"CAD/CAM; Principles and Applications", P N Rao, Tata McGraw Hill	2004

Course Name	**:**	**OPERATIONS RESEARCH**
Course Code	**:**	**PEN 303**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of the course the students should be able to describe, formulate and solve problems related to linear programming, queuing and simulations in an industrial and service environment.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION AND FORMULATION:** Origin and development of operations research, Scope of Operations Research (OR), General methodology of OR, applications of OR to industrial problems. Formulation of LP model for some common industrial problems—product mix, blending, resource allocation, inventory, replacement and similar other problems. Primal and dual problems, Transportation and assignment models. Degeneracy in transportation problems.	**10**
2	**LINEAR PROGRAMMING:** Graphical solution, Simplex method of solution, quality and sensitivity analysis. Application of linear programming and sensitivity analysis in industrial problems	**8**
3	**QUEING THEORY:** Analysis of the following queues with Poisson's pattern of arrival and exponentially distributed service times, Single channel queues with infinite customer populations	**7**
4	**MONTE CARLO SIMULATION:** Need for simulation, advantages and disadvantages of simulation, methods of simulation. Generation of normal random numbers with any given distribution. Use of random numbers for system simulation.	**5**
5	**PERT AND CPM:** Network representation. Critical path computations. Construction of the time schedule. Linear programming formulation of CPM. PERT calculations.	**4**
6	**DYNAMIC PROGRAMMING:** Recursive nature of computations in DP. Forward and Backward recursion. Selected DP applications: Knapsack/fly away/cargo-loading model, Work force size model, Equipment replacement model, Investment model, Inventory models.	**4**
7	**REPLACEMENT THEORY :** Introduction. Failure mechanism of item. Assumptions of replacement theory. Replacement decisions. Types of replacement problem.	**4**

Course Outcomes: By the end of this course, the students will be able to:	
1	Apply Linear programming methods to any given problem
2	Perform Monte Carlo simulation for a given case study
3	Apply the queuing model for a given study
4	Apply the PERT/CPM for a constraint based problem of service/ manufacturing
5	Apply the Dynamic programming on several cases for service/manufacturing
6	Understand the fundamentals and cases of Replacement Problem

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"An Introduction to Operations Research", Taha, H.A., 9th Ed., Prentice Hall of India	2011
2	"Operations Research", Panneerselvam R., PHI	2011
3	"Operations Research",P. K. Gupta and D.S. Hira, S. Chand	2008

Course Name	**:**	**PRODUCTION AND OPERATIONS MANAGEMENT**
Course Code	**:**	**PEN 304**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:

At the end of the course the students should be able to describe the concepts of operations and inventory management; provide inputs to use JIT, Lean and such systems to improve the efficiency.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO OPERATIONS MANAGEMENT:** Factors affecting Operations Management, Operations as system, Decision making in POM	**3**
2	**OPERATIONS STRATEGIES IN GLOBAL ECONOMY:** Global business conditions, Operations strategy, Forming Operations Strategies	**4**
3	**DEMAND FORECASTING:** Qualitative Forecasting Methods, Quantitative Forecasting Models	**5**
4	**PRODUCT, PROCESS, AND SERVICE DESIGN:** Process planning and design, Major factors affecting progress design decisions, Types of process designs, Interrelations among product design, Process design & Inventory policy	**6**
5	**JUST-IN-TIME & LEAN MANUFACTURING:** Philosophy, Benefits of JIT manufacturing, Success and JIT manufacturing, JIT in service companies. Lean Manufacturing: Introduction-definition and scope-continuous vs. lean production-benefits and methodology-process oriented continuous improvement teams-leanmanufacturing education-product oriented continuous improvement teams-cell manufacturing training-redesign of plant layout- cross training of team members	**10**
6	**INVENTORY MANAGEMENT:** Nature of inventories, Opposing views of inventories, Fixed- order Period and Quantity systems, Inventory models, inventory planning, ERP & ERP-II	**5**
7	**MANUFACTURING OPERATIONS SCHEDULING:** Scheduling process- Focused Manufacturing, Scheduling product focused manufacturing, computerized scheduling system	**5**
8	**MAINTENANCE MANAGEMENT:** Planned production maintenance, preventive maintenance, machine reliability, secondary maintenance department responsibilities, Concept and advantages of TPM	**4**

Course Outcomes: By the end of this course, the students will be able to:	
1	Identify wastes in a given process and suggest methods to improve the process
2	Identify and apply systems of inventory, lean or JIT principles for a given case study/ system

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Productions and Operations Management", Chase Aquilano& Richard Irwin, McGraw Hill series	2010
2	"Productions and Operations Management", Adam & Ebert Prentice Hall	2008
3	Production and Operations Management: An Applied Modern Approach" Joseph S. Martinich , Willy Student Edition	2008
4	"Operations Management",Gaither, Frazier – Thomson South Western	2002

Course Name	**:**	**INDUSTRIAL ENGINEERING II**
Course Code	**:**	**PEN 305**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:

At the end of the course the students should be able to describe quality management systems, statistical processes and application of reliability engineering; apply the concepts of supply chain and value engineering.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**QUALITY MANAGEMENT :** Introduction to the concepts of Inspection, quality control, quality assurance and CWQM. Quality trilogy, Con tenuous improvement philosophy – Kaizen , Components of TQM, PDCA Cycle, TQM implementation, Improvement through elimination of wastes, 5S campaign, 4M checklists. Planning process and strategies for continuous improvement, Organizational structure, education and training, communications, process and project management for quality improvement, costs of quality, use and evaluation of quality costs. Zero Defect programmes, identification and solution of quality problems – Pareto, Cause and Effect and Force Field analysis, Brainstorming, Quality Circles, QC tools and their applications. QFD, JIT philosophy and techniques.	**10**
2	**STATISTICAL PROCESS CONTROL :** Statistical process control, systematic approach process variability, Control Charts for variables and attributes. Acceptance sampling plans – single, double, multiple and sequential – for attributes and variables, minimum inspection per lot, formulation of inspection lots and selection of samples. OC curve. Doge-Romig tables and ABC standards, AOQL, and LTPD plans.	**8**
3	**RELIABILITY ENGINEERING:** Reliability; Definition and Basic concepts, Mean Time Between failures (MTBF), Mean Time To Repair (MTTR) deviation of the Reliability function, Statistical failure modes. Exponential, Gamma, Weibull, Lognormal and Fatigue life models. Point and interval estimation procedures for the above distributions. Reliability in terms of Hazard rate – Hazard models and bath-tub curve applicability of Weibull distribution.	**10**
4	**SUPPLY CHAIN AND LOGISTICS MANAGEMENT:** Overview of Supply Chain and supply chain management. Supply chain performance and profitability. Role of Supply Chain Management and its Scope and importance. Performance Drivers and obstacles. Achieving strategic fit. Logistics and Competitive Strategy.	**6**
5	**VALUE ENGINEERING:** Introduction: History, development and scope of value management, value analysis vs. Value engineering principles of costing and cost estimation, benefits. Basic concepts of value engineering: Selection of project, team members, general phase, information phase, creation phase, evaluation phase investigation and implementation phase, audit.	**8**

Course Outcomes: By the end of this course, the students will be able to:	
1	Identify and distinguish between different Statistical techniques and sample plans,
2	Design and apply the control charts for a given application,
3	Formulate and solve supply chain management problem of Service/Manufacturing Industry,
4	Solve the given basic problems related to reliability engineering,
5	Do value analysis for any process/ product.

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	"Fundamental of Quality Control and Improvement, Amitava Mitava, 3 Edn, Wiley	2012
2	"Fundamental of Supply Chain Management: Text and Cases", Michal H. Huges, Third Edition, Wiley Publishers.	2011
3	"Supply Chain Management: Text and Cases" , Jannat Shah, Pearson Publications	2009
4	"Effective Manpower Management", Y.P Singh, AnmolPublisitions Pvt Ltd.	2001

Course Name	**:**	**THERMAL ENGINEERING**
Course Code	**:**	**PEN 311**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of the course the students should be able to get familiarized with the fundamental of thermodynamics and heat transfer.

Lecture wise breakup	**Total No. of Lectures – 42**	**Number of Lectures**
1	**BASIC CONCEPTS:** Macroscopic and Microscopic Approach, Concept of Continuum, Thermodynamic System, Surrounding and Boundary, Thermodynamic Equilibrium, State, Path, Process, cycle, Quasi-static Process, Reversible and Irreversible Process, Working Substance. Thermodynamic Properties like Pressure, Volume and Temperature, Zeroth Law of Thermodynamics. Temperature Scales, Concept of Heat and work in Thermodynamics.	**4**
2	**FIRST LAW OF THERMODYNAMICS:** Joule's Paddle wheel Experiment; Mechanical Equivalent of Heat, First Law for a closed system undergoing a Cycle, First Law for a closed system undergoing a change of state. Different forms of stored Energy, Enthalpy, Energy of An isolated System, Perpetual Motion Machine of First kind.	**4**
3	**FIRST LAW APPLIED TO FLOW PROCESSES:** Flow Process and Control Volume, flow work, Steady and Unsteady Flow Process, Steady Flow Energy Equation, Engineering Applications of Steady Flow Energy Equation, Throttling Process, Flow Work and Non Flow work, Variable flow Processes, Limitation of First Law.	**4**
3	**SECOND LAW OF THERMODYNAMICS:** Qualitative Difference between Heat and Work, Thermal Reservoir, Statements of 2 nd Law by Max.Planck and Claussius, Equivalence between two statements, Energy Analysis of Heat Engine, Refrigerator and Heat Pump Reversibility and Irreversibility, Causes of Irreversibility Carnot Theorem, Carnot cycle, Absolute Thermodynamic Temperature, Scale, Efficiency of the Reversible Heat Engine, Equality of Ideal Gas Temperature and Kelvin Temperature.	**6**
5.	**ENTROPY:** Classius Theorem, Classius Inequality and concept of Entropy, Entropy change in an Irreversible Process, Application of Entropy Principle, Entropy Transfer with Heat Flow, Entropy generation in closed and open System, Thermodynamics Equations relating properties of System, Reversible Adiabatic work in a Steady flow System. Entropy and direction, Entropy and disorder.	**6**
6	**GAS POWER CYCLES:** Air Standard efficiency, Mean Effective Pressure, Otto, Diesel, Dual, Brayton, Stirling and Ericson Cycle, Comparison of cycles.	**5**
7	**REFRIGERATION AND AIR CONDITIONING:** Working of simple vapour compression cycle, representation of various process on pH diagram, , Air conditioning principle, humidity, relative humidity, representation of various air conditioning processes on psychrometric charts.	**5**
8	**HEAT TRANSFER:** Introduction to different modes, Principles of conduction convection and radiation and basic laws	**3**

Course	**Outcomes:** By the end of this course, the students will be able to:	
1	Understand laws of thermodynamics.	
2	A fundamental understanding of laws of thermodynamics and application to wide range of systems.	
3	Familiarity with efficiencies of heat engines and other engineering devices	

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Thermodynamics:: An Engineering Approach,", Yunus A. Cengel, Michael A. Boles, McGraw-Hill Education	2014
2	"Engineering Thermodynamics", P.K. Nag, Tata McGraw-Hill Education	2013
3	"Engineering Thermodynamics", Gordon Rogers & Yon Machew	2006
4	"Thermodynamics", Yunus Cengel and Mike Boles	2006

Course Name	**:**	**DESIGNING FOR AUTOMATION**
Course Code	**:**	**PEN 402**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of the course the students should be able to describe the importance of automation in industries and the use of different techniques like hydraulic, pneumatic, electrical and PLC's to improve the automation.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**OVERVIEW OF INDUSTRIAL AUTOMATION:** Automation in production systems, Automation principles and strategies, Levels of automation, Automation at device level.	**4**
2	**PNEUMATIC CONTROL:** Production, distribution and conditioning of compressed air, Pneumatic control components, Pneumatic actuators, Pneumatic valves, Air-hydraulic equipment, Pneumatic control system design, Logic control circuits, Pneumatic circuit design for various applications.	**8**
3	**HYDRAULIC CONTROL:** Components of hydraulic control system, Hydraulic actuators, Hydraulic valves, Accumulators, Hydraulic circuit design and analysis	**6**
4	**ELECTRICAL CONTROL:** Electrical actuators: Stepper motors, DC and AC motors, Motor selection	**8**
5	**SYSTEM MODEL ANALYSIS:** System model analysis, Model formulation, Transfer functions, System response, Linear system analysis.	**8**
6	**PROGRAMMABLE LOGIC CONTROLLERS:** PLC system overview, PLC features, Basic PLC programming, PLC selection, Examples of PLC industrial applications	**8**

Course Outcomes: By the end of this course, the students will be able to:	
1	Choose different automation methods for a given application.
2	Identify the functioning of hydraulic/ pneumatic and electrical circuits.
3	Prepare a simple automation circuit and explain its different components.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Automation, Production Systems and Computer-Integrated Manufacturing", M.P. Groover, Pearson Education	2014
2	"Programmable Logic Controllers", R. Ackermann, J. Franz, T. Hartmann, A. Hopf, M. Kantel, B. Plagemann, Festo Didactic	2014
3	"Fluid Power with Applications" A.Esposito, Pearson Education India	2003

Course Name	**:**	**SMART MATERIALS**
Course Code	**:**	**PEN 403**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:

By the end of this course, student should be able to apply basic principles and mechanisms of smart materials and devices and provides a spring board for further study, demonstrate knowledge and understanding of the physical principles underlying the behaviour of smart materials, describe the basic principles and mechanisms of the important smart materials, demonstrate knowledge and understanding of the engineering principles in smart sensors, actuators and transducer technology, propose improvements on the design, analysis, manufacturing and application issues involved in, integrating smart materials and devices with signal processing and control capabilities to engineer smart structures and products.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION:** Overview of Smart Materials and their properties, Classification of Smart Materials, Development of smart materials and devices, Areas of application of devices.	**5**
2	**PIEZOELECTRIC AND ELECTROSTRICTIVE MATERIALS:** constitutive relationship, electromechanical coupling coefficients, piezoelectric constants, piezoceramic materials, variation of coupling coefficients in hard and soft piezoceramics, polycrystalline vs single crystal piezoelectric materials, polyvinyldene fluoride, piezoelectric composites.	**6**
3	**MAGENTOSTRICTIVE AND MAGNETOELECTRIC MATERIALS:** constitutive relationship, magneto-mechanical coupling coefficients, Joule Effect, Matteuci Effect, Wiedemann effect, Giant magnetostriction in Terfenol-D, Trefnol-D particulate composites, Galfenol and Metglas materials.	**6**
4	**SAHPE MEMORY ALLOYS:** Synthesis, Types of shape memory alloys, Nickel-titanium alloy(Nitinol), Cu based alloys, Chiral materials, Applications, Fasteners, Fibers, Reaction vessels, Nuclear Reactors, Chemical plants, Satellite Antenna, Blood clot filter, Plastics.	**5**
5	**ELECTRORHEOLOGICAL (ER) AND MAGNETORHEOLOGICAL (MR) FLUIDS:** Suspensions and ER fluids, ER phenomenon, charge migration mechanism, ER fluid actuators, applications of ER fluids, Composition of MR fluid, application of MR fluids.	**5**
6	**SENSOR AND ACTUATOR**: Sensing technology, types of Sensors, Physical Measurement using Piezoelectric Strain measurement, Inductively Read Transducers, THE LVOT, Fiber Optic Techniques, Chemical and Bio-Chemical sensing in structural Assessment, Absorptive chemical sensors, Spectroscopes, Fibre optic Chemical Sensing Systems and Distributed Measurements, Actuator techniques, Actuator and actuator	**10**

	materials, Piezoelectric and Electrostrictive material, Magneto structure material, Shape Memory Alloys, Electrorheological Fluids, Electromagnetic actuation, Role of actuators and Actuator Materials.	
7	**MEASURING TECHNIQUES** : Strain Measuring Techniques using Electrical strain gauges, Types, Resistance, Capacitance, Inductance, Wheatstone Bridges, Pressure transducers, Load cells, Temperature compensation, Strain Rosettes	**5**

Course Outcomes: by the end of this course student will be able to	
1	Understand the behavior and applicability of various smart materials.
2	Design and conduct experiments, analyze and interpret data related to smart materials and devices.
3	Design a system, component, or process based on smart materials to meet desired needs.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Piezoelectric materials and devices: Applications in Engineering", M.S. Vijaya	2013
2	"Smart Electronic materials : Fundamentals and Applications", Jasprit Singh	2005
3	"Smart materials and New technologies", M. Addington, Schodek, L. Daniel	2005

Course Name	**:**	**RAPID PROTOTYPING**
Course Code	**:**	**PEN 404**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of the course the students should be able to describe different processes in rapid prototyping and rapid manufacturing and enumerate its applications.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** History of RP systems, Survey of applications, Growth of RP industry, and classification of RP systems.	**3**
2	**STEREO LITHOGRAPHY SYSTEMS** Principle, Process parameter, Process details, Data preparation, data files and machine details, Application.	**4**
3	**SELECTIVE LASER SINTERING** Type of machine, Principle of operation, process parameters, Data preparation for SLS, Applications.	**4**
4	**FUSION DEPOSITION MODELLING** Principle, Process parameter, Path generation, Applications.	**3**
5	**SOLID GROUND CURING** Principle of operation, Machine details, Applications. Laminated Object Manufacturing: Principle of operation, LOM materials. Process details, application.	**6**
6	**CONCEPTS MODELERS** Principle, Thermal jet printer, Sander's model market, 3-D printer. GenisysXs printer HP system 5, object Quadra systems.	**4**
7	**RAPID TOOLING** Indirect Rapid tooling, Silicone rubber tooling, Aluminum filled epoxy tooling, Spray metal tooling, Cast kirksite, 3Q keltool, etc. Direct Rapid Tooling Direct. AIM.Quick cast	**6**

	process, Copper polyamide, Rapid Tool, DMILS, Prometal, Sand casting tooling, Laminate tooling soft Tooling vs.hard tooling	
8	**SOFTWARE FOR RP** STL files, Overview of Solid view, magics, imics, magic communicator, etc. Internet based software, Collaboration tools.	**6**
9	**RAPID MANUFACTURING PROCESS OPTIMIZATION** Factors influencing accuracy. Data preparation errors, Part building errors, Error in finishing, influence of build orientation. Applications and case studies	**6**

Course Outcomes: By the end of this course, the students will be able to:	
1	Understand the importance of rapid prototyping in the present scenario
2	Apply the rapid tooling concepts to different products areas such as industrial and consumer requirements
3	Understand the different stages in RP along with the software requirements.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Rapid Prototyping: Principles and Applications in Manufacturing" Chua, C.K., and Leong, L.F., John Wiley & Sons Ltd.	2014
2	"Stereo Lithography and other RP & M Technologies", Paul F. Jacobs: SME, NY.	2012
3	"Rapid Manufacturing", Flham D.T &Dinjoy S.S Verlog London.	2001
4	"New Technology"ABhattacharaya, Institution of Engineers, India	2000
5	"Rapid Prototyping", Terry Wohlers Wohler's Report " Wohler's Association	2000

Course Name	**:**	**MODERN MANUFACTURING**
Course Code	**:**	**PEN 405**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:
At the end of the course the students should be able to describe different non-traditional manufacturing methods available and which can be used to enhance the manufacturability.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION:** Evolution, need, types, classification and comparison between conventional and advanced (modern) manufacturing processes (AMP).	**3**
2	**MECHANICAL PROCESSES:** Ultrasonic machining (USM), Rotary Ultra Sonic Machining (RUM), AJM, WJM, AWJM, processes – Process principle and mechanism of material removal; Process Parameters; Process Capabilities; Applications; Operational characteristics; Advantages and Limitations.	**4**
3	**THERMAL METAL REMOVAL PROCESSES:** Electric Discharge Machining: Introduction, machine, mechanism of metal removal, dielectric fluid, spark generator, EDM tools (electrodes) Electrode feed control, Electrode manufacture, Electrode wear, EDM tool design : Choice of machining operation, electrode material selection, under sizing and length of electrode Machining time, Flushing – Pressure flushing synchronized with electrode movement, EDM process characteristic: Metal removal rate, Accuracy surface finish, Heat affected Zone. Machine tool selection, Application: EDM accessories / applications, electrical discharge grinding, Travelling wire EDM.	**6**
4	**ELECTRO CHEMICAL TYPE AMPS:** ECM – Process principle; Mechanism of material removal; Process Parameters; Process Capabilities; Applications and limitations	**3**
5	**THERMAL TYPE AMPS:** EDM, Wire Electro Discharge Machining (WEDM), LBM, EBM, IBM, PAM processes – Process principle and mechanism of material removal; Process parameters and characteristics; Surface finish and accuracy; Process Capabilities; Applications; Limitations.	**6**
6	**ADVANCED FINE FINISHING PROCESS:** Abrasive Flow Machining (AFM), Magnetic Abrasive Finishing (MAF), Magneto Rheological Abrasive Finishing (MRAF) - Process principle; Process equipment; Process Parameters; Process Capabilities; Applications; Operational characteristics; Advantages and Limitations.	**4**
7	**CHEMICAL TYPE AMPS:** Process principle and details of Chemical Machining (CHM), Photo-Chemical Machining (PCM), and Bio-Chemical Machining (BCM) processes; Advantages, applications and limitations.	**4**

8	**DERIVED AND HYBRID PROCESSES:** Electro Stream Drilling (ESD), Shaped Tube Electro Machining (STEM), Electro Chemical Honing (ECH), Electro Chemical Deburring (ECDE), Electro Chemical Discharge Machining (ECDM) - Process Parameters; Process Capabilities; Applications; Limitations, Introduction to form machining.	**6**
9	**RAPID PROTYPING (RP):** Introduction to RP techniques and materials, Stereolithography, Selective laser sintering, Fused deposition modeling, Three-dimensional printing, Laminated Object Manufacturing, Rapid Tooling, Rapid Manufacturing, advantages, applications and applications of RP.	**6**

List of Experiments:		**Number of Turns**
1	Perform an exercise on hydroforming	**2**
2	Perform an exercise on EDM	**3**
3	Perform an exercise on hybrid ECM/ ECDM	**3**
4	Perform an exercise on AFM	**2**
5	Perform a given exercise on burnishing	**3**

Course Outcomes: By the end of this course, the students will be able to:	
1	Identify, classify and differentiate between the various available techniques.
2	Apply and choose a particular modern manufacturing technique for a given problem

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Modern Machining Process",Pandey And Shahn, TATA McGraw Hill	2010
2	"Advanced Machining Processes", Vijay K. Jain, Allied Publishers Limited	2005
3	"New Technology" **A** Bhattacharaya, Institution of Engineers, India	2000

Course Name	**:**	**MACHINE TOOL DESIGN**
Course Code	**:**	**PEN 412**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of the course the students should be able to describe the various drives, structures and basic design principles used in these assemblies.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** Classification of Machine Tools, Working and Auxiliary Motions in Machine Tools, Parameters Defining Working Motions of a Machine Tool, General Requirements of Machine Tool Design	**2**

2	**MACHINE TOOL DRIVES** Selection of Electrical Motor, Stepped and Stepless Output, Upper and Lower limits of Machine Tools, Layouts of Intermediate Spindle Speeds, Selection of Values of Common Ratio, Speed and Feed Gear box Design, Gearboxes with Clutched Drives, Feed in Reciprocating Machines, Feed in Drilling Machines, Feed in Milling Machines, Feed in Lathe, Cutting Screw Design, Double-bound Gears, Mechanical Drives for Reciprocation. Stepless Drives, Mechanical, Hydraulic, Electrical Stepless Drives.	**(18)**
3	**STRENGTH AND RIGIDITY OF MACHINE TOOL STRUCTURES** Design Criteria for Machine Tool Structures, Static and Overall Compliance of Machine Tool, Design of Lathe Beds, Design of Radial Drill Column, Force Analysis of a Shaping Machine Ram, Analysis of Straining Actions on a Milling Machine Structure, Analysis and Design of Tailstock Assembly.	**8**
4	**ANALYSIS OF GUIDEWAYS AND POWER SCREWS** Design of Slideways for Wear Resistance, Design of Slideways for Stiffness, Guideways Operating under Liquid Friction Conditions, Design of Power Screws	**8**
5	**ANALYSIS OF SPINDLES AND SPINDLE SUPPORTS:** Functions of Spindle Unit and Requirements, Design calculations of Spindles, Sliding Bearings, Hydrodynamic and Hydrostatic Journal Bearings	**6**

Course Outcomes: By the end of this course, the students will be able to:	
1	Identify design principles used in different machine elements.
2	Choose different criterion and design a speed/ or feed gear box.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Machine Tool Design and Numerical Control", N K Mehta, , Tata McGraw-Hill	2012
2	"Fundamentals of machining and machine tools", Mridul Singal, I. K. International Pvt Ltd.	2008
3	Machine Tool Design, Vol. I-IV", N Acherken, Mir Publishers, Mascow	2001
4	"Machine Tool Vibration", S ATobias, J. Wiley, 1965, London	1965
5	"Principles of Machine Tools", G C Sen, A Bhattacharyya, J.N. Sen for and	1988

Course Name	**:**	**ROBOTICS**
Course Code	**:**	**PEN 413**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:

At the end of the course the students should be able to describe the basic functioning, principles, classification and uses of robots in industrial applications.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1.	**ROBOT TECHNOLOGY:** Fundamentals, General characteristics, Basic components, Robot anatomy, Robot selection.	**3**
2.	**ROBOT CLASSIFICATION:** Classification, Arm geometry, Degrees of freedom, Power sources, Types of motion, Path Control	**3**

3.	**ROBOT SYSTEM ANALYSIS:** Robot kinematics modeling, DH parameters, Forward and inverse kinematics, Robot dynamics, Dynamic properties of robots.	**6**
4.	**TRAJECTORY PLANNING:** Cartesian vs joint space trajectory planning, Polynomial trajectories, Cubic and quintic interpolation, Higher order trajectories, 4-3-4 trajectory for pick and place operation	**4**
5.	**ROBOT END EFFECTORS:** Types of end-effectors, Mechanical grippers, Gripper force analysis, Other type of grippers, Special purpose grippers, Gripper selection and design, Process tooling, Compliance	**6**
6	**SENSORS:** Robot sensors, Sensor classification, Proximity sensors, Photoelectric sensors, Micro switches, Rotary position sensors, Usage and selection of sensors.	**6**
7.	**VISION:** Visual sensing, Machine vision- image acquisition, digitization, processing, analysis and interpretation, Machine vision applications, Other optical methods	**4**
8.	**ROBOT PROGRAMMING:** Programming methods, Programming languages, Levels of robot programming, Motion interpolation, Sample programs	**4**
9.	**INDUSTRIAL APPLICATIONS:** Automation in manufacturing, Robot applications, Material handling applications, Processing applications, Assembly operations, Inspection operations, Evaluating the potential of a robot application	**6**

Course Outcomes: By the end of this course, the students will be able to:	
1	Classify different robots and identify their various components.
2	Understand and perform simple analysis on inverse kinematics.
3	Evaluate and select a gripper for different applications
4	Understand the roles of sensors, vision systems and applications of industrial robots

Suggested Books:

No.	**Name of Book/ Authors/ Publisher**	**Year of Publication**
1	"Industrial Robotics", Groover. Weiss, Nagel and Ordrey, McGraw Hill	2012
2	"Ïntroduction to Robotics Mechanics and Controll", Johan J. Craig, Pearson Edition.	2008
3	"Robot Technology Fundamentals", J G Keramas, Delmar Publications	1999

Course Name	**:**	**THEORY OF METAL CUTTING**
Course Code	**:**	**PEN 414**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

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Course Objectives:

At the end of the course the students should be able to describe mechanisms in metal cutting, identify and design the variables, cutting parameters and tools used in the process.

Total No. of Lectures – 42

Lecture wise breakup	**Number of Lectures**

1	**MECHANISM OF CHIP FORMATION** Steady of deformation, mechanism of deformation slip, twinning & dislocation, types of chips, single hear plane model and zone theory for determination of dynamic shear strain. Chip formation in drilling, chip formation in milling, effect of cutting variables on chip reduction coefficients. Numerical problems.	**8**
2	**MECHANISM OF CUTTING** force system in turning, merchant circle diagram, friction and shear force, shear stress in turning, energy in cutting process, Kronenberg relation and velocity relation, chip deviation and other effects on cutting forces. Force system in drilling, force system in milling (Vulf& simulated Model), Numerical problems.	**10**
3	**DETERMINATION OF CUTTING FORCES** Theoretical determination of cutting forces--shear angle relation (Ernst & Merchant, kronenberg, Lee & shaffer), practical determination of cutting forces-Design fundamental of tool force dynamometers turning, drilling, milling and grinding dynamometers (mainly strain gauge type).Tool Life, Machine-ability, Metal Cutting Optimization (Gilbert Model), tool life test (mainly facing tool life test) Machined surface finish --variables that effect surface finish.	**10**
4	**TOOL LIFE & MACHINEABILITY** Tool life, factors affecting tool life, criteria for tool life, mechanism of tool failure, machine- ability and measurement of machine ability index.	**6**
5	**DESIGN OF CUTTING TOOLS** Design of turning tool mainly high production tool, design of twist drills, design of form milling cutters, designs of round internal broach (pull type) of thin strips and circular discs.	**8**

Course Outcomes: By the end of this course, the students will be able to:	
1	Understand the mechanism of chip formation
2	Understand the tool failure mechanisms and calculate the tool life for a given condition
3	Able to design a single point cutting tool for a given application

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Fundamentals of Metal Cutting and Machine Tools", B. L. Juneja, Nitin Seth, New Age International.	2014
2	"Principles of Metal Cutting", Gopal Chandra Sen, Amitabha Bhattacharyya, New Central Book Agency	2012
3	"Metal Cutting Principles", M.C.Shaw, MIT	2002

Course Name	**:**	**CONCURRENT ENGINEERING**
Course Code	**:**	**PEN 415**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of course, students should be able to understand the importance, concept, tools and techniques of concurrent engineering.

Total No. of Lectures – 42

Lecture wise breakup	**Number of Lectures**

1	**INTRODUCTION:** Concurrent engineering concepts, sequential versus concurrent engineering, importance of concurrent engineering, benefits of concurrent engineering.	**8**
2	**DESIGN FOR MANUFACTURING AND ASSEMBLY:** Mathematical modelling between design and manufacturing, design for manufacturing and assembly approach, concurrent product design, material balance equation, cost equation, average manufacturing lead time.	**13**
3	**DESIGN METHODOLOGY:** Design for X, Design of experiments and Taguchi's method, Group technology based design, Design for quality, pseudo measure of product optimality, quality function deployment, improvement in unit cost and quality of manufactured products.	**8**
4	**COMPUTER AIDED ENGINEERING ANALYSIS AND PROTOTYPING:** Geometric modelling, Feature based design, product data exchange, prototyping, finite element modelling and analysis, optimization.	**5**
5	**IMPLEMENTATION AND CASE STUDIES:** Difficulties associated with performing concurrent engineering, life cycle costing, and case studies.	**8**

Course Outcomes: By the end of this course, the students will be able to:	
1	Formulate a design mathematically.
2	Understand the design for assembly approach using concurrent product design.
3	Able to design a industrial part and hence product using suitable CAD software.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Product Design for Manufacture and Assembly, Third Edition", Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight, CRC Press.	**2010**
2	"Manufacturing Design, Production, Automation and Integration", Benhabib, B., CRC Press.	**2003**
3	"Product Design for Manufacture and Assembly", Boothroyd, G., Dewhurst, P., and Knight, W., Marcel Dekker Inc.	**2002**

Course Name	**:**	**CNC MACHINES AND PROGRAMMING**
Course Code	**:**	**PEN 416**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:
At the end of the course the students should be able to describe different elements in the CNC machines, generate the part programming for tool paths and identify the fixed cycles.

Total No. of Lectures – 42

Lecture wise breakup		**No. of Lectures**
1	**INTRODUCTION:** Introduction to NC/CNC/DNC and its role in FMS and CIMS, Basics elements of CNC system	**4**
2	**CONSTRUCTIONAL DETAILS CNC MACHINES:** CNC Hardware Elements including drives, actuators & sensors, Machine structure- Static, Dynamic and Thermal load factors. Guide-ways- Antifriction Linear Motion (LM) Guide ways, Re-circulating Ball Bushings, Linear Bearings with Balls and Rollers.	**8**

3	**TRANSMISSION SYSTEMS:** Mechanical Transmission System: Screw and Nut, Re-circulating Ball screws, Re-circulating Roller screws. Rack-and-pinion. Spindle and Spindle Bearings: Hydrodynamic bearing, Hydrostatic Bearings, Antifriction bearings	**8**
4	**CNC PART PROGRAMMING:** Introduction to Part Programming, Axis identification and coordinate systems, referencing, structure of CNC part program, programming formats, Radius and Length Compensation Schemes	**7**
5	**ADVANCED PROGRAMMING FEATURES:** Canned Cycles, Radius and Length Compensation Schemes, Computer Assisted CNC part programming using APT language and applications.	**7**
6	**TOOLING FOR CNC MACHINE TOOLS:** Tooling requirements of CNC machines, work and tool holding devices in CNC machines.	**4**
7	**RECENT DEVELOPMENTS IN CNC MACHINE TOOLS:** DNC and parametric programming, Simulation, Application of advanced CAM software and programming case studies.	**4**

List of Experiments:		**Number of Turns**
1	Demonstration and exposure to various tools, features and operating of VMC	**2**
2	Part programming and Drilling exercise on VMC	**3**
3	Part programming and Milling exercise on VMC	**3**
4	Exercise on radius compensation and canned cycles	**3**
5	Exposure to CNC simulation using software	**3**

Course Outcomes:	
1	Understand the importance of CNC machines and its advantages in terms of performance efficiency.
2	Write part programs for a given job for turning/drilling/ milling operations
3	Identify the tooling and operations of CNC machines and their differences from conventional machines

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Machine Tool Design and Numerical Control", N K Mehta, Tata McGraw-Hill, 3rd ed.	2014
2	"Automation, Production Systems and Computer-Integrated Manufacturing", by M P Groover	2014
3	"Mechatronics", HMT Tata McGraw-Hill.	2000
4	"Numerical control & Computer Added Manufacturing", T K Kundra, P N Rao, N K Tewari, Tata McGraw-Hill.	1998

Course Name	**:**	**PRODUCT DESIGN AND DEVELOPMENT**

Course Code	**:**	**PEN 417**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of the course the students will be able to understand the concept of product design, development and planning.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**UNDERSTANDING DESIGN :** Design & its nature, Design activities: Design exploration, Design generation, Design evaluation, Design communication, Design Ability: Human Brain & whole brain thinking, Intuition vs. logical thinking, Difference between Scientist/Engineer & a designer, Design problems: Design brief, ill-defined problems, Final design description, Four stage design process model	**4**
2	**PRODUCT DEVELOPMENT:** What is product development, Characteristics of successful product development, Who designs & develops products, Challenges of product development, Phases of product development process.	**3**
3	**CONSTANT AND TIME DEPENDANT FAILURE MODELS:** Exponential, weibull, normal and lognormal distributions	**2**
4	**PRODUCT PLANNING :** Product planning, Types of product development projects, Product Planning process (steps).	**2**
5	**CONCEPT DEVELOPMENT PHASE:** Identifying Customer Needs Product Specifications: What are specifications, When are specifications established?, Establishing target specifications. Setting the final specifications .The activity of concept generation, A five-step method Concept Selection & Concept Testing	**6**
6	**SYSTEM LEVEL DESIGN:** Product Architecture, Industrial design	**3**
7	**DETAIL DESIGN:** Design for manufacturing & Robust design ,Computer Aided Design: Geometric modeling approaches, Wireframe & surface modeling, NURUBS, Solid modeling, Features, Parametric & Variational Design, Computer Aided Engineering Analysis, CAD/CAM Data Exchange, Rapid prototyping	**6**
8	**TESTING & REFINEMENT:** Prototyping basics, Principles of prototyping, Prototyping technologies, Planning for Prototypes.	**3**
9	**TYPES OF MAINTENANCE:** Corrective, Breakdown, Predictive, Replacement, Preventive and Proactive maintenance strategies, Preventive maintenances v/s. repair, Computerized Maintenance Management System, Reliability under preventive maintenance.	**4**
10	**DESIGN FOR MAINTAINABILITY:** Quantifiable measures of maintainability, maintainability management tasks during the product life cycle, life cycle costing, life cycle cost estimation models, spare parts management	**3**
11	**INTRODUCTION TO TPM AND RCM:** Classification, Principles, applications and case studies	**2**

Course Outcomes: By the end of this course, the students will be able to:	
1	Students should be able to understand the concept of prototyping.
2	Students should be able to design a product using computer aided design.
3	Students should be able to carry out product development and planning process.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Product Design & Development", K.T. Ulrich & S.D. Eppinger, , TMH	2009
2	"Engineering Design Methods-Strategies for Product Design", Cross N., John Wiley & Sons	2008
3	"Product Design for Manufacture and Assembly", Boothroyd G., Dewhurst P., and Knight, Marcel Deckker, 2nd Ed. ,	2002

Course Name	**:**	**ADVANCE WELDING TECHNOLOGY**
Course Code	**:**	**PEN 421**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:
At the end of the course the students should be able to describe different welding process, classify them based on applications and identify the testing methods.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**NON FUSION WELDING PROCESSES** Resistance, Friction, Explosive, Ultrasonic Welding: Principle, method of operation, process variables and applications.	**8**
2	**HEAT FLOW IN WELDING** Calculation of peak temperature; width of Heat Affected Zone; cooling rate and solidification rates; weld thermal cycles; residual stresses and their measurement; weld distortion and its prevention.	**6**
3	**EFFECT OF WELDING PARAMETERS** Effect of voltage, current, wire feed rate, welding speed, polarity on weld bead geometry.	**8**
4	**AUTOMATION IN WELDING** Semi automatic welding, Automatic welding, Automated welding, Remote welding, Robot welding, Adaptive controls.	**8**
5	**SPECIFIC WELDING APPLICATIONS AND INNOVATIONS** Welding in wind, Welding at low ambient temperature, Welding in vacuum, Underwater welding and Welding in space, Welding of ceramics and plastics.	**6**
6	**WELDABILITY** Definition of weld-ability, methods weld-ability evaluation, weld-ability of carbon steel, stainless, steel, cast Iron, and aluminum, welding defects, brazing, soldering, thermal spraying and surfacing, Pre-weld and post weld treatments.	**6**

List of Experiments :		Number of Turns
1	Fabrication exercise by using Ultrasonic welding machine	2
2	Fabrication exercise by using Wire butt welding machine	2
3	Fabrication exercise by using SAW machine	2
4	Analyze the effects of welding parameters on bead geometry of the weld	4
5	Analyze the effects of welding parameters on the weld characteristics of spot welding machine	2
6	Study of friction welding process	2

Course Outcomes: By the end of this course, the students will be able to:	
1	To select the appropriate welding process.
2	Analyze the effects of welding conditions on bead geometry.
3	Able to learn the specific welding applications and innovations.

Suggested Books:		
Sr. No.	Name of Book/ Authors/ Publisher	Year of Publication/ Reprint
1	"Welding Engineering and Technology", RS Parmar, Khanna Publishers	2010
2	"Welding Processes and Technology", RS Parmar, Khanna Publishers	2013
3	"Welding Metallurgy", Kuo, S., John-Wiley & Sons Inc.	2003
4	"Welding Handbook: Metals and their weldability", American Welding Society, Volume 1-5	1982

Course Name	**:**	**ADVANCE CASTING TECHNOLOGY**
Course Code	**:**	**PEN 422**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of the course the students should be able to describe the principles in solidification, designing the casting systems and controlling the defects.

Total No. of Lectures – 42

Lecture wise breakup		Number of Lectures
1	**INTRODUCTION:** Ferrous and non-ferrous materials and their properties, pattern allowances, sand properties, testing and control, special sand additives, metallurgical consideration of cast iron, SG iron, steel, aluminum, Mg- alloys and Ti-alloys for casting process, progressive and directional solidification.	6
2	**PATTERN AND CASTING DESIGN:** Pattern design, recent developments in pattern design, materials and construction; Casting design considerations- review of casting design, recent trends.	6
3	**CASTING PROCESSES:** Review and critical comparison of various established process, cold chamber and hot chamber die casting, recent d e.g. low pressure and high pressure moulding, full moulding process, hot and cold box moulding, ceramic shell molding, squeeze and pressed casting	8
4	**RISERS AND GETTING SYSTEM:** Riser design, risering curves, NRL method of riser design, feeding distance, risering of complex casting, risering of alloy other than steel.	
5	**INTERNAL STRESSES AND SURFACE FINISH:** Residual stresses, defects and surface residual stresses, hot tears and cracking in casting,	8

	stress relief, defects and their causes & remedies	
6	**TESTING, INSPECTION AND QUALITY CONTROL:** testing of sand, recent development e.g. index, compatibility, X-ray mould ability & X-ray radiography, magnetic particle, dye penetrant and ultrasonic inspection, use of statistical quality control in foundray.	**3**
7	**HEAT-TREATMENTOFCASTINGS:** Heat treatment of steel, iron and stainless steel castings	**2**
8	**FURNACE TECHNOLOGY** Furnaces used in foundry, Crucible, Hearth, Resistance, Arc and Induction furnaces; their construction, operation & applications. Heat treatment furnaces and drying ovens used in foundry. Energy saving in melting practices. Melting practices for ferrous and non-ferrous alloys.	**5**
9	**MECHANIZATION:** Foundry mechanization, pollution control in foundries, inspection, repair and salvage of castings, quality control in foundries, casting design consideration, application software in casting	**4**

Course Outcomes: By the end of this course, the students will be able to:	
1	Design the gating and risering systems for a given illustration/ data
2	Understand the different possible defects and its remedies in metal casting
3	Identify methods to improve the foundry performance

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Foundry Technology", Beeley Peter R., Butterworth – Heinemann.	2010
2	"Principles of Foundry Technology", Jain P.L., Tata McGraw hill	2010
3	"Principles of Metal Casting Processes", Richard W. Heine, McGraw Hill	2004
4	"ASME Foundry Hand book", Oscar John Horger, Vol 1, McGraw-Hill	1965

Course Name	**:**	**MAINTENANCE AND RELIABILITY**
Course Code	**:**	**PEN 423**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of the course the students should be able to describe the concept of reliability and failure analysis for a given work environment

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**BASIC CONCEPTS OF RELIABILITY:** Concept, Terms, course objectives, applications, area of use, use of reliability in industry. Introduction to Probability Concepts	**4**
2	**BASIC RELIABILITY MODELS:** The Reliability function**,** mean time to failures, hazard rate function, bath tub curve, conditional reliability, probability density function, failure rate, failure density, hazard rate, uncertainty measures.	**5**
3	**CONSTANT AND TIME DEPENDANT FAILURE MODELS:** Exponential, weibull, normal and lognormal distributions	**4**

4	**RELIABILITY OF SYSTEMS:** Series and parallel-connected systems, Concept of redundancy, k out of n standby system, course objectives, applications, redundant standby systems, system structure functions, minimal cuts and minimal paths, common mode failures, three state devices	**5**
5	**DETERMINATION OF RELIABILITY (STATE DEPENDANT SYSTEMS):** Markov analysis, load sharing system, standby systems, degraded systems, Reliability allocation with redundancies	**4**
6	**FAILURE ANALYSIS:** Introduction to failure mode and effect analysis, FMEA and FMECA, criticality analysis, Fault tree diagram, event tree.	**4**
7	**AVAILABILITY:** Concept and definitions, availability models, system availability.	**2**
8	**INTRODUCTION TO MAINTENANCE:** Course objectives and importance of maintenance, Functions of Maintenance, maintainability vs. maintenance.	**2**
9	**TYPES OF MAINTENANCE:** Corrective, Breakdown, Predictive, Replacement, Preventive and Proactive maintenance strategies, Preventive maintenances v/s. repair, Computerized Maintenance Management System, Reliability under preventive maintenance.	**5**
10	**DESIGN FOR MAINTAINABILITY:** Quantifiable measures of maintainability, maintainability management tasks during the product life cycle, life cycle costing, life cycle cost estimation models, spare parts management	**4**
11	**INTRODUCTION TO TPM AND RCM:** Classification, Principles, applications and case studies	**3**

Course Outcomes: By the end of this course, the students will be able to:	
1	Understand basic reliability Models
2	Evaluate and allocate the reliability on various sub component of a system
3	Identify the situations where different types of maintenance like PM, BD or corrective can be applied
4	Apply the concept of reliability and estimate the life of a given equipment from past data
5	Analyze the failure data

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Reliability Maintainability and Risk", Dr. David J. Smith, Eighth Edition	2011
2	"Reliability, Maintenance and Safety Engineering", A. K. Gupta, Laxmi Publications, Ltd.	2009
3	"Reliability and Maintenance engineering", R.C. Mishra, New Age international Publisher	2006
4	"Reliability Engineering", Srinath L.S, Fourth Edition, East West Press	2005
5	"Improving Maintenance and Reliability Through Cultural Change", Stephen J. Thomas, Industrial Press Inc.	2005

Course Name	**:**	**FLEXIBLE MANUFACTURING SYSTEM**
Course Code	**:**	**PEN 424**
Credits	**:**	**4**
L T P	**:**	**3-1-0**
Course Objectives:		
The course has been designed to make the students understand the applications of flexible manufacturing systems and appreciate its importance		

Total No. of Lectures – 56

Lecture wise breakup		**No. of Lectures**
1	Introduction to Manufacturing Systems, Different types of manufacturing Systems. Volume Variety relationships for understanding manufacturing systems, Flexibility and automation Different types of flexibility in manufacturing, Different types of FMS building blocks of flexible manufacturing system; Work station, Storage retrieved system, material handling systems and computer control system.	**(12)**
2	Machining system of FMS; Horizontal & Vertical machining Centers. Integrated Material Handling, Automated Guided Vehicles and modern trends.	**(12)**
3	Automatic Storage and Retrieval System. FMS control System. Cellular Manufacturing Systems.	**(10)**
4	Group technology; Past faculties, part classification and coding production flow analysis, Machine Cell design, Computer Aided Process Planning.	**(10)**
5	Layout consideration for flexible manufacturing Scheduling of flexible manufacturing system.	**(6)**
6	FMS simulation, Latest trends and Case studies	**(6)**

Course Outcomes: By the end of this course, the students will be able to:	
1	Identify the work systems where the FMS technology can be used
2	Identify the different types of flexibilities that exist in a given work environment and how they can be used.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Groover, M. P., "Automation, Production System and CIM" Ed.,Prentice Hall.	2013
2	Rankey, P.,"Design and Operations of FMS",North-Holland Publishing.	1983
3	Warnecke, H. J. (Ed.), "Flexible Manufacturing System", Springer.	1985
4	Bonetto, R., "FMS in Practice", North Oxford Academic Publishers.	1988

Course Name	**:**	**FINITE ELEMENT ANALYSIS**
Course Code	**:**	**PEN 425**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of the course the students should be able to describe the concept of designing & development with respect to modeling and analysis of a system using finite element analysis.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**Lecture wise breakup** Product development driven by concurrent engineering; role of CAE (Computer-Aided Engineering) in Product design; mathematical abstractions of product for functionality verification	**4**
2	**INTRODUCTION TO FEM** The Finite Element Method, Elements and Nodes, Modeling the problem and Checking Results, Discretization and other Approximations, Responsibility of the user, Elementary Matrix Algebra.	**6**
3	**BARS AND BEAMS** Linear Static Analysis: Stiffness Matrix Formulation: Bar Element, Stiffness Matrix Formulation: Beam Element, properties of stiffness matrices – Avoiding Singularity, Mechanical Loads and Stresses, Thermal Loads and Stresses	**6**
4	**PLANE PROBLEMS** Constant Strain Triangle (CST),s Linear Strain Triangle (LST), Bilinear Quadrilateral (Q4), Quadratic Quadrilateral (Q8), Improved Bilinear Quadrilateral (Q6), Elements with "Drilling" dof, Elements of more General Shape, Loads, Stress Calculation	**8**
5	**ISOPARAMETRIC ELEMENTS AND SOLUTION TECHNIQUES** Node Numbering and Matrix Sparsity, Equation solving, Transformations, Isoperimetric Elements Formulation, Gauss Quadrature and Isoperimetric Elements, Choice of Quadrature Rule and Instabilities, Stress Calculation and Gauss Points, Nature of Finite Element Solution, Convergence Requirements – Patch Test, Infinite Media and Infinite Elements, Substructures, Symmetry, Constraints	**8**
6	**MODELING, ERRORS AND ACCURACY IN LINEAR ANALYSIS** Modeling in General, Structure Behavior and Element Behavior, Element Tests and Element Shapes, Test Cases and Pilot Studies, Material Properties, Loads, Connections, Boundary Conditions, Planning the Analysis, Numerical Error : Sources and Detection, Common Mistakes, Checking the Model, Critique of FE Results, Stress Concentrations – Sub-modeling, Convergence with Mesh Refinement, Error Measures and Adaptivity.	**8**
7	**THERMAL ANALYSIS** Some Basic Equations, Finite Elements in Thermal Analysis, Radiation and Other Nonlinearities, Thermal Transients, Modeling Considerations.	**8**
8	**VIBRATION AND DYNAMICS** Basic equations – Vibration, Mass matrices, Undamped Free Vibration, Damping,Reduction, Modeling Equations.	**8**

Course Outcomes: By the end of this course, the students will be able to:	
1	Understand and write the basic concepts/ steps in modeling
2	Model a given part/ product using basic principles.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Applied Finite Element Analysis", G. Ramamurty, I. K. International Pvt. Ltd.	2010
2	"An Introduction to the Finite Element Analysis, 3rd Ed.", Reddy, J.N., McGraw-Hill Education (ISE Editions).	2005
3	"Finite Element Analysis For Engineering & Tech.", Tirupathi R. Chandrupatla, Universities Press	2004
4	"Textbook of Finite Element Analysis, 1st Ed.,", Seshu, P., Prentice Hall of India Pvt. Ltd.	2003

MINOR SPECIALIZATION COURCES (MSC) FOR OTHER DEPARTMENT STUDENTS

Course Name	**:**	**COMPUTER INTEGRATED MANUFACTURING (Minor Specialization)**
Course Code	**:**	**PEN 431**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of the course the students should be able to describe geometric transformations and modeling along with identifying the concepts of process planning, material handling and cellular manufacturing.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**COMPUTER AIDED DESIGN:** The Product Design Process, CAD System Input – Output Devices, Selection of CAD/CAM Systems	**2**
2	**COMPUTER GRAPHICS AND TRANSFORMATION:** Geometric Transformations, Homogeneous Representation, Composition of Transformations	**6**
3	**GEOMETRIC MODELING:** Geometric Modeling Approaches, Wireframe Modeling, Surface Modeling, Solid Modeling, Parametric and Variational Design, Rapid Prototyping	**6**
4	**COMPUTER AIDED ENGINEERING ANALYSIS:** Finite Element Modeling, Design Optimization, Commercial Packages to Support Product Modeling and Analysis	**4**
5	**PROCESS PLANNING AND CONCURRENT ENGINEERING:** Process Planning, Computer Aided Process Planning, Concurrent Engineering and Design for Manufacturing, Advanced Manufacturing Planning	**4**
6	**MATERIAL HANDLING AND IDENTIFICATION TECHNOLOGIES:** introduction to Material Handling, Material transport Equipment, Storage System Performance and Location Strategies, Conventional Storage Methods and Equipment Automated Storage Systems, Automatic Identification and Data Capture, Bar Code Technology, Radio Frequency Identification, Other AIDC Technologies	**4**
7	**CELLULAR MANUFACTURING:** Part Families, Parts Classification and Coding, Production Flow Analysis Cellular Manufacturing, Applications of Group Technology	**4**
8	**FLEXIBLE MANUFACTURING SYSTEMS:** FMS Components, FMS Applications and Benefits, FMS Planning and Implementation Issues.	**4**

9	**INSPECTION TECHNOLOGIES:** Inspection Metrology, Conventional Measuring and Gaging Techniques, Coordinate Measuring Machines, Surface Measurement, Machine Vision, Other Optical Inspection Methods, Noncontact Non-optical Inspection techniques	**3**
10	**PRODUCTION PLANNING AND CONTROL SYSTEMS:** Aggregate Production Planning and Master Production Schedule, Material Requirements Planning, Capacity Planning, Shop Floor Control, Inventory Control, Extensions of MRP	**3**
11	**CASE STUDIES:** Application oriented case studies on computer aided designs, material handling and flexible manufacturing systems	**2**

Course Outcomes: By the end of the course, the students will be able to	
1	Identify and differentiate the different components involved in CAD
2	Perform simple geometric transformations
3	Describe the importance of flexible and cellular manufacturing systems and its advantages in industries.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Systems Approach to Computer Integrated Design and Manufacturing", Nanua Singh, John Wiley Sons	2007
2	"CAD/CAM; Principles and Applications", P N Rao, Tata McGraw Hill	2004
3	"Automation Production Systems and CIM", Groover, Prentice Hall	2001

Course Name	**:**	**INDUSTRIAL ENGINEERING – II (Minor Specialization)**
Course Code	**:**	**PEN 432**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:

At the end of the course the students should be able to describe quality management systems, statistical processes and application of reliability engineering; apply the concepts of supply chain and value engineering.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**QUALITY MANAGEMENT** Introduction to the concepts of Inspection, quality control, quality assurance and CWQM. Quality trilogy, Con tenuous improvement philosophy – Kaizen , Components of TQM, PDCA Cycle, TQM implementation, Improvement through elimination of wastes, 5S campaign, 4M checklists, Organizational structure, education and training, communications process, costs of quality, use and evaluation of quality costs. Zero Defect programmes, identification and solution of quality problems – Pareto, Cause and Effect and Force Field analysis, Brainstorming, Quality Circles, QC tools and their applications. QFD, JIT philosophy and techniques.	**8**
2	**STATISTICAL PROCESS CONTROL** Statistical process control, systematic approach process variability, Control Charts for variables and attributes. Acceptance sampling plans – single, double, multiple and sequential – for attributes and variables, minimum inspection per lot, formulation of inspection lots and selection of samples. OC curve. Doge-Romig tables and ABC standards, AOQL, and LTPD plans.	**8**

3	**RELIABILITY ENGINEERING** Reliability; Definition and Basic concepts, Mean Time Between failures (MTBF), Mean Time To Repair (MTTR) deviation of the Reliability function, Statistical failure modes. Exponential, Gamma, Weibull, Lognormal and Fatigue life models. Point and interval estimation procedures for the above distributions. Reliability in terms of Hazard rate – Hazard models and bath-tub curve applicability of Weibull distribution.	**8**
4	**SUPPLY CHAIN AND LOGISTICS MANAGEMENT** Overview of Supply Chain and supply chain management. Supply chain performance and profitability. Role of Supply Chain Management and its Scope and importance. Performance Drivers and obstacles. Achieving strategic fit. Logistics and Competitive Strategy.	**6**
5	**VALUE ENGINEERING** Introduction: History, development and scope of value management, value analysis vs. Value engineering principles of costing and cost estimation, benefits. Basic concepts of value engineering: Selection of project, team members, general phase, information phase, creation phase, evaluation phase investigation and implementation phase, audit.	**8**
6	**CASE STUDIES:** Technical case studies on project management for quality improvement, Statistical process control, reliability and value engineering.	**4**

Course Outcomes: By the end of this course, the students will be able to:	
1	Identify and distinguish between different Statistical techniques and sample plans
2	Design and apply the control charts for a given application
3	Solve the given basic problems related to reliability engineering

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Fundamentals of Quality Control and Improvement", Amitava Mitava, Wiley	2012
2	"Supply Chain Management", Sunil Chopra, 5th Edition, Pearson Publications	2012
3	"A Textbook of Human Resource Management, 1E", R. S. Dwivedi , Vikas Publishing House Pvt Ltd,	2009

Course Name	**:**	**FORMING AND WELDING (Minor Specialization)**
Course Code	**:**	**PEN 433**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:
At the end of the course the students should be able to describe various requirements and applications of heat treatment, classify and identify the different welding processes.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**METAL FORMING:** Introduction, classification, effect of forming parameters, hot and cold working processes, true strain curves, determination of flow stress, Tresca and Von Misces criteria, metal forming lubrication, lubrication mechanism, boundary mixed and hydrodynamic lubrication.	**10**
2	**ROLLING:** Classification of rolling processes, rolling mills, products, variables, rolling defects and controls. Defects & Remedies.	**3**
3	**DRAWING:** Drawing of rods, wires, tubes, variables in drawing and operations, analysis of drawing forces. Defects & Remedies.	**3**

4	**FORGING:** Open and closed forging, Hammer, Press and Drop forging, analysis of forging forces, sticking and sliding friction. Defects & Remedies.	**3**
5	**EXTRUSION:** Classification of extrusion processes, equipment and variables used in extrusion. Defects & Remedies.	**3**
6	**WELDING:** Classification of welding processes, physics of arc, arc blow, welding symbol, types of V-I characteristics, different types of power sources**,** Classification and selection of welding electrodes, welding fluxes,	**6**
7	**METAL TRANSFER:** Forces affecting metal transfer, classification of modes of metal transfer, parameter effecting metal transfer.	**2**
8	**WELDING PROCESSES:** Principle, advantages disadvantages and applications of Gas welding, SMAW, MIG, TIG, SAW, Electro-slag, Plasma, EBW and LBW process. Welding defects, brazing and soldering, thermal spraying. Heat affected zones. Introduction to Non-Fusion welding processes: resistance welding, solid state welding.	**6**
9	**TESTING AND CHARACTERIZATION OF MATERIALS:** Destructive and non-destructive testing of materials: tensile, bend and impact testing of weldment and on weld metal, dye penetrant, magnetic particle testing.	**6**

List of Experiments:		**Number of Turns**
1	Fabrication exercise by using MMA welding machine	**2**
2	Practical exercise on brazing	**2**
3	Practical exercise on MIG/ TIG welding	**2**
4	Practical exercise on SAW	**2**
5	Study of friction welding process	**2**
6	Wire drawing exercise on the draw bench	**2**
7	Practical exercise on ultrasonic welding process	**2**

Course Outcomes: By the end of this course, the students will be able to:	
1	To select and compare the various forming process.
2	To select and compare the various welding process.
3	Should be able to fabricate a welding job.
4	Able to learn the specific welding applications and innovations.
5	Choose different heat treatment processes for a given requirement
6	Classify and choose a particular welding process for a given requirement

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"A text book of Production Engineering" , PC Sharma Publisher S Chand	2014
2	"Welding Engineering and Technology", RS Parmar, Khanna Publisher	2013
3	"AWS handbooks", 9th Edition, Volume-2	2011

Course Name	**:**	**INDUSTRIAL ENGINEERING – I (Minor Specialization)**
Course Code	**:**	**PEN 434**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:
At the end of the course the students should be able to describe productivity and its improvement techniques, identify the methods in work study, work measurement and ergonomic aspects in work study.

Lecture wise breakup		Number of Lectures
1	**INTRODUCTION** Definition and scope of Industrial engineering role of an industrial engineer in industry, functions of industrial engineering department and its organization, qualities of an industrial engineer	2
2	**PRODUCTIVITY AND WORK STUDY** Productivity concept and definition: Introduction, definitions of productivity, Productivity measurement at national, industrial and enterprise level, Benefits of higher productivity. Productivity in the individual enterprise: Introduction, Productivity measurement approaches at the enterprise level, Productivity of materials, Productivity of land, buildings, machines and manpower, Factors contributing to productivity improvement. Techniques for productivity improvement: Introduction, Work content and ineffective time, Improving productivity for reducing work content, Improving productivity by reducing ineffective time.	8
3	**WORK STUDY** Introduction, basic procedure, prerequisites of conducting a work study. The human factor in application of work study: Introduction, management and supervisor; their role in work study, the works study man. The influence of working conditions on work study: Introduction, factors affecting working conditions, occupational safety and health, fire prevention and protection, layout and housekeeping, lightning and climate conditioning, noise and vibrations, ergonomics, arrangement of working time, conclusion	8
4	**METHOD STUDY** Introduction to method study and the selection of job: Introduction, definition and objective of method study, procedure of method study. Flow and handling of materials: Introduction, plant layout, developing the new layout, the handling of materials Tools for recording the movement of worker: Introduction, string diagram, flow process chart; man type, travel chart, multiple activity chart. Introduction, the principles of motion economy, classification of movements, further notes on workplace layout, notes on the design of jigs, tools and fixtures, machine controls and displays of dials, the two handed process chart, Simo chart.	8
5	**WORK MEASUREMENT** Purpose of work measurement, the basic procedure, the techniques of work measurements, Work sampling: Introduction, basic concept and procedure, Time study: rating: Introduction, the quality worker, the average worker, standard rating and standard performance. Predetermined time standards (PTS): Introduction, definition, advantages of PTS system, Criticisms of PTS system, different forms of PTS system, use of PTS system, and application of PTS system.	8
6	**WORK DESIGN** Concept of job enlargement, job enrichment and job rotation, effective job design consideration technological and behavioral factors	2
7	**ERGONOMICS** Introduction to ergonomics, consideration in designing man machine systems with special reference to design of displays and control	2
8	**CASE STUDY** Practical case studies on management of productivity, work study, methods study and ergonomics.	4

List of Experiments:		Number of Turns
1	Study and experiment on one hand process flow chart	**1**
2	Study and experiment on two hand process flow chart	**1**
3	Exercise on time study using stop watch	**1**
4	Exercise on nut bolt washer assembly using process flow chart	**1**
5	Exercise on string chart	**1**
6	Sample exercise on ergonomic application	**1**

Course Outcomes: By the end of this course, the students will be able to	
1	Apply work measurement techniques for a given job
2	Draw the flow process charts for a given process
3	Identify and perform time study for simple applications.
4	Apply ergonomic concepts in work environment.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Introduction to Work Study", George Kanawaty, International Labour Organization	2003
2	"Handbook of Industrial Engineering: Technology and Operations Management", Gavriel Salvendy, John Wiley & Son.	2001
3	"Work Design Occupational Ergonomics", Stephan Konz & Steven Johnson's, McGraw Hill th	2001

Course Name	**:**	**MACHINING TECHNOLOGY (Minor Specialization)**
Course Code	**:**	**PEN 435**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:

At the end of the course the students will be able to study and understand the basic elements, classification and applications of some important conventional machines like lathes, shapers, milling, drilling and grinding and understand the principles of some non-conventional machining technologies.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** Classification of M/c Processes, Kinds of Motions in M/c tools, Tool materials & Cutting fluids	**4**
2	**LATHE & LATHE OPERATIONS:** Classification of lathes & Capstan turrets, Geometry of a single Pt tool, Speed, Feed & Depth of Cut, Turning, facing, taper turning, parting, chamfering & threading.	**6**
3	**DRILLING MACHINES :** Classifications, Nomenclature of a Drill, Drilling operations such as boring, reaming, tapping.., Speed, feed & M/c time calculations	**4**
4	**MILLING M/C :** Classifications, Specs, Indexing devices, Up Milling & Down Milling, Milling Attachments, Cutter geometry, Speed, feed & M/c time calculations.	**4**
5	**GRINDING MACHINES** Classifications & Applications. Surface, Internal & Centre-less grinding, Wheel Selection, Standards, M/c times. Dressing& truing of Grinding wheels	**3**
6	**SHAPING, PLANING AND BROACHING** Types & classification of Shapers, Planers, Specifications, QRM, Speed, Feed & Machining time calculations. Job holding devices & applications. Broaching Tools, parameters	**2**
7	**THORY OF METAL CUTTING** Types of Chips, Mechanics of Chip Formation, Relevance of Shear Angle, Merchant Circle, Lee & Shafer's theory, Forces in Turning, Drilling & Milling, Mechanisms of tool failures, Tool life, Mach inability, Cutting fluids in machining.	**4**
8	**NON CONVENTIONAL MACHINING PROCESSES** Abrasive jet M/c. Ultrasonic Machining, Electro-Chemical M/c Electric Discharge m/c, Electron beam M/c, Laser Beam M/c, Plasma Arc Machining Electro-Chemical Grinding, Chemical M/c, Abrasive Flow Machining	**4**
9	**HIGH VELOCITY METAL FORMING** Electro-hydraulic Forming, Mechanical High Velocity Forming, Magnetic pulse Forming & Explosive forming	**3**
10	**GEAR MANUFACTURING PROCESSES** Introduction & Methods used. Production of Spur, Bevel & Worm gears. Casting, Powder Metallurgy, Molding & Rolling Gear Hobbing & Gear Shaping Processes Bevel Gear Generator & Gear Finishing Operations. Gear Shaving, Gear Burnishing & Gear Grinding Operations	**4**
11	**APPLICATIONS AND CASE STUDIES** Technical case studies on process improvements and technological advancements on conventional and non conventional processes.	**4**

Course Outcomes: By the end of this course, the students will be able to:	
1	Choose specific machines for a particular job
2	Understand the basic mechanisms like quick return mechanism in shaper and half lever mechanism in lathe
3	Understand the principles of metal cutting and find out the machining times for a given data.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Materials and Processes In Manufacturing", John Wiley & Sons, DeGarmo	2011
2	"Fundamentals of Metal Cutting & Machine Tools", B L Juneja & G S Sekhon, New Age International Publication.	2010
3	"Modern Machining Process", P C Pandey& H S Shan, Tata McGraw Hill	2008
4	"Production Technology", PC Sharma, S Chand Publications	2007
5	"Introduction to Machining Science", Lal, G. K., New Age Publications	2007
6	"Manufacturing Science", Ghosh, A., & Mallik, A.K.,, East West Press Pvt. Ltd.	1999

Course Name	**:**	**TECHNOLOGY MANAGEMENT**
Course Code	**:**	**PEN 461**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of the course the students should be able to describe the evolution on technology, its contributions along with inputs for facing the changing technology.

Lecture wise breakup	**Total No. of Lectures – 42**	**Number of**
1	**TECHNOLOGY MANAGEMENT:** Issues and applications, Concepts of technology; Role and importance of technology management, Dimensions of technology management, technology management in India.	**2**
2	**TECHNOLOGY CHANGE:** Nature of technology change, Motivation for technology change. Invention and Innovation. Technology Life Cycle, Technology monitoring.	**3**
3	**TECHNOLOGY FORECASTING:** Objectives and approaches, Methodology of technological forecasting, Delphin technique, growth curves, Morphological analysis technological discontinuities Indian Technology Vision 2020.	**5**
4	**TECHNOLOGY PLANNING:** Technology and Socio Economic Planning, Choice of Technology, Process of Technology generation. Integrating business and technology strategies, Technology development approaches, technology audit. Organization for technology management; technological change and manufacturing complexity, risk in new technology projects, implementing technology.	**5**
5	**MANAGEMENT OF R & D:** Corporate strategy, Selection of R & D projects, Managing R & D,	**4**
6	**Marketing of R & D MANAGEMENT OF INNOVATION:** Radical and Cyclic Innovation Processes. Technology Strategy and innovation.	**4**

7	**TECHNOLOGY ABSORPTION AND DIFFUSION:** Technology dependence, Concepts in technology absorption, constraints in technology absorption. Management of technology absorption, technology absorption and adaptation scheme (TAAS), Concept of diffusion of technology, perspective on diffusion, developing diffusion strategies.	**5**
8	**TECHNOLOGY TRANSFER:** Models of Technology Transfer, Technology Transfer modes, Dimensions of Technology Transfer, Dimensions of technology transfer, Pricing of technology Government policies of technology transfer.	**5**
9	**ROLE OF INTELLECTUAL PROPERTY RIGHTS:** Nature of IPR, Patent, Trademark and copy rights Legal aspects.	**3**
10	**MANAGING PROCESS TECHNOLOGY:** Continuous improvement technology integration, product and process technology techniques of improvement, economics if improvement.	**3**
11	**TECHNOLOGY AS A COMPETITIVE STRATEGY:** Competitive analysis, core competitive competencies, technology leadership, adoption of new technology, marketing of new technology. Case studies on technology management	**3**

Course Outcomes: By the end of this course, the students will be able to:	
1	Identify the different techniques to manage changing technology.
2	Understand the importance of technology changes and develop adaptive strategies

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Total Quality Management for Engineers", M Zaire, Woodhead publishing Ltd.	2015
2	"Strategic Technology Management", Frederick Betz, McGraw Hill	2009
3	Technology, Innovation, and Educational Change: A Global Perspective", Robert B. Kozma	2003

Course Name	**:**	**TOTAL QUALITY MANAGEMENT**
Course Code	**:**	**PEN 462**
Credits	**:**	**4**
L T P	**:**	**3-0-2**

Course Objectives:
At the end of the course the students should be able to describe the evolution on quality, the contributions to quality at world level and understand its statistical control elements.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION:** Importance, Evolution, contribution of Deming, Juran, Crossby, Taguchi etc. Current understandings.	**6**
2	**QUALITY; ELEMENTS OF QUALITY:** Quality of design, quality of conformance; quality costs- interrelationship of costs, economics of quality of design and quality of conformance.	**6**
3	**QUALITY CONTROL SYSTEMS:** Q.C function, system concept, Q.C. system, quality planning, quality policies, quality audit, new design review, Q.C. organization. Quality system standards ISO 9000.	**6**
4	**ELEMENTS OF STATISTICAL INFERENCE:** Distribution of sample means, their characteristics and central limit theorem, process variation, process capability, sampling plans; single and double sampling plans, sequential sampling plans, QC curve for sampling plans, AQL and ASN concepts. Theory of control charts, chance causes and assignable causes, In control process and out of control process, Control charts for process control X & R, P & C charts.	**12**
5	**QUALITY ASSURANCE:** Sporadic process control, chronic quality problems process- tools and techniques, improvement, Break through, Managements Role	**6**
6	**QUALITY:** Training, problem solving techniques, team building, motivation, Q.C. circles	**6**

List of Experiments:		**Number of Turns**
1	Experiments on using the sampling tables and normal distribution curve for a manufacturing problem	**3**
2	Construct X bar and R control charts for turning operation on lathe	**3**
3	Construct p and np chart for variable and fixed sample size for the casting defects	**3**
4	Construct the c and u control charts for textile industry problem	**3**
5	Draw AOQ and ASN curves for goods purchase case in mass.	**2**

Course Outcomes: By the end of this course, the students will be able to:	
1	Identify the different parameters effecting quality for a given case/ illustration.
2	Develop a basic sampling plan and apply different control charts.
3	Construct Variable and Attribute control charts
4	Understand and apply different methods to improve the quality levels (sigma levels)

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Total Quality Management", Dale. H Besterfield, Glen H Besterfield, Pearson Education India	2011
2	"Total Quality Management,. L. Suganthi and Anand Samuel, 2nd edition	2004
3	"Total Quality Management: An Introductory Text", Paul T.J. James, Prentice hall of India	2010

Course Name	**:**	**OPERATIONS RESEARCH**
Course Code	**:**	**PEN 463**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
At the end of the course the students should be able to describe, formulate and solve problems related to linear programming, queuing and simulations in an industrial and service environment.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION AND FORMULATION:** Origin and development of operations research, Scope of Operations Research (OR), General methodology of OR, applications of OR to industrial problems. Formulation of LP model for some common industrial problems—product mix, blending, resource allocation, inventory, replacement and similar other problems. Primal and dual problems, Transportation and assignment models. Degeneracy in transportation problems.	**10**
2	**LINEAR PROGRAMMING:** Graphical solution, Simplex method of solution, quality and sensitivity analysis. Application of linear programming and sensitivity analysis in industrial problems	**8**
3	**QUEING THEORY:** Analysis of the following queues with Poisson's pattern of arrival and exponentially distributed service times, Single channel queues with infinite customer populations	**7**
4	**MONTE CARLO SIMULATION:** Need for simulation, advantages and disadvantages of simulation, methods of simulation. Generation of normal random numbers with any given distribution. Use of random numbers for system simulation.	**5**
5	**PERT AND CPM:** Network representation. Critical path computations. Construction of the time schedule. Linear programming formulation of CPM. PERT calculations.	**4**
6	**DYNAMIC PROGRAMMING:** Recursive nature of computations in DP. Forward and Backward recursion. Selected DP applications: Knapsack/fly away/cargo-loading model, Work force size model, Equipment replacement model, Investment model, Inventory models.	**4**
7	**REPLACEMENT THEORY :** Introduction. Failure mechanism of item. Assumptions of replacement theory. Replacement decisions. Types of replacement problem.	**4**

Course Outcomes: By the end of this course, the students will be able to:	
1	Apply Linear programming methods to any given problem
2	Perform Monte Carlo simulation for a given case study
3	Apply the queuing model for a given study
4	Apply the PERT/CPM for a constraint based problem of service/ manufacturing
5	Apply the Dynamic programming on several cases for service/manufacturing
6	Understand the fundamentals and cases of Replacement Problem

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"An Introduction to Operations Research", Taha, H.A., 9th Ed., Prentice Hall of India	2011
2	"Operations Research", Panneerselvam R., PHI	2011
3	"Operations Research",P. K. Gupta and D.S. Hira, S. Chand	2008

General Science Courses (GSC)

Course Name	:	**ENVIRONMENTAL SCIENCES**
Course Code	:	**GSC101**
Credits	:	**3**
L T P	:	**3 0 0**

Course Objectives:
This course aims to acquaint students with the basics of Environmental Sciences.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	Multi-discipline nature of environmental studies as applied to different engineering streams - Definitions, scopes and explanations.	6
2	Types of Ecosystems – System dynamics – Understanding ecosystems, Ecosystem degradation, Resource utilization, Ecosystem diversity, Habitat classification.	6
3	Natural Resources; Renewable and non-renewable- Natural resources and associated problems, Non-renewable resources, Renewable resources	6
4	Energy and Environment- Fossil fuel, Geothermal, tidal, nuclear, solar, wind, hydropower & biomass.	6
5	Environment pollution- Air Pollution, Water Pollution, Soil Pollution, Marine Pollution, Noise Pollution, Thermal Pollution, Nuclear hazards	6
6	Cleaner Production and life cycle analysis: - LCA methodology, steps and tools, EIA and Environment audit	6
7	Environment Development and Society:- Emerging technology for sustainable development and environment management, public participation and provision in management and legislation.	6

Course Outcomes:	
1	Students will be able to relate the importance of Environmental Sciences for sustainable development of society.
2	Students will be able to understand the problems and remedies of Environmental Sciences.

Text Books:	
Sr. No.	**Name of Book/ Authors/ Publisher**
1	Environmental Science Ceonage Learning Publication, Miller G.T. and Spool Mar
2	Environmental Studies, Tata McGraw Hill Pub., Banny Joseph

Course Name	:	**MATHEMATICS I**
Course Code	:	**MAN 101**
Credits	:	**4**
L T P	:	**3-1-0**

Course Objectives:
To make the students understand the behavior of infinite series and their use.
To make the students learn the concepts related to functions of several variables and their applications.
To make the students learn the methods of evaluating multiple integrals and their applications to various problems..

To make the students learn the methods to formulate and solve linear differential equations and apply them to solve engineering problems

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INFINITE SERIES** Infinite series and convergence, alternating series, power series and convergence. Taylor's and Maclaurin's Series. (Scope as in Chapter 8, Sections 8.1, 8.3 – 8.9 of Reference Book 1).	8
2	**MULTIVARIABLE FUNCTIONS** Limit, Continuity and Partial Derivatives; Euler's Theoem for Homogeneous functions; Differentiability, Linearization and Differentials; Chain rule; Extreme values and Saddle Points; Lagrange multipliers; Taylor's Formula**.** (Scope as in Chapter 12, Sections 12.1 – 12.6, 12.8 – 12.10 of Reference Book 1).	10
3	**SOLID GEOMETRY** Cylinders and Quadric surfaces, Cylindrical and Spherical Coordinates. (Scope as in Chapter10, Sections10.6 and 10.7 of Reference Book 1)	4
4	**INTEGRAL CALCULUS** Area between plane curves; Volumes of solids of revolution; Lengths of plane curves; Areas of surfaces of revolution. Double integrals in rectangular and Polar form, Triple integrals in Rectangular, Cylindrical and Spherical coordinates, Substitutions in Multiple Integrals. (Scope as in Chapter 5, Sections 5.1, 5.3, 5.5, 5.6 and Chapter 13 .Sections 13.1, 13.3, 13.4,13.6 and 13.7 of Reference Book 1).	8
5	**ORDINARY DIFFERENTIAL EQUATIONS** First order exact differential equations, Integrating factor, Orthogonal trajectories, Second and Higher order Linear Differential Equations with constant coefficients, Differential Operators, Methods of Variation of Parameters and Undetermined Coefficients, Euler Cauchy Equation, Wronskian. (Scope as in Chapter 1, Section 1.5, 1.8 Chapter 2, 2.1-2.4, 2.6, 2.9-2.10, 2.13- 2.15 of Reference Book 2).	12

Course Outcomes:	
1	The students are able to test the behavior of infinite series.
2	The students are able to analyze functions of several variables and their applications.
3	The students are able to evaluate multiple integrals and apply them to practical problems.
4	The students are able to solve linear differential equations.

Reference Books:	
Sr. No.	**Name of Book/ Authors/ Publisher**
1	G. B. Thomas, R. L. Finney. Calculus and Analytic Geometry, Ninth Edition, Pearson Education.
2	E. Kreyszig. Advanced Engineering Mathematics, Eighth Edition, John Wiley.
3	B. V. Ramana. Higher Engineering Mathematics, Tata McGraw Hill.

Course Name	**:**	**PROBABILITY AND STATISTICS**
Course Code	**:**	**MAN 103**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:

At the end of this course, the students should be able to use statistical methods to collect and analyze the data. The students should be able to estimate unknown parameters of populations and apply the tests of hypotheses.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**RANDOM VARIABLES AND PROBABILITY DISTRIBUTIONS** Random variables, Discrete, Continuous and Joint Probability distributions, Marginal and Conditional distributions, Independent random variables, Expectation, Variance and Covariance, Means and variances of linear combinations of random variables, Chebyshev's inequality, Binomial, Poisson, Uniform and Normal distributions, Normal and Poisson approximations to Binomial, Moments, Moment generating function.	20
2	**SAMPLING DISTRIBUTIONS & ESTIMATION** Population, Sample, Sampling distributions, Law of large numbers, Central limit theorem, Distribution of sample mean, Difference of means, Proportions and difference of proportions, Chi-square distribution, Student's t-distribution, Estimation of parameters, Point estimate, Confidence interval for mean, difference of means and proportions.	16
3	**TESTS OF HYPOTHESES** Hypothesis, Test statistic, Critical region, Significance level, Single Sample and Two Samples tests for mean.	6

Course Outcomes: By the end of this course, the student will be able to:	
1	Collect and analyze the data statistically.
2	Describe sampling distributions of sample means and sample proportions
3	Estimate unknown parameters of the population from a sample.
4	Construct confidence intervals for mean difference of means and proportions; and perform hypothesis tests for means.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	Probability and statistics for Engineers and Scientists, Walpole, Myers, Myers and Ye, Pearson Education	2012
2	Introduction to Mathematical Statistics, Hogg and Craig, Pearson Education	2013
3	Miller and Freund's: Probability and Statistics for Engineers, Richard A. Johnson, Prentice Hall	2010
4	John E. Freund's: Mathematical statistics with Application, Miller and Miller, Pearson Education	2012

Course Name	**:**	**MECHANICS**
Course Code	**:**	**PYN - 105**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives:
To acquaint about the engineering aspects of Mechanics To familiarize Kinematics and Kinetics of rigid body To inculcate the application of Mechanic concepts in engineering To familiarize the application of relative motion analysis in the design of energy system

Total No. of Lectures – 36

Lecture wise breakup		**Number of Lectures**
1	**KINEMATICS OF A PARTICLE**: Introduction. Rectilinear Kinematics: General Curvilinear Motion. Curvilinear Motion: Rectangular Components, Normal and Tangential Components, Cylindrical Components. Absolute Dependent Motion Analysis of Two Particles. Relative-Motion Analysis of Two Particles Using Translating Axes. Motion of a Projectile.	5
2	**KINETICS OF A PARTICLE: FORCE AND ACCELERATION**: Newton's Laws of Motion. The Equation of Motion. Equation of Motion for a System of Particles. Equations of Motion: Rectangular Coordinates, Normal and Tangential Coordinates, Cylindrical Coordinates. Central-Force Motion and Space Mechanics.	4
3	**KINETICS OF A PARTICLE: WORK AND ENERGY**: The Work of a Force. Principle of Work and Energy. Principle of Work and Energy for a System of Particles. Power and Efficiency. Conservative Forces and Potential Energy. Conservation of Energy.	3
4	**KINETICS OF A PARTICLE: IMPULSE AND MOMENTUM**: Principle of Linear Impulse and Momentum. Principle of Linear Impulse and Momentum for a System of Particles. Conservation of Linear Momentum for a System of Particles. Impact. Angular Momentum. Relation Between Moment of a Force and Angular Momentum. Angular Impulse and Momentum Principles.	4
5	**PLANAR KINEMATICS OF A RIGID BODY:** Rigid-Body Motion. Translation. Rotation About a Fixed Axis. Absolute General Plane Motion Analysis. Relative-Motion Analysis: Velocity, Instantaneous Center of Zero Velocity, Acceleration. Relative-Motion Analysis using Rotating Axes.	4
6	**PLANAR KINETICS OF A RIGID BODY: FORCE AND ACCELERATION:** Moment of Inertia. Planar Kinetic Equations of Motion. Equations of Motion: Translation, Rotation About a Fixed Axis, and General Plane Motion.	4
7	**PLANAR KINETICS OF A RIGID BODY: WORK AND ENERGY:** Kinetic Energy. The Work of a Force. The Work of a Couple. Principle of Work and Energy. Conservation of Energy.	3
8	**PLANAR KINETICS OF A RIGID BODY: IMPULSE AND MOMENTUM:** Linear and Angular Momentum. Principle of Impulse and Momentum. Conservation of Momentum. Eccentric Impact.	3
9	**THREE-DIMENSIONAL KINEMATICS OF A RIGID BODY**: Rotation About a Fixed Point. The Time Derivative of a Vector Measured from a Fixed and Translating-Rotating System. General Motion. Relative-Motion Analysis using Translating and Rotating Axes.	3
10	**THREE-DIMENSIONAL KINETICS OF A RIGID BODY**: Moments and Products of Inertia. Angular Momentum. Kinetic Energy. Equations of Motion. Gyroscopic Motion. Torque free motion.	3

Course Outcomes:	
1	The student will be able to understand the concepts of Mechanics.
2	The students will be able to apply the concepts of Mechanics in fluid of energy.
3	The students will be able to understand various types of motion characteristic and found characteristic of rigid body.

Suggested Books:	
Sr. No.	**Name of Book/ Authors/ Publisher**
1	R.C. Hibbeler, Dynamics (11th Ed) P e a r s o n Publishers.
2	F.P. Beer et al. Dynamics (8th Ed) Mc GrawHill Publishers.
3	Merriam and Kraige; Dynamics (5th Ed) W i l e y and Sons Publications Merriam and Kraige.
4	R.C. Hibbeler, Statics (11th Ed) Pearson Publishers.

Course Name	**:**	**APPLIED CHEMISTRY**
Course Code	**:**	**CHN101**
Credits	**:**	**4**
L T P	**:**	**3 0 3**

Course Objectives: Upon completion of this course, students will have fundamental knowledge of the following:
Concepts of water and its analysis, polymer chemistry, solid state chemistry, lubricants, coordination chemistry and substitution reactions as applied to various industries. Spectroscopic methods required for the characterization of engineering materials. Design and development of novel future engineering materials and processes. Experiments related to applications of analysis and chemical processes relevant to various Industries.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**WATER TREATMENT AND ITS ANALYSIS:** Boiler feed water and its problems, Water Softening techniques, Domestic Water treatment, Chemical Analysis and related numerical problems	7
2	**POLYMER CHEMISTRY:** Classification, Mechanism and methods of polymerization, preparation, properties and uses of few engineering.	5
3	**SOLID STATE CHEMISTRY**: Introduction to structure and bonding-ionic solids, crystal defects and applications of defect structure (transistors, rectifiers, photovoltaic cells and computer chips).Introduction to ceramics.	6
4	**LUBRICANTS/ FUEL CELL TECHNOLOGY/CORROSION:** Functions mechanism, classification, properties and analysis of Lubricants and related numerical problems. Introduction to electrochemistry, types of electrodes, Reference electrodes, Ion-selective electrodes, Concentration cells, Batteries, Fuel cells/ Types of corrosion, dry and wet corrosion and their mechanisms, types of electrochemical corrosion, factors influencing corrosion, Prevention of corrosion.	6
5	**ATOMIC AND MOLECULAR SPECTROSCOPY: AAS**- Principle, instrumentation and applications of UV,IR and NMR spectroscopy and related problems.	10
6	**COORDINATION CHEMISTRY:** Crystal Field Theory, Splitting of octahedral, tetrahedral and square planner complexes, Applications of crystal field theory.	4
7	**AROMATIC ELECTROPHILIC AND NUCLEOPHILIC SUBSTITUTION:** Reaction mechanisms and applications.	4

Course Outcomes: Students who complete the course will have demonstrated the ability to do the following:	
1	Apply the knowledge for water treatment and its analysis for processing and its disposal which is relevant to all Industries for efficient utilization of water as an essential industrial resource.
2	Develop and design new materials based on knowledge of polymers, solid chemistry and substitution reactions
3	Hands on experience for carrying out experiments with precision for characterization and estimation of materials by wet analysis.
4	Will be able to carry out Instrument based spectroscopic analysis of new materials and interpretation of relevant data.

Reference Books:	
Sr. No.	**Name of Book/ Authors/ Publisher**
1	Atkin's Physical Chemistry by Peter Atkins, Julio de Paula, 7th Edition, Oxford University Press.
2	Concise Inorganic Chemistry Vth Edition J D Lee 2003 (Chapman & Hall)
3	A Textbook of Engineering Chemistry by Shashi Chawla, Dhanpat Rai& Co. Pvt. Ltd.
4	Introductory Polymer Chemistry by G.S.Mishra, John Wiley & Sons, New York, 1993.
5	Basic Inorganic Chemistry by F.A. Cotton, G. Wilkinson and P.L. Gaus, 3rd Ed., John Wiley & Sons.
6	Puri, Sharma and Pathania: Principles of Physical Chemistry, W.H. Freeman & Co, 2008.
7	Organic Chemistry by Joseph M.Hornback Brooke/Cole Publishing Company U.S.A.
8	D. S. Pavia, G.M. Lasmpman and G.S. Kriz : Introduction to Spectroscopy, 4th Edition, Thomson learning, Indian Edition 208.
9	Chemistry for environmental engineering by C. N. Sawyer, P. McCarty, G. F. Parkin, Mc Graw Hill Inc, New York.

Course Name	**:**	**ETHICS AND SELF AWARENESS**
Course Code	**:**	**HSS 101**
Credits	**:**	**2**
L T P	**:**	**2-0-0**

Course Objectives:
To provide basic knowledge about ethics, values, norms and standards and their importance in real life. To improve the personality of students by their self-assessment

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO ETHICS** Concept of Ethics – Nature, Scope, Sources, Types, Functions and Factors influencing Ethics, Approaches to Ethics – Psychological, Philosophical and Social, Broader Ethical Issues in Society	**6**
2	**VALUES, NORMS, STANDARDS AND MORALITY** Concept and Role, Relation with Ethics, Psycho-Social Theories of Moral Development – Kohlberg and Carol Gilligan	**4**
3	**ETHICS AND BUSINESS** Concept of Business Ethics – Nature, Objectives and Factors influencing Business Ethics, 3 C's of Business Ethics, Ethics in Business Activities, Ethical Dilemmas in Business, Managing Ethics	**5**
4	**SELF-AWARENESS** Concept of Self Awareness – Need, Elements, Self Assessment – SWOT Analysis, Self Concepts – Self-Knowledge, Assertiveness and Self-Confidence, Self-Esteem	**4**
5	**SELF-DEVELOPMENT** Concept of Self-Development, Social Intelligence, Emotional Intelligence, Managing Time and Stress, Positive Human Qualities (Self-Efficacy, Empathy, Gratitude, Compassion, Forgiveness and Motivation), Personality Development Models – Johari Window, Transactional Analysis, Myers Briggs Type Indicator, Self-Awareness and Self- Development Exercises	**9**

Course Outcomes:	
1	Helps to distinguish between right and wrong in both personal and professional life
2	Students learn about their strengths, weaknesses, opportunities & threats and work enthusiastically to transform weaknesses into strengths and threats into opportunities

Reference Books:	
1	Murthy, C.S.V., "Business Ethics – Text and Cases", Himalaya Publishing House
2	Hartman, Laura P. and Chatterjee, Abha, "Business Ethics", Tata McGraw Hill
3	Rao, A.B., "Business Ethics and Professional Values", Excel Books
4	Velasquez, Manuel G., "Business Ethics – Concepts and Cases", Prentice Hall
5	Corey, G., Schneider, Corey M., and Callanan, P., "Issues and Ethics in the Helping Professions", Brooks/Cole
6	Hall, Calvin S., Lindzey, Dardner and Cambell, John B., "Theories of Personality", Hamilton Printing Company
7	Leary, M.R., "The Curse of Self: Self-awareness, Egotism and the Quality of Human Life", Oxford University Press

Course Name	**:**	**COMMUNICATION SKILLS (BASIC)**

Course Code	**:**	**HSS 102**
Credits	**:**	**2**
L T P	**:**	**1-0-2**

Course Objectives:
The main aim of the course is to build competence in English grammar and vocabulary and to enhance effective communication by developing Reading, Writing, Listening and Speaking skills of students.

Total No. of Lectures – 28

Lecture wise breakup		Number of Lectures
1	**FUNDAMENTALS OF COMMUNICATION SKILLS** Scope and Significance of Communication Skills, Listening, Speaking, Reading and Writing	**3**
2	**WRITING SKILLS** Basics of Grammar – Placing of Subject and Verb, Parts of Speech, Uses of Tenses, Active-Passive, Narration	**3**
3	**VOCABULARY BUILDING AND WRITING** Word Formation & Synonyms, Antonyms, Words Often Confused, One-Word Substitutes, Idioms and Phrasal Verbs, Abbreviations of Scientific and Technical Words	**3**
4	**SPEAKING SKILLS** Introduction to Phonetic Sounds & Articulation, Word Accent, Rhythm and Intonation	**3**
5	**READING AND COMPREHENSION** Two comprehensive prose passages	**2**

List of Experiments:		Number of Turns
1	Introducing Oneself, Exercise on Parts of Speech & Exercise on Tense	**2**
2	Exercise on Agreement, Narration, Active Passive Voice & Dialogue Conversation	**2**
3	Exercise on Writing Skills and Listening Comprehension (Audio CD)	**2**
4	Practice of Phonemes, Word Accent, Intonation, JAM Session	**2**
5	Individual Presentation, Extempore and Picture Interpretation	**2**
6	Vocabulary Building Exercises (One Word Substitute, Synonyms, Antonyms, Words Often Confused etc.) & Group Discussion	**2**
7	Reading Comprehension & Organizational Correspondence and Debate	**2**

Course Outcomes:	
1	The students will be able to perform better in their academic and professional life.
2	The student will gain self-confidence with improved command over English.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"The Essence of Effective Communication", Ludlow R. and Panton F., Pubs: Prentice Hall.	1992
2	rd Education.	2008
3	"High School English Grammar", Wren and Martin, Pubs: S. Chand & Company Ltd.	2007
4	th College Publishing.	2009
5	nd Pubs: Oxford University Press.	2012
6	"Effective Business Communication", Rodrigues M.V., Pubs: Concept Publishing Company, Delhi.	2003
7	"English Vocabulary in Use", McCarthy M. and Felicity O' Dell, 2nd Edition, Pubs: Cambridge University Press.	2010
8	"The Pronunciation of English", Jones D., Pubs: Universal Book Stall.	1992

Course Name	**:**	**COMMUNICATION SKILLS (ADVANCED)**
Course Code	**:**	**HSS 103**
Credits	**:**	**2**
L T P	**:**	**1-0-2**

Course Objectives:
The main aim of the course is to enhance communication skills of students for better performance in professional life and to improve their overall personality with the use of advanced techniques in speaking and writing and also to train them in using both verbal and non-verbal communication effectively.

Total No. of Lectures – 28

Lecture wise breakup		Number of Lectures
1	**INTRODUCTION TO COMMUNICATION PROCESS** Scope, Significance, Types and Levels, Technical Communication, Tools of Effective Communication	**3**
2	**SPEAKING SKILLS AND PERSONALITY DEVELOPMENT** Interpersonal Communication, Oral Presentation, Body Language and Voice Modulation (Para linguistics and Non- Verbal), Negotiation and Persuasion, Group Discussion, Interview Techniques (Telephonic and Video Conferencing)	**6**
3	**ADVANCED Technical Writing** Job Application, CV Writing, Business Letters, Memos, Minutes, Notices, Report Writing & Structure, E-mail Etiquette, Blog Writing	**4**
4	**COMMUNICATION AND MEDIA** Social and Political Context of Communication, Recent Developments in Media	**1**

List of Experiments:		Number of Turns
1	**ORGANIZATIONAL COMMUNICATION** Verbal and Non-Verbal Communication at different levels of organization, Role Play, Case Studies	**2**
2	**SPEAKING TECHNIQUES** Mock Interviews, Participation in Group Discussions, Making and Presenting Power Point	**4**
3	**STANDARD ENGLISH & PRACTICE SESSION** Intonation and Pronunciation, Exposure to Standard English, Sounds, Stress and Rhythm, Comprehension on British and American English	**4**

4	**PRACTICE ON TECHNICAL WRITING** Writing Letters, Memos, Minutes, CV, Job Applications, Reports and e-mails	**4**

Course Outcomes:	
1	The students will gain proficiency in English language for both professional and personal life.
2	The students will learn technical aspects of communication for better performance in extra-curricular activities, recruitment process and prospective jobs.
3	The students will be able to refine their personality through a grip over advanced techniques of language.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	th Education (India).	2007
2	nd Pubs: Oxford University Press.	2012
3	th Education Asia, New Delhi.	2009
4	"Business Correspondence and Report Writing", Sharma R.C. and Mohan K., Pubs: McGraw Hill	1994
5	nd Ltd.	1997
6	"Handbook for Technical Writing", McMurrey D.A. and Buckley J., Pubs: Cengage Learning.	2012
7	rd Edition, Pubs: Cole Publishing	1996
8	"The Definitive Book of Body Language", Pease A. and Pease B., Pubs: Manjul Publishing House Pvt. Ltd.	2005

Course Name	**:**	**ECONOMICS**
Course Code	**:**	**HSS 201**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objectives:
The main aim of this course is to make students understand how society manages its scarce resources for achieving maximum satisfaction and to make them learn about economic aspects related to a consumer, firm, market and economy.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO ECONOMICS** Nature of Economics, Economic Thoughts, Economic Activities, Relationship of Economics with other Social Sciences and Engineering	**3**
2	**THEORY OF CONSUMER BEHAVIOUR** Demand: Types, Law of Demand, Demand Supply Curve, Determinants of Demand and Change in Demand (Movement of Demand and Shift of Demand) with Case Studies Elasticity of Demand: Nature, Degrees, Types, Factors Affecting Elasticity of Demand and its Application in present scenario Laws of Consumption: Concept and Applicability of Law of Diminishing Marginal Utility and Law of Equi-Marginal Utility	**9**
3	**THEORY OF PRODUCTION AND COST** Cost: Concept and Types Production: Concept, Scale of Production, Law of Variable Proportion Returns to Factor and Returns to Scale: Causes and Implications Economies and Diseconomies of Scale: Concept and Types Relevance of Production and Cost Concept in present context	**5**
4	**THEORY OF MARKET** Market: Concept and Types (Perfect Competition, Monopoly and Monopolistic Competition), Nature and Relevance of different Markets in present scenario – Case Study	**5**
5	**BASIC CONCEPTS OF MACRO ECONOMICS** National Income: Concept and Measurement Methods, Determination of Equilibrium of Income	**6**

	Inflation: Concept, Causes and Effect of Inflation, Measures to Control Inflation, Case Study on Impact of Inflation	

Course Outcomes:	
1	The students are expected to apply engineering knowledge to maximize profit, satisfaction and welfare.
2	The students are able to identify the forces that affect the economy.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Modern Economics", Ahuja H. L., Pubs: Sultan Chand and Co. Ltd, New Delhi.	2012
2	"Economics For Engineers", Gupta M. L. and Gupta S.P., Pubs: ESS PEE Publications.	
3	"Business Economics", Ahuja H. L., Pubs: Sultan Chand and Co. Ltd, New Delhi.	2010
4	"Macro Economic Theory", Jhingan M.L., Pubs: Konark Publisher Pvt. Ltd., New Delhi.	1986
5	"Principles of Microeconomics", Stiglitz J.E. and Walsh C.E., 4th Edition, Pubs: W.W. Norton & Company.	2006
6	"Principles of Macroeconomics", Stiglitz J.E. and Walsh C.E., 4th Edition, Pubs: W.W. Norton & Company.	2006
7	"Principles of Economics", Mankiw N.G., 7th Edition, Pubs: Cengage Learning	2014
8	"Economics", Samuelson P.A. and Nordhaus W.D., 18th Edition, Pubs: McGraw Hill.	2004

Course Name	**:**	**PRINCIPLES OF MANAGEMENT**
Course Code	**:**	**HSM 401**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objectives:
The main aim of this course is to make students understand the management process and principles along with its application in practical life and to help them manage different jobs and situations with the help of management functions.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO MANAGEMENT** Nature of Management: Art or Science, Principles and Functions of Management	**3**
2	**EVOLUTION OF MANAGEMENT THOUGHT** Classical Theories: Bureaucratic, Scientific and Administrative Approach	**6**

	Neo-Classical Theories: Human Relations and Human Behaviour Approach Modern Theories of Management Relevance of Management Thought in present scenario – Management Cases	
3	**PLANNING** Nature of Planning, Planning Process, Application of Planning Process in a Hypothetical Situation, Types of Planning, Types of Plans, Management by Objective (MBO)	**4**
4	**ORGANIZING** Concept of Organization, Departmentation, Forms of Organization Structure Analysis of Organization Structure – Case Studies Hypothetical Formation of an Organization	**4**
5	**STAFFING** Human Resource Planning: HRP Process, Job Analysis: Job Description, Job Specifications and Used of Job Analysis Recruitment: Sources and Methods Selection: Selection Process, Role Playing and Case Study on Selection Tests and Interviews Training and Development: Techniques, Performance Appraisal: Methods Case Study on Staffing Practices	**6**
6	**DIRECTING** Concept, Leadership: Importance and Styles, Motivation: Theories and their relevance in present scenario, Communication: Process, Types and Barriers of Communication Management Game on Leadership, Motivation and Communication	**3**
7	**CONTROLLING** Nature and Process of Controlling, Requirements for Effective Controlling	**2**

Course Outcomes:	
1	The students will be able to apply management concepts and principles in daily life and thus, will be able to manage things efficiently and effectively.
2	The students will learn how to get work done easily by using management knowledge and functions.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Principles and Practices of Management", Rao V.S.P. and Narayana P.S., Pubs: Konark Publishers.	1987
2	"Principles & Practice of Management", Prasad L.M., 8th Edition, Pubs: Sultan Chand & Sons.	2012
3	"Essentials of Management: International and Leadership Perspective", Weihrich H. and Koontz H., 9th Edition, Pubs: McGraw Hill.	2012
4	"The New Era of Management", Daft R.L., 11th Edition, Pubs: Cengage Learning.	2014
5	"Management: Text and Cases", Rao V.S.P. and Krishna V.H., Pubs: Excel Books.	2008
6	"Fundamentals of Management: Essential Concepts and Applications", Robbins S.P, DeCenzo D.A., Bhattacharya S. and Agarwal M.N., 6th Edition, Pubs: Pearson India.	2009

Course Name	**:**	**BUSINESS ENVIRONMENT AND BUSINESS LAWS**
Course Code	**:**	**HSM 402**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objectives:

The main aim of this course is to make students understand different types of environment influencing business decisions and to provide knowledge about different laws that needs to be followed for initiating and managing business.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO BUSINESS** Scope and Characteristics of Business, Classification of Business Activities Forms of Ownership of Business: Sole Proprietorship, Partnership and Company	**5**
2	**BUSINESS ENVIRONMENT** Internal Environment: Concept and Elements (Value System, Vision Mission Objectives, Management Structure, Human Resources, Company Image etc.) SWOT Analysis: Concept and Case Study External Environment: Micro Environment (Suppliers, Customers, Competitors, Market Intermediaries etc.) and Macro Environment – PESTEL Analysis (Political, Economic, Social, Technological, Ecological and Legal), Case Study on Impact of Environment on Business	**7**
3	**GLOBALIZATION** Concept, Pros and Cons of Globalization, Impact of Global Environment on Business Globalization of Company – Case Study	**4**
4	**CORPORATE SOCIAL RESPONSIBILITY** Concept, Social Responsibility towards different stakeholders, Rationale for CSR CSR – Case Studies	**2**
5	**CORPORATE GOVERNANCE** Concept, Elements and Essentials of Good Governance	**3**
6	**CONTRACT LAW** Concept, Types and Essentials Elements of Contract	**3**
7	**PARTNERSHIP LAW** Nature of Partnership, Provisions of Partnership Act, Issues Related to Partnership Firm, Hypothetical Formation of a Partnership Firm	**2**
8	**COMPANY LAW** Nature of Company, Provisions of Company Act, Issues Related to Incorporation of Company, Hypothetical Formation of a Company	**2**

Course Outcomes:	
1	The students will be able to analyze the impact of environment on business and formulate appropriate business strategies to compete in the competitive world.
2	The students will learn how companies follow corporate governance and social responsibility practices along with fulfilling economic objectives.
3	The students will gain knowledge about application and implementation of various business laws in practice.

Suggested Books:

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Business Environment: Text and Cases", Cherunilam F, 22nd edition, pubs Himalayan Publications	2013
2	"Legal Aspects of Business", Pathak A., 5th Edition, Pubs: McGraw Hill Education.	2013
3	"Essential of Business Environment: Text, Cases and Exercises", Aswathappa	2011

	K., 11Edition, Pubs: Himalaya Publication.	
4	"Business Law Including Company Law", Gulshan S.S. and Kapoor G.K., 15 Edition, Pubs New Age International (p) Ltd. Edition, Pubs: Sultan Chand publishing	2011
5	"Business Law and Corporate Laws", Tulsian P.C., 1 Sultan chand & sons	2011
6	Fundamentals of Business Organization & Management", Bhushan Y.K., 19 Pearson India."	2013
7	"Corporate Governance: Principles, Policies and Practices", Fernando A.C., 2 Edition Pubs :	2011

Course Name	**:**	**ENTREPRENEURSHIP AND PROJECT MANAGEMENT**
Course Code	**:**	**HSM 403**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objectives:

The main aim of this course is to make prospective engineers familiar with the concept of entrepreneurship and MSMEs and to provide knowledge about different aspects to be considered while formulating the business plan for a new entrepreneurial venture. This course also intends to create awareness among students about financial and marketing functions that is required for a new venture.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO ENTREPRENEURSHIP** Concept of Entrepreneurship, Characteristics and Functions of Entrepreneur Forms of Ownership of Business, Factors Affecting Entrepreneurship Case Studies of Entrepreneurs	**6**
2	**WOMEN ENTREPRENEURSHIP** Nature of Women Entrepreneurship, Problems of Women Entrepreneurs, Institutional Initiatives for Promotion of Women Entrepreneurs	**2**
3	**MICRO, SMALL AND MEDIUM ENTERPRISES (MSMES)** Concept of MSMEs, Schemes of MSMEs Functions of Entrepreneurial Development Programmes (EDPs)	**2**
4	**PROJECT IDENTIFICATION** Idea Generation, Project Life Cycle, Concept of SWOT Analysis SWOT Analysis of Selected Project	**2**
5	**PROJECT PLANNING AND FORMULATION** Elements of Project Formulation: Product, Technical (Location, Scale, Technology, Production Process, Layout, Manpower, Resources etc.), Market, Finance and Economic Aspects Feasibility Analysis: Financial Viability and Profitability, and Socio-Economic Desirability	**7**
6	**PROJECT REPORT** Formulation of Business Plan and Project Report, Hypothetical Example of a Real-Life Project	**2**
7	**FINANCE AND MARKETING FUNCTION** Concept of Finance, Finance Related Terminologies, Sources of Finance, Cost Estimations Marketing Mix: Product, Place, Price, Promotion, People, Process and Physical Evidence Marketing Segmentation Targeting and Positioning	**5**
8	**DISCUSSIONS ON ADDITIONAL READING** (any one of the following in the semester) - The New Age Entrepreneurs - The $100 Startup: Fire your Boss, Do what you Love and Work Better to Live More - A Guide to Entrepreneurship - Dhandha: How Gujaratis Do Business - Rokda: How Baniyas Do Business - Take Me Home - Business Families of Ludhiana	**2**

Course Outcomes:	
1	The students will be able to apply engineering knowledge effectively in the field of entrepreneurship development.
2	The students can make effective use of entrepreneurial knowledge to start and manage their venture.
3	The students will learn to check the feasibility of a new project to maintain its long run sustainability.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Dynamics of Entrepreneurial Development & Management", Desai V., 5th Edition, Pubs: Himalaya Publishing House.	
2	"Projects: Planning, Analysis, Selection, Financing, Implementation and Review", Chandra P., 8th Edition, Pubs: McGraw-Hill Education (India).	2014
3	"Entrepreneur's Toolkit", Harvard Business School, Pubs: Harvard University Press.	2004
4	"Entrepreneurship", Hisrich R.D., Peters M.P. and Shepherd D.A., Pubs: McGraw Hill Education.	2006
5	"Essentials of Project Management", Ramakrishna K, Pubs: PHI Learning.	
6	"Entrepreneurship", Roy R., 2nd Edition, Pubs: Oxford University Press	2011
7	"Entrepreneurship Development in India", Gupta C.B. and Srinivasan N.P., Pubs: Sultan Chand and Sons.	2013

Course Name	**:**	**FINANCIAL MANAGEMENT**
Course Code	**:**	**HSM 404**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objectives:
The main aim of this course is to make students learn different financial decisions i.e. investing, financing and dividend, required to be taken by a company and provide knowledge about the functioning of the financial system (financial markets, financial institutions, financial services and financial instruments) of the country.

Total No. of Lectures – 28

Lecture wise breakup		Number of Lectures
1	**INTRODUCTION TO FINANCIAL MANAGEMENT** Concept of Finance, Terminology Related to Finance, Financial Decisions, Factors Affecting Financial Decisions, Risk-Return Trade-Off	**3**
2	**FINANCIAL SYSTEM** Concept and Role of Financial System in Indian Economy	**2**
3	**FINANCIAL MARKETS AND INSTRUMENTS** Concept and Relevance of Money Market and Capital Market Money Market Instruments: Call Money, Treasury Bills, Commercial Papers, Certificate of Deposits Capital Market Instruments: Equity Shares, Preference Shares and Debentures Hypothetical Trading in Financial Markets	**5**
4	**FINANCIAL SERVICES** Nature and Functions of Financial Services: Merchant Banking, Mutual Funds, Factoring, Forfaiting, Credit Rating Case Study on Financial Services	**6**

5	**FINANCIAL INSTITUTIONS** Nature and Functions of Financial Institutions: Reserve Bank of India (RBI), Securities and Exchange Board of India (SEBI), Discount and Finance House of India (DFHI)	**2**
6	**LONG TERM INVESTMENT DECISIONS** Capital Budgeting: Concept, Importance, Factors Techniques/Methods with Numerical Applications (Pay Back Period, Accounting Rate of Return, Net Present Value, Internal Rate of Return and Profitability Index), Case Study	**3**
7	**SHORT TERM INVESTMENT DECISIONS** Working Capital: Nature, Type and Factors Affecting the Requirement of Working Capital, Case Study	**2**
8	**FINANCING DECISIONS** Capital Structure: Essentials and Approaches of Capital Structure Sources of Finance (long-term and short-term), Financial Leverage: Concept and Numerical Application, Case Study	**3**
9	**DIVIDEND DECISIONS** Types of Dividend, Dividend Policy: Nature and Factors Affecting Dividend Policy, Case Study	**2**

Course Outcomes:	
1	The students will learn to make best combination of financial decisions by considering risk and return trade-off.
2	The students will identify how business can gain maximum through the financial system.
3	The students will understand how to manage funds effectively so as to maximize returns.

Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Financial Management", Shah P., 2nd Edition, Pubs: Dreamtech Press	2009
2	"Financial Markets and Services", Gordon E. and Natarajan K., 3Edition, Pubs: Himalayan	2006
3	"Financial Management: Theory and Practice", Chandra P., 8 Edition, Pubs Education (India).	2012
4	Financial Management", Pandey I.M., 10Edition, Pubs: Vikas Publishing House Pvt. Ltd	2010
5	"Cases in Financial Management", Pandey I.M. and Bhat R., 3 Editions, Pubs: McGraw Hill Education (India).	2012
6	"Financial Institutions and Markets: Structure, Growth and Innovations", Bhole L.M. and Mahakud J., 5th Edition, Pubs: McGraw Hill Education (India).	2009
7	The Indian Financial System: Markets, Institutions and Services", Pathak B.V., 3 Edition Pubs: Pearson India.	2010
8	Financial Management and Policy", Horne J.C.V. and Dhamija S., 12 Edition Pubs: Pearson India	2011

Course Name	**:**	**MARKETING MANAGEMENT**
Course Code	**:**	**HSM 405**
Credits	**:**	**3**
L T P	**:**	**2-1-0**

Course Objectives:
The main aim of this course is to make students understand about the marketing concepts to be applied in real life and the marketing process for delivering value to customers.

Total No. of Lectures –28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO MARKETING** Concepts, Role, Scope and Types of Marketing, Case Study on Marketing Management	**3**
2	**MARKETING RESEARCH** Scope and Process of Marketing Research, Hypothetical Marketing Research Analysis	**3**
3	**CONSUMER AND BUSINESS MARKETS** Types of Markets, Building Customer Value Consumer and Business Buying Behaviour: Factors Influencing Behaviour and Buying Decision Process	**4**
4	**SELECTION OF MARKETS** Segmentation: Factors and Bases, Targeting and Positioning Preparation of STP of Selected Product	**3**
5	**MARKETING MIX** 7 P's of Marketing Mix: Product, Price, Physical Distribution, Promotion, People, Process and Physical Evidence Formulation of Marketing Mix of Selected Product	**3**
6	**PRODUCT DECISIONS** Product (Good or Service) Characteristics, Product Life-Cycle, Packaging and Branding, Product Development and Management	**3**
7	**PRICING DECISIONS** Pricing Policies and Strategies, Factors Influencing Pricing	**3**
8	**PHYSICAL DISTRIBUTION DECISIONS** Marketing Channels, Channel Players, Physical Distribution, Managing Distribution, Analysis of Supply Chain Management – Case Studies	**3**
9	**PROMOTION DECISIONS** Nature of Promotion Decisions, Managing Mass Communication and Personal Communication Analysis of Promotional Strategies – Case Studies	**3**

Course Outcomes:	
1	The students will learn how to market goods and services effectively to different segments so as to deliver value to customers.
2	The students will be able to formulate marketing mix and marketing strategies for different products and different sets of customers.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Marketing Management: Concepts, Cases, Challenges and Trends", Govindarajan M, 2 Edition, Pubs: PHI Learning.	2009
2	"Marketing Management", Kotler P., Keller K.L., Koshy A. and Jha M., 14 Edition, Pubs Pearson India.	2012
3	Marketing Concepts and Strategies", Dibb S., Simkin L., Pride W.M. and Ferrell O.C., Pubs: Cengage Learning.	2012
4	Marketing Management", Kumar A. and Meenakshi N., 2 Edition, Pubs: Vikas Publishing House Pvt. Ltd., Noida.	2011
5	"Marketing Management", Saxena R., 4th Edition, Pubs: McGraw Hill Education (India).	2013
6	"Marketing: Managerial Introduction", Gandhi J.C., 1st Edition, Pubs: McGraw Hill Education.	1987
7	"Marketing", Etzel M.J., Walker B.J., Stanton W.J. and Pandit A., 14 Edition, Pubs McGraw Hill Education (India).	2010
8	Super Marketwala: Secrets to Winning Consumer India", Mall D., 1 Edition, Pubs: Random House India.	2014

Course Name	**:**	**COMPUTER PROGRAMMING (BASIC)**
Course Code	**:**	**CSN104**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:
To develop logical skills so that students should be able to solve basic computing problems. To learn the syntax and usage of C programming constructs.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO PROGRAMMING** Evolution of languages: Machine languages, Assembly languages, High-level languages. Software requirements for programming: System softwares like operating system, compiler, linker, loader; Application programs like editor. Algorithm, specification of algorithm. Flowcharts.	4
2	**PROGRAMMING IN C** Data types in C, Formatted input-output for printing integer, floating point numbers, characters and strings.	2
3	**OPERATORS AND EXPRESSION** Expressions in C and their evaluation. Precedence and associativity rules. Operators: arithmetic operators, relational operators, logical operations, bitwise operators, miscellaneous operators.	6
4	**STATEMENTS** Decision making structures: if, if-else, nested if and if-else, switch. Control structures: for, while, do-while. Role of statements like break, continue, goto.	6
5	**ARRAYS** Concept and use of arrays, declaration and usage of arrays, 2-dimensional arrays.	6
6	**FUNCTIONS** Advantage of modularizing C program into functions, function definition and function invocation. Methods of passing parameters to a function: call-by-value, call-by-reference; Passing arrays to functions, Recursion, Library functions.	4
7	**POINTERS** Pointer declaration and initialization, constant pointers, pointers to constant objects, pointer arithmetic, relationship between pointer and arrays.	4
8	**SCOPE AND LIFETIMES** Scope and lifetime of a variable, storage classes: auto and typedef.	2
	USER-DEFINED DATA TYPES Structures- definition, declaration, use, accessing structure members directly or through pointer structure, structure having arrays and pointers as members, self referential structures, passing structures to functions. Unions: definition, declaration, use, accessing union members directly or through pointer structure.	6
	FILES Concepts of files and basic file operations.	2

Course Outcomes:	
1	The student will demonstrate proficiency in C programming language.

Text Books:	
1	Let Us C, Yashwant Kanetkar, BPB Publications
2	Programming in C: A practical approach, Ajay Mittal, Pearson Education

Reference Books :	
1	The C programming language, Kernighan Ritchie, Pearson Education
2	Programming in ANSI C, Balaguruswamy, Tata McRaw Hill
3	Computing Fundamentals, Peter Nortan, Tata McRaw Hill

Course Name	**:**	**COMPUTER PROGRAMMING (ADVANCED)**
Course Code	**:**	**CSN105**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:

To develop logical skills so that students should be able to solve basic computing problems.
To learn the syntax and usage of C programming constructs at advanced level.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION TO STRUCTURED PROGRAMMING** Introduction to topics: decision making, Iteration, functions: functions with variable number of arguments, multiple file programs, concept of linking.	6
2	**ARRAYS** Array declaration and use, Two-dimensional arrays and multi-dimensional arrays. Strings and Character arrays. Operations on arrays such as insertion, searching, sorting, merging.	6
3	**POINTERS** Pointer expression, pointer arithmetic, pointer to array, pointer to functions, dynamic memory allocation, dynamic allocation of arrays. Call functions through function pointers, Accessing members of arrays through pointers.	6
4	**PREPROCESSOR DIRECTIVES** Introduction, Various preprocessor directives, macros with and without arguments, conditional compilation.	6
5	**STRUCTURE, UNION, ENUMERATION AND BIT-FIELDS** Definition, declaration and initialization, structures containing arrays, array of structures, structure having structures, pointers to structures, self-referential structures, dynamic allocation of structures; Unions: Definition, declaration and initialization. Concepts of interrupts interrupt programming, enumerations and bit-fields.	8
6	**FILES** Concept of file, file operations, text mode and binary mode, command line arguments.	4
7	**INTRODUCTION TO OBJECT ORIENTED PROGRAMMING** Classes and objects, basic features of object oriented programming like encapsulation, abstraction, polymorphism, etc.	3
8	**APPLICATIONS** Projects related to the development of Terminate and Stay resident (TSRs), graphical applications, text-editors, etc.	3

Course Outcomes:	
1	The student will demonstrate proficiency in C programming language.

Text Books:	
1	Let Us C, Yashwant Kanetkar, BPB Publications
2	Programming in C: A practical approach, Ajay Mittal, Pearson Education

Reference Books:	
1	The C programming language, Kernighan Ritchie, Pearson Education
2	Programming in ANSI C, Balaguruswamy, Tata McRaw Hill
3	Computing Fundamentals, Peter Nortan, Tata McRaw Hill

Course Name	**:**	**ENGINEERING DRAWING**
Course Code	**:**	**ESC 101**
Credits	**:**	**4**
L T P	**:**	**2-0 -4**

Course Objectives:
At the end of this course, the student should be able to understand the basic concepts of Engineering Drawing. The student should be able to visualize and draw the two and three dimensional objects. The student should also be able to apply drafting softwares in various types of problems.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	Introduction to Engg. Graphics, System of Projections, Orthographic projections, Lettering, Dimensioning rules	2
2	Projections of points and lines, Projection of lines on different planes, Traces and true length of the lines	2
3	Projections of planes/laminae on reference planes, classification of Primary and secondary planes, examples	2
4	Classification of solids, Projections of solids on the basis of positions of the axis of various solids on reference planes	3
5	Sectioning of solids, True and apparent sections, sectioning on the basis of position of section planes	3
6	Developments of surfaces, Parallel line, Radial line and Triangulation methods of development of right and oblique solids	3
7	General introduction to Perspective projection, isometric views, Isometric lines & Axes, Four centre and off set method of drawing ellipse from circle, conversion of orthographic views to isometric views and vise-versa	3
8	Introduction to AutoCAD software for drawing of 2D projections, practical exercises on points, lines, planes and solids	10

List of Experiments:		**Number of Turns**
1	Exercises on projection of Points on drawing sheets	1
2	Exercises on projection of lines on drawing sheets	1
3	Exercises on projection of planes on drawing sheets	1
4	Exercises on projection of solids on drawing sheets	2
5	Exercises on sections of solids on drawing sheets	1
6	Exercises on Developments of surfaces and Isometric projections on drawing sheets	2
7	Practice of exercises on points and lines using AutoCAD software	1
8	Practice of exercises on planes using AutoCAD software	2
9	Practice of exercises on solids and developments using AutoCAD software	2
10	Practice of exercises on isometric projections using AutoCAD software	1

Course Outcomes: At the end of this course, the students will be able to:	
1	Understand the basic concepts of Engineering Graphics.
2	Visualize the actual objects and convert them in to readable drawings.
3	Understand the drawing standards, conventions and symbols that are in common usage.
4	Draw the common Engineering drawings using available drafting softwares.
5	Come up with innovative conceptual ideas by using Drafting softwares.

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Engineering Drawing", P. S. Gill, S.K. Kataria & Sons	2012
2	"Engineering Drawing", D.A. Jolhe, Tata McGraw Hill	2010
3	"Engineering Graphics with Auto CAD", James Bethune, Prentice Hall, India	2003

Course Name	**:**	**FLUID MECHANICS**
Course Code	**:**	**ESC102**
Credits	**:**	**4**
L T P	**:**	**3 0 2**

Course Objectives:
To learn the basic concept of fluid mechanics. To understand the analytical method of solving fluid mechanics problem

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** Fluids, Brief history of Fluid Mechanics, Properties of Fluid, Viscosity, Capillarity, Surface Tension, Compressibility, Normal and Shear Stresses in Fluid Flows, Regimes of Flow	4
2	**FLUID STATICS** Pascal's Law of measurement of pressure, Types of forces on a fluid system, manometers and gauges, forces on partially and fully submerged bodies including that on curved surfaces, Buoyancy, stability of floating bodies, centre of gravity, Metacentric height.	**6**
3	**KINEMATICS OF FLUID FLOW** Langrangian and Eulerian methods, description of properties in a moving fluid, local and convective acceleration, Streamlines, Path lines, Streak lines, Laplace equation, Stream function, velocity potential and flownets.	**4**
4	**DYNAMICS OF FLUID FLOW** Equation of conservation of mass, differential form of continuity equation. External forces, Euler's equation of motion, Bernoulli's equation, simple application to one dimensional flow, linear momentum and angular momentum, momentum theorem, moment of momentum theorem	**8**
5	**VISCOUS FLOW** Pressure gradient in steady uniform flow, flow between parallel plates, Qualitative aspects of viscous flows, Hagen-Poiseulli's flow, Transition from laminar to turbulent flow, turbulent flow in circular pipe, Navier Stokes equation (without derivation).	**5**
6	**FLOW THROUGH PIPES** Introduction, energy and hydraulics grade line, non-dimensional formulation of the pipe flow problem, head losses in pipes & pipe fittings, pipe in series & parallel, reservoir problem.	**5**
7	**DIMENSIONAL ANALYSIS AND SIMILITUDE** Buckingham's Theorem, non-dimensional groups, Geometric, Kinematic and Dynamic Similarity, Hydraulic Models.	**4**
8	**FLOW MEASUREMENT** Venturimeter, orifice meter, Pitot tube, Orifices, mouth pieces, notches, weirs, Current meter.	**6**

List of Experiments:	
1	Flow Measurement by Orifice Meter
2	Flow Measurement by Venturimeter
3	Flow Measurement by V Notche
4	Computation of various coefficients involving in through orifice.
5	Determination of friction factors of pipes Minor losses in pipes
6	Determination of friction factors of pipes
7	Verification of Bernoulli's theorem
8	To determination of the metacentric height of a given vessel under unloaded condition.

Course Outcomes:	
1	To apply the learned techniques in real life problems related to fluid mechanics.

Text Books:	
1	G.L. Asawa, "Experimental Fluid Mechanics-Volume I" Nem Chand & Brothers
2	B. S. Kapoor, "Manual of Fluid Mechanics" Khanna Publishers
3	S. Singh, "Experiments in Fluid Mechanics-Second Edition" PHI Publications

Reference Books:	
1	Frank M. White, "Fluid Mechanics", McGraw Hill.
2	H. Rouse , "Elementary Mechanics of Fluids"
3	Streeter, V.L.,"Fluid Mechanics" McGraw Hill Co
4	Lewitt, E.H.,"Hydraulics and the Mechanics of Fluids" Pitman

Course Name	**:**	**INTRODUCTION TO MANUFACTURING**
Course Code	**:**	**ESC 103**
Credits	**:**	**4**
L T P	**:**	**2-0-4**

Course Objectives:
At the end of the course the students should be able to describe the properties of engineering materials and different manufacturing processes. The students should be able to select appropriate manufacturing process and manufacture a job in the different shops and areas of applications.

Total No. of Lectures – 28

Lecture wise breakup		**Number of Lectures**
1	**INTRODUCTION** Classification of manufacturing processes, classification of engineering materials, comparison of material properties of metals, ceramics and plastics, crystal structures, strain hardening effects, stress-strain curves. Safety measures in workshop.	3
2	**MATERIALS AND HEAT TREATMENT** Objective of heat treatment, classification of heat treatment, annealing, normalizing, hardening & tempering, case hardening, carburizing, nitriding, flame hardening, induction hardening, applications of heat treatment.	4
3	**FOUNDRY** Pattern, properties of pattern material, types of pattern, cores. Types of sand, moulding sand ingredients. Types of moulding processes. Types of casting processes: sand casting, shell casting, investment casting and centrifugal casting. Casting defects & remedies. Case studies and applications.	4
4	**FORMING** Metal forming, types and applications, hot & cold working, forging, drawing, rolling and sheet metal operations.	3

5	**MACHINING** Metal removal processes, machines, single-point tool, cutting tool geometry, lathe - types, elements and main parts of lathe, drilling, milling and grinding machines. Applications.	3
6	**FINISHING** Surface finishing processes, principle and applications, lapping, honing, super finishing, polishing, buffing, electroplating, galvanizing.	2
7	**WELDING** Classification of welding processes, mechanism of arc formation, arc welding processes, gas welding, and resistance welding, principles and applications, welding defects, causes and remedies. Soldering and brazing. Applications and case studies in welding.	3
8	**PLASTICS MANUFACTURING** Types and properties of plastics, thermosetting and thermoplastic resins, elastomers. Fabrications of plastics, injection moulding, blow moulding, extrusion moulding etc.	2
9	**MODERN MANUFACTURING PROCESSES** Introduction, classification, electric discharge machining (EDM), electro chemical machining (ECM), laser beam machining (LBM) and Rapid Prototyping Techniques. Case studies on modern and hybrid manufacturing processes.	2
10	**CASE STUDIES** Considerations of selecting manufacturing processes for industrial products like compact disc, PCB and emerging technological applications.	2

List of Experiments:		**Number of Turns**
1	To prepare half lap T & L joint in the carpentry shop.	1
2	To prepare the pattern of half nut in carpentry shop.	1
3	To prepare cube from a piece of round bar in forging shop.	1
4	To study the lathe, milling, planer, and shaper operations.	1
5	To manufacture a multi-operational job on lathe/milling in the machining shop.	1
6	To prepare series and parallel wiring connections in the electrical shops.	1
7	To prepare the butt joint by SMAW in welding shop.	1
8	To prepare the mould of a given pattern in foundry shop.	1
9	To cast the prepared mould in foundry shop.	1
10	To prepare a square job in the fitting shop.	1
11	To prepare rectangular box in sheet-metal shops.	1
12	To prepare different joints in the sheet-metal shop.	1

Course Outcomes: By the end of this course, the students will be able to:	
1	Compare the properties of the engineering materials.
2	Select the appropriate manufacturing process for a given job/ application.
3	Identify the advantages and limitations of different manufacturing processes.
4	
5	

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"Manufacturing Engineering and Technology", Serope Kalpakjian and Steven Schmid, Pearson Publications.	2009
2	"A Textbook of Production Technology: Manufacturing Processes", P. C. Sharma, S. Chand & Company Ltd.	2004
3	"Foundry, Forming and Welding", P.N. Rao, Tata M/C Graw Hill Publication.	2007
4	DeGarmo, Materials and Processes In Manufacturing, John Wiley & Sons	2011

Course Name	**:**	**SOLID MECHANICS**
Course Code	**:**	**ESC 204**
Credits	**:**	**4**
L T P	**:**	**3 1 0**

Course Objectives:
At the end of this course the student will be able to understand the basic concepts of behavior of the materials and analysis the basic structural elements like beams, columns, trusses and circular shafts. The student will be able to apply this knowledge for the design of various civil engineering structures.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**PROPERTIES OF MATERIALS** Introduction, uni-axial tension test, idealized stress- strain diagrams, isotropic, linear, elastic, visco-elastic and plastic materials, compression test, impact test, fatigue test, torsion and bending test.	4
2	**SIMPLE STRESSES & STRAINS** Concept of stresses and strains, relationship between elastic constants, extension of uniform bar & tapered bar under its own weight and due to load applied, stresses produced in compound bars due to axial loads, thermal stresses,	4
3	**COMPOUND STRESSES:** General state of stress, resultant stress and strain circle, prinicipal stresses and principal strains, Mohercircle for compound stresses and strais	4
4	**SHEAR FORCE AND BENDING MOMENT IN BEAMS** Shear force, bending moment, Relation between load, SF and BM, SFD , BMD and axial force diagram for determinate beams under various types of loading.	6
5	**BENDING AND SHEAR STRESSES IN BEAMS** Pure bending ,bending stresses, eccentric loading combined bending and direct stresses , Middle Third rule, composite beams, Variation of shear stresses for various cross-sections of a beam.	5
6	**ANALYSIS OF PLANE TRUSSES** Different types of trusses, Analysis of plane trusses by method of joints and method of sections.	5
7	**TORSION** Torsion equation for circular shaft , shafts under action of varying torque, torsion of composite shafts.	4
8	**COLUMNS & STRUTS** Criteria for stability of columns, Buckling of columns, Euler's theory for various end restraints, Rankine's formula, eccentrically loaded struts, struts with initial curvature, struts with lateral loading.	5
9	**DEFLECTION OF BEAMS** Slope and Deflection in beams by double integration method, Macaulay's method, Moment area method under the action of various loading conditions; slope and deflection in built in and propped beams.	5

Course Outcomes: By the end of this course the student will be able to:	
1	Analysis the simple civil engineering structures under different loading conditions.
2	Understand the behaviour of basic structural elements.
3	Apply this knowledge for the design of various civil engineering structures.
4	
5	

Suggested Books:		
Sr. No.	**Name of Book/ Authors/ Publisher**	**Year of Publication/ Reprint**
1	"An introduction to the Mechanics of Solids", Crandall & Dahi, McGrawHill.	1978
2	"Strength of Material", G.H. Ryder, MacMillan.	2002
3	"Mechanics of Solids", E.P. Popov, Pearson Education.	1978
4	"Mechanics of Materials", E.J. Hearn, Elsevier Publications.	2001
5	"Mechanics of Materials", Punmia and Jain, Laxmi Publications (P) Ltd.	2013
6	"Mechanics of Materials", R.C.Hibbeler, Pearson Higher education.	2013
7	"Strength of Materials", S. Ramammurtham and R. Narayanan, Dhanpat Rai Publishing Comp	2014

Course Name	**:**	**OPTIMIZATION TECHNIQUES**
Course Code	**:**	**MAN 402**
Credits	**:**	**4**
L T P	**:**	**3-1-0**

Course Objectives
At the end of this course, the student shoule be able to describe the need of Optimization Techniques , develop the ability to form mathematical model of optimization problems , identify and solve linear models of optimization problems , apply and to describe the limitations of classical methods to solve nonlinear models for optimization problems , apply and to describe the limitations of gradient based and direct iterative methods to solve nonlinear problems.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	**LINEAR PROGRAMMING** Formulation, Graphical solution, Simplex method , Relation between Graphical and Simplex method, Unrestricted variables, Artificial variables, M-Method and Dual Phase method	**(14)**
2	**OPTIMIZATION TECHNIQUES** **UNCONSTRAINED PROBLEMS -** (Single and multivariable optimization) Necessary and sufficient conditions for extreme points **CONSTRAINED PROBLEMS - (**multivariable optimization) Equality constraints , Jacobian and Lagrangean methods , Application of Jacobian method to linear problems	**(12)**
3	**NON-LINEAR PROGRAMMING PROBLEMS** Geometric Programming **UNCONSTRAINED ALGORITHMS –** Direct methods, Dichotomous and Golden search ; Univariate and Hooke and Jeeves search methods ; Gradient methods , Cauchy's steepest ascent method and Newton's method.	**(12)**
4	**PROGRAMMING TECHNIQUES** Separable programming ,Geometric Programming	**(4)**

Course Outcomes:	
1	Form mathematical model of optimization problems
2	Distinguish between linear and nonlinear models .
3	Solve simple problems using classical / iterative methods .

Course Name	**:**	**ENVIRONMENTAL SCIENCES**
Course Code	**:**	**GSC101**
Credits	**:**	**3**
L T P	**:**	**3 0 0**

Course Objectives:
This course aims to acquaint students with the basics of Environmental Sciences.

Total No. of Lectures – 42

Lecture wise breakup		**Number of Lectures**
1	Multi-discipline nature of environmental studies as applied to different engineering streams - Definitions, scopes and explanations.	6
2	Types of Ecosystems – System dynamics – Understanding ecosystems, Ecosystem degradation, Resource utilization, Ecosystem diversity, Habitat classification.	6
3	Natural Resources; Renewable and non-renewable- Natural resources and associated problems, Non-renewable resources, Renewable resources	6
4	Energy and Environment- Fossil fuel, Geothermal, tidal, nuclear, solar, wind, hydropower & biomass.	6
5	Environment pollution- Air Pollution, Water Pollution, Soil Pollution, Marine Pollution, Noise Pollution, Thermal Pollution, Nuclear hazards	6
6	Cleaner Production and life cycle analysis: - LCA methodology, steps and tools, EIA and Environment audit	6
7	Environment Development and Society:- Emerging technology for sustainable development and environment management public participation , and provision in management and legislation.	6

Course Outcomes:	
1	Students will be able to relate the importance of Environmental Sciences for sustainable development of society.
2	Students will be able to understand the problems and remedies of Environmental Sciences.

Text Books	
Sr. No.	**Name of book/Authors/ Publishers**
1	Environmental Science Ceonage Learning Publication, Miller G.T. and Spool Mar
2	Environmental Studies, Tata McGraw Hill Pub., Banny Joseph