VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE
(VJTI)

MATUNGA, MUMBAI 400 019

(Autonomous Institute affiliated to University of Mumbai)

Curriculum
(Scheme of Instruction & Evaluation and Course contents)

(Revision 2018)
For

Third Year

Of

Four Year Undergraduate Programme Leading to
Bachelor of Technology (B. Tech.) Degree in Production Engineering

Implemented from the batch admitted in first year, 2018-19

B. Tech Production Engineering

Programme Educational Objectives (PEOs):

1. To prepare the Graduates with a sound foundation in the mathematical, scientific and engineering fundamentals and equip with modern tools so as to analyze, formulate, and solve real life manufacturing and industrial engineering problems.
2. To prepare graduates to become product and process design professionals for sustainable manufacturing.
3. To prepare the graduates for a successful career in Indian and Multinational organizations and to excel in their Postgraduate studies.
4. To encourage and motivate the graduates in the art of self-learning.
5. To inculcate a professional and ethical attitude, good leadership qualities and commitment to social responsibilities in the graduates' thought process.

Programme Outcomes:

1. Graduates will demonstrate basic knowledge in mathematics, science and engineering.
2. Graduates will demonstrate the ability to design and conduct experiments, interpret and analyze data, and report results.
3. Graduates will demonstrate the ability to improve a production process or system that meets desired specifications and requirements.
4. Graduates will demonstrate the ability to develop manufacturing friendly products and software packages by working with multidisciplinary teams and applying the knowledge gained during engineering and science laboratory classes.
5. Graduates will demonstrate the ability to identify, formulate and solve manufacturing related problems.
6. Graduates will demonstrate an understanding of their professional and ethical responsibilities.
7. Graduates will be able to demonstrate effective oral and written communication.
8. Graduates will have the confidence to apply engineering solutions in global and societal contexts.
9. Graduates will be capable of self-education and clearly understand the value of lifelong learning.
10. Graduates will be broadly educated and will have an understanding of the impact of engineering on society and demonstrate awareness of contemporary issues.
11. Graduates will be familiar with modern engineering software tools and equipment to analyze manufacturing related problems.

B. Tech. Production Engineering
Semester V

Scheme of Instruction and Evaluation (R-2018)

Sr No	Course Code	Course Name	Hr / Week			Credits	Scheme of Evaluation		
			L	T	P		TA	MST	ESE
1	R4PE3001S	Theory of Machines	3	0	0	3	20	20	60
2	R4PE3002T	Metal Forming Technology and Analysis	3	0	0	3	20	20	60
3	R4PE3003T	Machining and Process Engineering	3	0	0	3	20	20	60
4	R4PE3004T	Metrology and Quality Management	3	0	0	3	20	20	60
5	R4PE3005S	Metallurgy and Materials Technology	3	0	0	3	20	20	60
6	R4PE3006S	Industrial Engineering	3	0	0	3	20	20	60
7	R4HM3001L	Professional Communication Skill	1	0	2	2	60		40
8	R4PE3002P	Metal Forming Technology and Analysis Lab	0	0	2	1	60		40
9	R4PE3003P	Machining and Process Engineering Lab	0	0	2	1	60		40
10	R4PE3004P	Metrology and Quality Management Lab	0	0	2	1	60		40
			19	0	8	23			

Abbreviations:

L: Lecture, **T**: Tutorial, **P**: Practical, **TA**: Teacher Assessment, **MST**: Mid-Semester Test, **ESE**: End Semester Examination.

B. Tech. Production Engineering
Semester VI

Scheme of Instruction and Evaluation (R-2018)

Sr No	Course Code	Course Name	Hr / Week			Credits	Scheme of Evaluation		
			L	T	P		TA	MST	ESE
1	R4PE3007S	Machine Design	3	0	0	3	20	20	60
2	R4PE3008T	Metal Casting and Welding Technology	3	0	0	3	20	20	60
3	R4PE3009T	Mechatronics and Automation	3	0	0	3	20	20	60
4	R4PE3010T	CAD CAM CIM	3	0	0	3	20	20	60
5		Professional Elective 1	3	0	0	3	20	20	60
6		Open Elective 1	3	0	0	3	20	20	60
7	R4PE3011S	MIS ERP	2	0	0	P/NP			
8	R4PE3008P	Metal Casting and Welding Technology Lab	0	0	2	1	60		40
9	R4PE3009P	Mechatronics and Automation Lab	0	0	2	1	60		40
10	R4PE3010P	CAD CAM CIM Lab	0	0	2	1	60		40
			20	0	6	21			

Abbreviations:

L: Lecture, **T**: Tutorial, **P**: Practical, **TA**: Teacher Assessment, **MST**: Mid-Semester Test, **ESE**: End Semester Examination.

List of Professional Elective 1

Sr. No.	Course Code	Course Title
1.	R4PE3101S	Artificial Intelligence and Expert Systems
2.	R4PE3102S	Dynamics of Machinery
3.	R4PE3103S	Automobile Engineering
4.	R4PE3104S	Plastics Processing Technology
5.	R4PE3105S	Industrial Robotics
6.	R4PE3106S	Business Analytics
7.	R4PE3107S	Procurement and Inventory Management

List of Open Elective 1

Sr. No.	Course code	Course Title
1.	R4PE3601S	Project Management

Programme	B. Tech (Production Engineering)	**Semester** - V
Course Code	R4PE3001S	
Course Title	Theory of Machines	
Prerequisites	Applied Mechanics, Strength of Materials	

Course Outcomes: On the completion of this course, the learner will able to

1. Apply the principles and basic of mechanism.
2. Analyse the planar mechanisms for position, velocity and acceleration.
3. Analyse and design various elements of machines.
4. Employ principles of friction, balancing and vibration and can apply to engineering problems.

Syllabus

1.	**Basics of Mechanisms** Definitions and Basic kinematic concepts, Classification of mechanisms, Degree of freedom, Mobility, Kutzbach criterion, Gruebler's criterion, Grashof's Law, Kinematic inversions of four-bar chain and slider crank chains, Limit positions, Mechanical advantage, Transmission Angle. Description of some common mechanisms – Quick return mechanisms, Straight line generators, Dwell mechanisms, Ratchets and Escapements, Universal Joint, Basic structures of Robot Manipulators (serial & parallel).
2.	**Special Mechanisms** Straight line generating Mechanisms: Exact Straight-Line Generating Mechanisms – Peaucellier's and Hart's Mechanism. Approximate Straight-Line Generating Mechanisms – Watt's, Grasshopper and Tchebicheff's. Offset slider crank mechanisms, Pantograph. Hook joint- single and Double. Steering gear mechanisms – Ackerman, Davis.
3.	**Kinematics of Linkage Mechanisms** Displacement, velocity and acceleration analysis of simple mechanisms. Velocity analysis using instantaneous centers. Graphical method – Velocity and acceleration polygons, Coriolis component of Acceleration. Kinematic analysis by complex algebra methods, Vector approach, Computer applications in the kinematic analysis of simple mechanisms, Coincident points.

4.	**Kinematics of Cam Mechanisms** Definitions and Terminology, Classification of cams and followers, Displacement diagrams – Uniform velocity, parabolic, simple harmonic, cycloidal and polynomial motions. Derivatives of follower motions, Layout of plate cam profiles, Specified Contour cams, Circular arc and tangent cams, Pressure angle and undercutting, sizing of cams.
5.	**Gear and Gear Trains** Gear- Law of toothed gearing, Involutes and cycloidal tooth profiles, Spur Gear terminology and definitions, Gear tooth action, contact ratio. Interference and undercutting. Non-standard gear teeth – Helical, Bevel, Worm, Rack and Pinion gears [Basics only]. Gear Trains– Speed ratio, train value. Parallel axis gear trains, Epicyclic Gear Trains. Differentials Automobile gear box.
6.	**Friction** Surface contacts - Sliding and Rolling friction. Friction drives- Friction in screw threads, Bearings and lubrication, Friction clutches, Friction aspects in brakes, Friction in vehicle propulsion and braking. Belt and rope drives. Chains – types of chains, chordal action, variation in velocity ratio, Length of chain.
7.	**Balancing and Vibration** Introduction. Rotary masses: several masses in same plane, several masses in different planes. Balancing of reciprocating masses, primary balancing and secondary balancing. Balancing of locomotives- Variation of Tractive force, Swaying couple and Hammer blow. Vibration: Introduction, free vibrations; longitudinal, transverse and torsional vibrations. Dunkerly's equation, critical or whirling speed of shaft. Torsional vibrations of two rotor system-torsional equivalent shaft. Free torsional vibrations of a geared system. (Damped and forced vibrations are excluded).
8.	**Flywheel and Gyroscope** Turning moment diagram, Fluctuation of speed, fluctuation in energy, function of flywheel estimating inertia of flywheel. Gyroscope: Gyroscopic couple, Effect of precision motion on the stability of moving vehicles such as motor car, motor cycle, air plane and ship.

9.	**Virtual Mechanism Simulation** Virtual mechanism can be taught using software environment as more lucid and effective way. While several commercial and free software exist that can be used to compliment the teaching and learning, a significant amount of time is required to learn the software first, and then use it. 2-D and 3-D CAD packages with associative capabilities. 2-D stand-alone dynamic analysis programs, and 3-D dynamic analysis programs that work with solid modeling software. MechAnalyzer is a 3D model-based software can be used for effective teaching and learning Mechanisms.
	Text Books
1.	S.S. Rattan: Theory of Machines, McGraw-Hill Education (India) Private Limited.
2.	A.G. Ambekar: Mechanism and Machine Theory, Prentice Hall of India, New Delhi.
	References
1.	Amitabha Ghosh and Asok Mullick: Theory of Mechanisms and Machines, East-West Affiliated.
2.	P.L. Ballaney: Theory of Machines and Mechanisms, Khanna Publications.
3.	Thomas Bevan: Theory of Machines, CBS Publishers and Distributors.
4.	Joseph Shigley, G.R Pennock and John Uicker: Theory of Machines, Oxford University Press.
5.	Graham Kelly: Schaum's Outline of Theory and Problems of Mechanical Vibrations, Tata McGraw-Hill Publication.
6.	John Hannah and Stephens R.C., Mechanics of Machines, Viva Low-Prices Student Edition.

Programme	B. Tech (Production Engineering)	**Semester** - V
Course Code	R4PE3002T	
Course Title	Metal Forming Technology and Analysis	
Prerequisites	Strength of Materials, Manufacturing Technology	

Course Outcomes: On the completion of this course, the learner will able to

1. Based on the critical understanding of processes, students would select appropriate forming processes along with parameters to manufacture a given part.

2. Student would analyse the metal forming process so as to determine various forces and determine the load requirement.

3. Students would design rolls for rolling and dies for various processes – forging, extrusion, drawing and select optimal equipment and machines for manufacturing a given part.

4. Student would design tooling for sheet metal working – simple, compound, combination press tools.

Syllabus

1. **Fundamentals of Metal Forming**

Introduction – Classification and comparative study of metal forming process. Effect strain hardening, recrystallization, effect of temperature, speed, friction and lubrication and metallurgical structure on metal forming process, difficulties encountered in plastic forming. Super plastic forming.

Deformation zone geometry, workability and sheet metal formability, formability limit diagram, residual stresses. Materials and alloys for forming. Forming material and product specifications. Modern trends in metal forming.

2. **Analysis of Metal Forming**

State of stress, true stress strains. Three-dimensional stress analysis and stress tensor, principal stresses, stress deviator. Octahedral shear stress and shear strain. Yield criterion- Von Mises and Tresca yield criteria; comparison of yield criteria. Sheet metal production, mechanical properties and their assessment, Forming Limit Diagram (FLD), stress and strain paths. Analysis of plastic deformation and load calculation for forging, rolling, extrusion, rod/wire drawing and tube drawing using various methods- Slab method, slip line method. Design considerations in forming processes.

3.	**Rolling** Scope and importance of rolling, classification of rolling mills; principles and process characteristics, layout and accessories for rolling mills, roll bite, reduction, elongation, spread, blooming, slabbing, billet, plate, and sheet, structural and merchant mills. Roll Pass Design: Roll pass Scheduling for various sections, mill automation, defects in rolled products. Metal Deformation in Rolling Stresses in rolling, load and torque calculation in rolling, non-conventional rolling, helical, ring and tyre rolling, other allied rolling processes.
4.	**Forging** Hammers and presses principles, construction, operation and maintenance of different types of hammers and presses. Closed Die Forging: Material flow in forging, multi-impression die design (fullering, rolling, edging, bending, blocking and finishing impressions) allowances and tolerances, load calculation and selection of hammer; upset forging machine (construction, operation and application), design of dies for upset forging machine.
5.	**Extrusion and Drawing of Wires, Rods and Tubes** Types of extrusion, extrusion process, scope and advantages, forward, backward and impact extrusion, pressure of extrusion, effect of friction, metal flow in extrusion; tube and sectional extrusion; equipment, tools and dies for Extrusion. Process and tooling, process analysis, lubrication of wire, rod, strip and tube drawing.
6	**Sheet Metal Working** Definition and classification of processes. Features, benefits and limitations of stamped parts and operations. Basic elements of shearing press tooling. Different types of press tool dies -Simple, compound, combination. Theory of Shearing and optimum cutting clearance. Calculations of cutting force, stripping force, center of pressure and specification of a press. Fine blanking. Design of dies for cutting operations. Single and multi-station dies inclusive progressive die design. Optimal strip layout. Methods of feeding the strip/coil material. Design and selection of Press tool elements viz. dies, punches, strippers, die sets, pilots, punch plates, ejectors/lifters. Forming Machines: Conventional and advanced machines including CNC shears, press brakes. Turret punching press etc. Sheet handling equipment. Tool design & design of inspection fixtures, component handling.

7	**Forming Sheet Metal Operations** Overview of important forming operations**.** Bending: Characteristics and types of bends. Press brake and operations. Theory of Bending and blank development. Basic bending die construction. Spring back and controlling measures. **Drawing:** Theory of drawing, Metal flow in drawing, Blank development, Determination of number of draws and redrawing limits, role of anisotropy in material, draw clearance considering wall thickening, drawing and blank holding forces. Lubrication. Analysis of defects in drawn parts. Single and double action presses, design of drawing die and combination die. Design of dies for cylindrical and rectangular cups. Study of Coining, Embossing, Horn Die.
8	**Miscellaneous Processes** Wire drawing, rotary swaging, metal spinning, high energy rate forming (HERF), high velocity forming (HVF): explosive forming, electro hydraulic forming, magnetic pulse forming, comparison of conventional and high velocity forming processes.
9	**Recent Advances in Metal Forming** Application of Expert System utilizing AI in area of sheet metal forming particularly deep drawing, Rolling, extrusion, bending etc.
	Text Books
1.	P. N. Rao: Manufacturing Technology, Tata McGraw Hill (TMH) Publication.
2.	P.H. Joshi: Press Tools - Design and Construction: A.H. Wheeler Publishing, New Delhi.
	References
1.	George Dieter: Mechanical Metallurgy, McGraw Hill International.
2.	Cyril Donaldson: Tool Design, Tata McGraw Hill Publication.
3.	Surendra Kumar: Technology of Metal Forming Processes, Prentice Hall Publication.
4.	G.W. Rowe: Principles of Industrial Metal Working Processes, CBS Publication
5.	American Society of Metals (ASM): Metals Handbook- Forming and Forging Vol.14, Vol 15
7.	Eugene Ostergaard: Basic Die Design, McGraw Hill Publication
8.	Society of Manufacturing Engineers, Michigan (USA): Fundamentals of Tool Design
9	R.S. Hingole: Advances in Metal Forming: Expert System for Metal Forming, Springer Verlag.

Programme	B. Tech (Production Engineering)	**Semester** - V
Course Code	R4PE3003T	
Course Title	Machining and Process Engineering	
Prerequisites	Manufacturing Technology	

	Course Outcomes: On the completion of this course, the learner will able to 1. Analyze the machining mechanisms and the tool geometry of single point and multipoint cutting tools. 2. Design / select the single point and multipoint cutting tools and cutting parameters for various applications. 3. Design Jigs / fixtures for a given part 4. Prepare process sheet for a given part containing all details
	Syllabus
1.	**Mechanics of Metal Cutting** Single point tool and tool signature. Orthogonal and oblique cutting, cutting mechanism, types of chips, Merchant's circle and theory; Ernest-Merchant Theory. Cutting Forces and effect of cutting variables, tool material and geometry, work material; empirical formulae for estimating cutting force and power.
2.	**Design Single Point Tools** Definition of various angle of single point tool as per American Standards; design and selection of solid tools, tipped tools and insert type tools **Form Tools** Types, constructional details and applications; Design aspects of important form tools.
3.	**Design of Tool for Hole Making Operations** **Drills** Constructional features and selection of two fluted drills to different machining conditions; grinding of drills; carbide tipped drills. Design features of core drills, countersinks, counter bores and spot facers. **Reamers:** Types, Constructional features and design of reamers. **Boring Tools:** Solid tools, tools bits for boring bars, micro boring inserts for boring bars, design of boring bars. **Broach Tools**: Types, Constructional features and design of broaches.

4.	**Cutters for Milling and Gear Cutting** Types, Constructional features and application of Peripheral, form and face milling cutters (Design is not needed) Types, Constructional features and application of gear cutter and hobs
5	**Unconventional Machining Processes** Classification and basic principles; study and applications of important processes of Abrasive Jet Machining (AJM), Electrical Discharge Machining (EDM), Laser Beam Machining (LBM),
6	**Design of Jigs and fixtures** Principles and elements of location and clamping. Types of jigs and fixtures. Tool guidance (bushes/setting block) and body construction. Design of jigs and fixtures for drilling, turning and milling bushes.
7.	**Process Sheet Design** Study of the parts to be processed, logical design of a process plan, stock preparations, blank selection with material estimates, selection of datum features, identification of machining surfaces, incorporation of dimensions including tolerance analysis, selection of machining methods with time estimates and time standard for each operation, Process Picture sheet including process symbols, processing dimensions. Process plan sheet design for complete manufacturing part.
	Text Books
1.	Juneja and Shekhon: Metal Cutting and Machine Tools
2.	A. Bhattacharya: Metal Cutting, Central Books.
3.	Kempster M H A: An Introduction to Jigs and Fixtures
	References
1.	Geoffrey Boothroyd: Fundamentals of Metal Cutting and Machine Tools.
2.	HMT Hand Book: Production Technology, TMH
3.	Arshinov: Metal Cutting and Cutting Tools Design, Mir Publishers Moscow.
4.	PN Rao: Manufacturing Technology Volume 2, McGraw Hill.
5.	P.H. Joshi: Jigs and Fixture, Tata McGraw Hill.
6	A. B. Chattopadhyay: Machining and Machine Tools, Wiley
7	P. C. Sharma: A Textbook of Production Engineering, S. Chand.

Programme	B. Tech (Production Engineering)	**Semester -** V
Course Code	R4PE3004T	
Course Title	Metrology and Quality Management	
Prerequisites	Manufacturing Technology, Production and Machine Drawing	

	Course outcomes: On the completion of this course, the learner will able to 1. Handle & operate precision measuring instruments/ equipment's. 2. Analyze simple machined components for dimensional stability & functionality. 3. Design Go and No-Go gauges for a given assembly.
	Syllabus
1.	**Introduction** Definition, types, need of inspection, terminologies, methods of measurement, selection of instruments, measurement errors, units, Measurement standards, calibration, statistical concepts in metrology. Standards of Measurement - Line, end and wave length standards, primary, secondary and tertiary standards, sub division of standards. Linear Measurements -Calipers, micro meters, surface plates, angle plates, V - blocks, straight edges, height and depth gauges, inside micrometers, bore gauges, slip gauges, accessories, types of slip gauges use and care of slip gauges.
2.	**Limits, Fits and Tolerances** Requirement of interchangeable manufacture, allowance and tolerance, limits and fits, hole based and shaft based systems, IS 919 : 1963, tolerance grades IT 01 to IT 05, types of fits, geometrical tolerance problem, Newall and ISO systems, general requirements of "GO" & "NO GO" gauging; Taylor's principle, positional tolerance, selective assembly
3.	**Comparators** Need for comparators, amplifying system; mechanical, mechanical-optical, electrical, electronic and pneumatic comparators; principle, construction and operation of various comparators.
4.	**Interferometry** Principles of interference, monochromatic source, concept of flatness, flatness testing, optical flats, interference patterns and their significance, optical interferometer, laser interferometer.

5.	**Angular Measurement** Angle standards, Vernier protractor, clinometers; sine bar, sine table and sine centre, spirit level, angle Dekkor, optical square, optical dividing head and rotary table. Taper and Radius measurement for internal and external surface using gauges, autocollimator and sine bar.
6.	**Surface Texture Measurement** Profile geometry, roughness and waviness, definition and significance of terms; band width selection, roughness standards specifying surface roughness parameters, R_a, R_z, R_p, etc.; RMS number, surface roughness measuring instruments (Tomlinson's surface meter etc), surface roughness symbols
7.	**Measurement of Screw Threads and Gears** Types of screw threads, definitions, proportions of ISO metric thread form; measurement of major and pitch diameters, two wire and three wire methods, floating carriage micrometer; measurement of internal threads; tolerance system and design of thread gauge; tools maker's microscope, limit gauges for internal and external threads, thread gauges and their applications. Gear Measurement using Gear caliper, gear tooth comparator and, gear measurement using rollers, master gears and Parkinson tester, tolerance for composite errors.
8.	**Control Charts** Introduction to SQC and statistical background. System of Chance Causes, Patterns of Variations, Interpretation of Lack of Statistical Control. Interpretation of Patterns of Variation on X & R Charts, Control Charts for Variables and attributes. Process Capability Analysis - Estimation Of Process Capability using Process Capability Indices, Viz: Cp, Cpk, Cpm, and Their Interpretation
9	**Acceptance Sampling** Background including normal, poison and binomial distribution. Different sampling plans. Lot-by-lot acceptance using single sampling plan, OC curves, sampling risk, AQL, LTPD, alpha and beta risk, construction of OC curve for given sampling plan and estimation of different parameters. Double sampling plans and Use of Dodge - Romig sampling plans.
10.	**Total Quality Management** Evolution of quality journey and key concepts of Quality guru. Principles and concepts of TQM.

	Text Books
1.	I.C. Gupta: Engineering Metrology, Dhanpat Rai Publications.
2.	R.K. Jain: Engineering Metrology, Khanna Publications.
	References
1.	Kulkarni and Bewoor: Metrology and Measurement, Tata McGraw Hill Publications.
2.	Statistical Quality Control: M. Mahajan, Dhanpat Rai Publication
3.	Total Quality Management: Besterfield Dale and others, Pearson Education

Programme	B. Tech (Production Engineering)	**Semester** - V
Course Code	R4ME3005S	
Course Title	Metallurgy and Materials Technology	
Prerequisites	Applied Physics	

Course outcomes: On the completion of this course, the learner will able to

1. Identify various defects and failure mechanisms
2. Interpret Iron-Iron carbide diagram, TTT diagram& their significance.
3. Select appropriate heat treatment process for specific requirements.
4. Understand effect of alloying elements on material properties

Syllabus

1. **Solidification and Structure of Metals**

Solid solutions. Formation of solids from liquids of pure metals and alloys, ingot defects and their remedies. Single crystal and polycrystalline structure, Classification and crystal structure, unit cell, co-ordination number, atomic packing, crystallographic notations.

3. **Crystal Imperfection**

Deformation and Strain hardening, Definition, classification, Point defects: their formation and effects. Dislocations: Edge and screw dislocations, their significance. Surface defects: Grain boundary, sub-angle grain boundary, stacking fault, and their significance. Dislocation generation by Frank Reed sources. Dislocation interactions. Elastic & plastic deformations and their significance. Deformation in single and polycrystalline materials. Mechanism of deformation, critical resolved stress. Deformability of FCC, BCC, HCP metals, slip system

Solid strengthening mechanisms

Strain hardening: Significance, Dislocation theory of strain hardening. Re-crystallization annealing and its stages, factors affecting recrystallization, Hot and cold working.

4. **Alloys and Theory of Alloying**

Solid solution theory. Classification and characteristics of different types of alloys. Phase diagram and its importance, different types of phase diagrams and their interpretation. Eutectic, Eutectoid, Peritectic alloys, conditions of their formation and importance. Solid solutions, conditions and importance of their formation. Intermediate alloys. Types and conditions of formation with importance. Important alloys of aluminum, copper, nickel, tin and zinc, their specifications, universal identification numbers and applications.

	Theory of Alloying- Significance of alloying, Definition. Classification and properties of different types of alloys. Alloy Phase Diagrams - Different types of alloy diagrams and their analysis, Tie bar and lever rules and their application. Dispersion hardening / age hardening
5.	**Principles and Technology of Heat Treatment** Equilibrium transformations in iron-iron carbide systems. Non-equilibrium transformations. Time-Temperature Transformations of austenite. Mechanisms of Pearlite, Bainite & Martensite Transformations. Principles of heat treatment of steels from T.T.T. diagram, Technology of heat treatment- Significance of austensization, homogenization and controlled decomposition of Austenite. Heat treatment furnaces, salt baths and cooling media, heat treatment in controlled atmosphere.
6.	**Heat Treatment Processes and Furnaces** Annealing, Normalizing, Hardening, Hardening media, hardenabilityand its method of determination; factors affecting hardenability. Tempering, transformations in tempering, temper embrittlement, temper colors. Austempering, Martempering. Case Hardening - Carburizing, Nitriding, Cyaniding, Carbonitriding. Induction hardening, Flame hardening. Annealing - Principle, process, and properties developed on Full Annealing; Spheroidizing; Normalizing - The process and its applications. Hardening- Hardening media, Salt baths, Hardenabilitiy, Tempering, Subzero treatment, Austempering, Martempering, Maraging and Ausforming process. Surface hardening - Surface Hardening methods. Their significance and applications. Carburizing, Nitriding, Cyaniding, Carbon-nitriding. Induction hardening and Flame hardening processes. Different types of furnaces for heat treatment and melting operations
7.	**Powder Metallurgy** Powder making methods. Powder compaction, Sintering, sintering mechanism. Applications of power metallurgy, Powder Metallurgy Process. Applications such as Oil Impregnated Bearings and Cemented Carbides. Limitations of Powder Metallurgy
8.	**Introduction to New materials** Composites: Basic concepts of composites, Processing of composites, advantages over metallic materials, various types of composites and their applications. Nano Materials: Introduction, Concepts, synthesis of nanomaterials, examples, applications and nano composites. Polymers: Basic concepts, Processing methods, advantages and disadvantages over metallic materials, examples and applications.
	Text Books
1.	V. Kodgire: Material Science & Metallurgy, Everest Publication House-Pune.
2.	William Callister: Materials Science and Engineering, Wiley India (P) Ltd.

	References
1.	V. Raghvan; Physical Metallurgy, PHI, New Delhi.
2.	V. Raghvan: Introduction to Material Science, PHI, New Delhi.
3.	E. Rollason: Engineering Metallurgy, ELBS.
4.	Y. Lakhtin: Engineering Metallurgy, C.B.S. Publishers & Distributors.
5.	Sidney Avner: Introduction to Physical Metallurgy, Tata-McGraw Hill.
6.	R. Higgins: Engineering Metallurgy Vol.-I and Vol-II, ELBS.

Programme	B. Tech (Production Engineering)	**Semester -** V
Course Code	R4PE3006S	
Course Title	Industrial Engineering	
Prerequisites	None	

	Course outcomes: On the completion of this course, the learner will able to 1. Analyze the productivity and information flow in industrial organizations by applying various industrial engineering techniques 2. Develop a deeper understanding of work study through implementation of method study and work measurement 3. Apply the ergonomic principles for workplace design 4. Assess various factors influencing facility locations and types of plant layout.
	Syllabus
1.	**Introduction to Industrial Engineering** Definitions and meaning of I.E.: Contribution by F.W. Taylor, Gilbreth, objectives of I.E. Production and Productivity - Factors affecting productivity and ways to improve productivity, industrial organizations, work and information flow in industry
2.	**Work Study** Definition, objective, Scope of method study, Basic procedure symbols and recording of facts, Charting conventions, Different types of Process Charts, Diagrams – Flow and String Diagram, Travel Chart Templates and Models, Micro Motion Study. Therbligs, Simo Chart, Critical Examination and Selection, Implementation Method. Definition, objective and techniques of work measurement, time study, stop watch method, performance rating, allowance, relaxation interference contingency, policy, calculation of standard time, work sampling its need and procedure, predetermined motion time study (PMTS).
3.	**Ergonomics and Industrial Safety** Definition, Man Machine system, Types of display, types of control, manual material handling, Anthropometry, Design of work place and working conditions, ILO Norms. Definition of accident, Cause of accident, Prevention of accident, safety measures factor acts, minimum wages act, Employers state Insurance act.

4.	**Facility Locations and Plant Layout** Factors affecting site selection: - Intangible factors for facility location, tangible factor for facility location, advantages and disadvantages of facility location in urban and rural areas. Plant Layout: - Characterization of an efficient layout objectives of plant layout, principles of plant layout, procedure in planning layout, types of plant, layout product/line layout, process/functional layout, fixed position/static layout, cellular/Group Technology layout, selection of material handling equipment.
5.	**Job Evolutions and Merit Rating Job Evolution** Objectives, advantages and procedure, job analysis, job description, job specification, methods of evolution. Merit rating: Objectives And Method of Merit rating.
6.	**Advanced Decision-making approaches for Industrial Engineering** Application of multi objective optimization for product customization and plant layout problems. Application of advanced decision-making approaches such as Analytical Hierarchy Process (AHP), Step-wise Weight Assessment Ratio Analysis (SWARA), Technique for Order Preference and Similarity to Ideal Solution (TOPSIS), for material selection, plant location selection, department allocation problems.
	Text Books
1.	ILO: Introduction to Work Study, Universal Publication.
2.	M. Mahajan: Industrial Engineering and Production Management, Dhanpat Rai Publications.
	References
1.	Martand Telsang: Industrial Engineering and Production Management, S. Chand Publications.
2.	L C Jhamb: Work Study and Ergonomics, Everest Publishing House.
3.	A. K. Gupta: Engineering Management, S. Chand Publications.

Programme	B. Tech (Production Engineering)	**Semester** - V
Course Code	R4HM3001L	
Course Title	Professional Presentation Skills	
Prerequisites	Business English	

Course outcomes: On the completion of this course, the learner will able to

1. Apply the principles and practices of business communication for communicating in a professional environment.
2. Design a technical document with correctness of language, appropriate vocabulary and style.
3. Display competence in oral and visual communication.
4. Demonstrate capabilities for self -assessment and development.

Syllabus

1. **Basics of Business Communication**

   a. Concept and meaning of communication
   b. Verbal and non-verbal communication
   c. barriers to the process of communication
   d. Channels of communication
   e. Role of communication in the age of information technology

2. **Technical Writing**

   a. Technical writing process
   b. Style and organization in technical writing
   c. objectivity, clarity, precision as defining features of technical communication
   d. Language and format of various types of business letters, reports; proposals, e-mails, minutes of meeting, research papers

3. **Self-Development and Assessment**

   a. Time Management
   b. Perception & Attitude
   c. Personal Goal Setting
   d. Emotional Intelligence
   e. Team work
   f. Creativity

4	**Spoken Communication** a. Group Discussion b. Presentation c. Interviews d. None verbal Communication e. Using Visual Aids
5.	Business Ethics & Etiquettes a. Business & Corporate Ethics b. Social and Business Etiquettes c. Interview Etiquettes.
	Text Books
1.	Ashraf Rizvi: Effective Technical Communication, Tata McGraw Hill.
2.	Meenakshi Raman and Sangeeta Sharma: Technical Communication, Cambridge University Press.
3.	Hory Shankar Mukharjee: Business Communication, Oxford University Press.
	References
1.	E.H. McGrath: Basic Managerial Skills for All, , PHI Learning Pvt Ltd.
2.	R. Subramanian: Professional Ethics, Oxford University Press.
3.	Barun K. Mitra: Personality Development and Soft Skills, Oxford University Press
4.	*https://learnenglish.britishcouncil.org/en/english-grammar*

Programme	B. Tech (Production Engineering)	**Semester** - V
Course Code	R4PE3002P	
Course Title	Metal Forming Technology and Analysis Lab	
Prerequisites	Strength of Materials, Manufacturing Technology	

	Course Outcomes: On the completion of this course, the learner will able to 1. Analyse and determine the load requirement for bulk and sheet metal forming processes. 2. Draw up roll pass scheduling for blooming mill and billet mill with necessary details. 3. Design and draw simple, productive and economical dies for upset and multi-impression drop forging to produce a given part. 4. Design press tools with maximal use of standard parts.
	Assignments
1.	Roll pass scheduling for blooming mill with plain and grooved rolls.
2.	Roll pass scheduling for billet mill.
3.	Design of multi impression forging die.
4.	Design of upset forging die.
5.	Design simple die for cutting operations.
6	Design of progressive die (minimum four operations)
7	Design of bending/forming/coining dies
8	Assignment containing at least 10 numerical problems on bulk and sheet metal deformations.
	Text Books
1.	P. N. Rao: Manufacturing Technology, Tata McGraw Hill (TMH) Publication.
2.	P.H. Joshi: Press Tools - Design and Construction: A.H. Wheeler Publishing, New Delhi.
	References
1.	Cyril Donaldson: Tool design, TMH.
2.	P.H. Joshi: Press Tools. Design and Construction: Wheeler Publishing, New Delhi.

3.	J. R. Paquin: Fourteen steps of die Design, R. E. Crowley Industrial Press.
4.	D. Eugene Ostergaard: Basic Die Design, McGraw Hill Publication
5.	American Society of Metals (ASM): Metals Handbook- Forming and Forging Vol.14.
6.	American Society of Metals (ASM): Sheet Metal Working Vol.15.

Programme	B. Tech (Production Engineering)	**Semester -** V
Course Code	R4PE3003P	
Course Title	Machining and Process Engineering Lab	
Prerequisites	Manufacturing Technology	

	Course Outcomes: On the completion of this course, the learner will able to 1. Analyze the machining mechanisms and the tool geometry of single point and multipoint cutting tools. 2. Demonstrate the regrinding of single point cutting tool. 3. Design the single point and multipoint cutting tools. 4. Select the correct processing parameters for different machining operations.
	Syllabus
1.	Experiment demonstrating Orthogonal & Oblique Cutting and determination of shear angle and different chip formation.
2.	Machining Time Calculations & comparisons with actual time while cylindrical turning on lathe and finding out the cutting efficiency.
3.	Regrinding or re-sharpening of single point cutting tool on Pedestal Grinder or Tool and Cutter Grinder.
4.	Evaluate the Tool Life of Single point Cutting Tool while machining on a Lathe Machine.
5.	Design Turning Tool, Milling Cutter, Twist Drill, Reamer, Broach and Form Tool.
6	Design and draw a drilling Jig, milling fixture and turning fixture
7.	Prepare process sheet for at least two parts.
	References
1.	Geoffrey Boothroyd: Fundamentals of Metal Cutting and Machine Tools.
2.	HMT: Production Technology, TMH
3.	Arshinov: Metal Cutting and Cutting Tools Design, Mir Publishers Moscow.

Programme	B. Tech (Production Engineering)	**Semester -** V
Course Code	R4PE3004P	
Course Title	Metrology and Quality Control Lab	
Prerequisites	Manufacturing Technology, Applied Probability and Statistics	

Course Outcomes: On the completion of this course, the learner will able to

1. Apply various metrology instruments for measuring various dimensions.

2. Apply advance measuring systems – CMM, Laser and Machine Vision for measuring complex dimensions

3. Design and draw gauges for Industrial applications.

4. Employ various statistical measures for quality control, acceptance sampling and process capability,

Experiments

Gear Measurement

Thread Measurement

Autocollimator

Optical Dividing Head

Dial Gauge Calibration

Sine Bar and Clinometers

Sigma Comparator

Coordinate Measuring Machine (CMM), Laser and Machine Vision System

Assignments

Design and drawing of following five types of gauges:

i. " Go" and "No GO" gauges for external dimensions and for internal dimensions
ii. Gauges for internal and external threads.
iii. Taper gauges.
iv. Flush pin gauge.

	Solving 10 major problems on statistical quality control involving control charts, acceptance sampling with OCC, and process capability studies.
	Text Books
1.	I.C. Gupta: A Textbook of Engineering Metrology, Dhanpat Rai Publications.
2.	R.K. Jain: Engineering Metrology, Khanna Publishers.
	References
1.	J.F.W. Galyer , C R Shotbolt: Metrology for Engineers Paperback , Cengage Publications
2.	K.W.P. sharp Practical Engineering Metrology; Pitman Publishing
3.	BIS Codes for Guage Design
4.	Douglas Montgomery: Statistical Quality Control, Wiley publications
5.	American Society of Metals (ASM): Metals Handbook- Forming and Forging Vol.14.
6.	American Society of Metals (ASM): Sheet Metal Working Vol.15.

Semester VI

Programme	B. Tech (Production Engineering)	**Semester** - VI
Course Code	R4PE3007S	
Course Title	Machine Design	
Prerequisites	Strength of Materials	

Course Outcomes: On the completion of this course, the learner will able to

1. Interpret basic design procedure and various design considerations.
2. Define, describe and distinguish static and fluctuating loads/stresses.
3. Solve numerical problems for safe design under static and fluctuating loads/stresses.
4. Design gears, joints, pressure vessels etc. for real life applications.

Syllabus

1. **Introduction**

Mechanical Engineering design, Traditional design methods, Design synthesis, Aesthetic considerations in design, Ergonomic considerations in design, Use of standard in design, Selection of preferred sizes, value analysis, Engineering materials, Selection of materials, manufacturing considerations in design, statistical considerations in design.

2. **Design of Machine Part Subjected to Static Load**

Modes of failure, FOS, Stress due to B. M., stress due to torsional moment, Eccentric axial loading, combined stress Direct and bending e. g. C- clamp, frame, screw press, frame etc.

3. **Design of Machine Parts Subjected to Fatigue Load**

Stress concentration, stress concentration factors, methods to reduce stress concentration effects, fluctuating stresses, fatigue failure, notch sensitivity, endurance limit, Rotating beam test. Fatigue strength, factor affecting fatigue strength, Soderburg, and Goodman diagram, S. N. diagram, cumulative damage in fatigue: - Miner's equation.

4. **Shafts, Keys and Couplings**

Transmission shafting, Design against static load and torsional rigidity, keys: Design of various types of keys, couplings: design of rigidity and flexible couplings

5.	**Design of Welded and Riveted Joint** Strength of butt and fillet weld, weld subjected to eccentric loading, bending and torsional loading. Design of riveted joints subjected to eccentric loading. Boiler riveted joints-longitudinal and circumferential joints-single riveted, double riveted and triple riveted joints having equal/ unequal cover straps, chain and zigzag riveted arrangements, use of Indian Boiler Regulation (IBR) in design.
6.	**Gears** Types of gears, V. R. for each type, selection of types of gear, modes of failure, gear design for maximum power transmitting capacity, Design of spur and helical gear, Lewis equation, Buckingham's Equation, Wear strength of spur & helical gears, gear lubrication.
7	**Pressure vessel** Thick and compound cylinders, determination of wall thickness of cylinders, hoop and radial stresses, plotting hoop and radial stress distribution curves.
8	**Design of IC engine Parts** IC engine cylinder wall and head, studs, connecting rod, piston, crankshaft, valve and valve spring.
	Text Books
1.	V. B. Bhandari: Design of Machine Elements, Tata McGraw Hill Co. Ltd.
2.	N. C. Pandya and C. S. Shaha : Elements of Machine Design, Charotar Publishing House
3.	J. E. Shigley, Mitchell: Mechanical Engineering Design, McGraw-Hill Publishing Co. Ltd
	References
1.	J. E. Shigley: Mechanical Engineering Design, McGraw Hill
2.	N. C. Pandya and C. S. Shaha: Machine Design, Charotar Publishing House
3.	Schaum Series: Machine Design, McGraw Hill.
4.	M. F. Spotts: Design of Machine elements, Prentice Hall India Ltd.

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Programme	B. Tech (Production Engineering)	**Semester -** VI
Course Code	R4PE3008T	
Course Title	Metal Casting and Welding Technology	
Prerequisites	Manufacturing Technology	

Course outcomes: On the completion of this course, the learner will able to

1. Ability to identify, formulate and model a casting
2. To learn and control the factors controlling casting defects
3. Fundamentally understand casting methods and their applications
4. Design gating system for metal casting processes

Syllabus

1. **Introduction**

Principle of casting. Overview and classification of Casting process.

Sand Casting**:** Basics, types and processes. Capability of sand-casting processes.

Moulding sand and mould making - Composition, characteristics and testing including mulling index; moldability index; compactability; deformability. Moulding methods and testing of moulds.

Pattern -Types, materials and making/ machining of patterns for different applications.

Core sand; characteristics and constituents, core making, baking and handling techniques; moulding and core making machines.

2. **Gating and Risering Design**

Progressive and directional solidification; rate of solidification; Chvorinov's Rule, electrical analog of solidification problem.

Riser design; risering curves; NRL method of riser design; feeding distance; risering of complex casting; risering of alloy other than steel; recent developments e.g. riser design by the application of geometrical programming.

3. **Melting and Solidification**

Selection and control of melting furnaces; melting, refining and pouring. Furnaces: cupola, electric and induction furnaces; comparative study and their suitability; charge calculation, handling of molten metal; ferrous and nonferrous foundry practice. Measurement of fluidity; effects of various parameters on fluidity. Methods of elimination and control of dissolved gases in castings.

Solidification: Solidification of pure metal and alloys, their characteristics; free solidification and solidification under force.

Fettling and inspection of castings; casting defects, causes and remedies; casting design.

4.	**Special Casting Processes** Die casting- die design and equipment selection. Investment casting.
5.	**Inspection and Quality Control** Casting defects and remedies. Review of x-ray and gamma ray radiography; magnetic particle; penetrant and ultrasonic inspections; use of statistical quality control in foundry.
6.	**Plastics -Manufacturing Technology** Plastics materials - types, chemical, physical, processing and engineering properties of plastics. Manufacturing processes of resins and plastics, raw materials, finished forms. Product Design: process, materials and tooling related aspects; specific beneficial (or otherwise) design features vis-à-vis other materials. Casting, moulding (Injection, transfer, compression), thermoforming, continuous extrusion (sections, sheets, and films), Calendaring. Design of Moulds: for injection, compression and transfer moulding feeding system, overflows, breathers and vents, cooling/heating of moulds, locking, ejection, mounting of moulds; construction and manufacturing aspects; two / three plate moulds, inserts, mould materials, machining, fabricating of moulds, polishing of cavities. Design of extrusion dies for different shapes, die materials, manufacture, mounting, heating / cooling of dies.
7.	**Welding Processes and Types of Joints** Classification of fusion welding processes, heat source intensity, and heat input rates, shielding methods. Heat and mass flow in welding, heat sources. Arc; definition, physics of arc, characteristics of arc, column; heat flow in electrode, weld pool and base metal. Types of weld joints, edge preparation, weld positioning, cleaning of edges, tack welding. Arc Welding**:** Electrodes, types of covering, welding techniques for manual welding, power sources, submerged arc welding, gas tungsten arc (GTA) and gas metal arc (GMA) welding, electric slag welding, plasma arc welding. Gas Welding **–** fuel gases, different flame types, filler metal, fluxes and application. Thermit Welding - Process, characteristics and applications
8.	**Resistance Welding:** Spot welding, electrode, nugget size, resistance and force, current and time, types of equipment, rocker arm press type, multiple welding guns and portable welders, applications, seam welding, projection welding, flash and butt welding, applications. **Radiation Welding:** Laser welding, electron beam welding types of electron gun, spot size beam power, operating voltage, pulse technique, deep penetration and applications. **Soldering and Brazing:** Capillary and wetting action, temperature range, filler metals and fluxes, processes and applications, design and strength of joints.

9.	**Weldability of Metals** Solidification of weld metal; heat affected zone (HAZ), factors affecting properties of HAZ; gas-metal, slag-metal and solid-state reactions in welding and their influence on soundness of weld joint; lamellar tearing and hydrogen damage; Weldability; definition, factor affecting the weldability of steel Carbon equivalent. weldability of steel, cast iron and aluminium alloys of commercial importance, failure analysis of welded joints. **Testing and Inspection of Weld Joints** Mechanical test for groove and fillet welds-full section, reduced section and all-weld- metal tensile tests, bend tests, fillet weld break tests, creep & fatigue testing. Non-Destructive Testing of Weldments; Visual inspection; Dye-penetrant inspection; Magnetic particle inspection; Ultrasonic inspection principle of ultrasonic testing, Radiographic inspection –principle of radiography, Standard procedure for specification and qualification of welding procedure; WPS and PQR, WPQ.
	Text Books
1.	P.N. Rao: Manufacturing Technology – Foundry, Forming and Welding, Vol - I, TMH.
2.	Ghosh and Mullick: Manufacturing Science, EW Affiliated
3.	A. S. Athalye: Hand book of Plastics Materials and Processing
	References
1.	B. Ravi: Metal casting Technology, PHI Publication.
2.	P.K. Jain: Principles of Foundry Technology, Tata McGraw Hill Publications.
3.	R. S. Parmar, Welding Technology, Khanna Publications
4	Radhakrishnan: Welding Technology, New Age Publisher
5.	ASM: Handbook Vol. XV

Programme	B. Tech. [Production Engineering]	**Semester -** VI
Course Code	R4PE3009T	
Course Title	Mechatronics and Automation	
Prerequisites	Fluid Mechanics and Machinery	

Course outcomes: On the completion of this course, the learner will able to

1. Formulate and design stable control system.

2. Design hydraulic circuits, pneumatic circuits, electro-pneumatic circuits, electro-hydraulic circuits, Hydro-pneumatic circuits, logic control circuits for industrial applications.

3. Write and execute assembly language program for µController 8051& µp 8085.

4. Draw ladder logic diagram for PLC.

Syllabus

1.	**Automation** Definition, concepts, where, what, how to apply, automation of machining processes, types of automation: low/medium/high cost, hard/flexible automation, semi/fully automated machine tools, special purpose machines, material transfer devices.
2.	**Control System Fundamentals** Control system concepts, classification of control systems, mathematical representation of system equations, derivation of system equations, response characteristics of components and Systems, frequency response analysis, stability of components and systems, root locus method of analysis, feedback control system elements, basic control actions and industrial automatic control.
3.	**Low Cost Automation Using Pneumatics** Operational principles and uses of pneumatic power systems, design and functioning of pneumatic components (compressors, service units, storage tank, control valves, linear and rotary actuators) and basic controls, construction of pneumatic controls and circuit diagrams for conveying, feeding, clamping, indexing, cutting and non/cutting operations; login control system and sequence control, electro pneumatic control and circuit design.

4.	**Logic Gates and Controls** Pneumatic logic gates: AND, OR, NAND and NOR; applications of basic control circuits based on these gates; introduction to the design and mode of operation of programmable logic control, conversion and documentation of control problems into run able PLC programme.
5.	**Electrical Control Devices** Features and design principles of electrical circuits, clutches, brakes, thermal relays, time relays, electrical circuits for machine tools.
	Text Books
1.	Fawcett J R: Pneumatic Circuits and Low-Cost Automation, Trade & Technical Press Ltd.
2.	Festo Series: Fundamentals of Pneumatics.
	References
1.	Mikell Groover: Automation, Production Systems and CIM, PHI.
2.	Pippenger John: Industrial Hydraulics, McGraw-Hill.
3.	Peter Dransfield: Engineering Systems and Automatic Control, Tan Chiang.
4.	S.K.Basu: Design of Machine Tools, Oxford & LBH Publishing Co Pvt. Ltd.
5.	S.N.Verma: Automatic Control System, Khanna Publishers.

Programme	B. Tech. (Production Engineering)	**Semester -** VI
Course Code	R4PE3010T	
Course Title	CAD CAM CIM	
Prerequisites	Manufacturing Technology	

	Course outcomes: On the completion of this course, the learner will able to 1. Describe the fundamental theory and concepts of computer graphics and geometric modeling. 2. Apply 2D, 3D transformation for the manipulation of objects. 3. Explain the basic concepts of NC, CNC machining and create a manual part programs. 4. Describe different manufacturing systems and techniques used in CIM.
	Syllabus
1.	**Computer Aided Design (CAD)** Introduction: History of CAD/CAM development, Definition of CAD/CAM tools, CAD/CAM Hardware and Software – Input and output devices, Need of CAD/CAM. Scan conversion: scan conversion algorithms for lines and circle. 2D & 3D Transformations: Translation, Rotation, Scaling, Mirror reflection, Shearing applied to solid objects. Projections Transformations: parallel, perspective. Curves& Surfaces. Geometric Modeling: Wire frame, Surface and Solid modeling, solid representation schemes such as B- rep, CSG, Feature based modeling, Euler theory etc. Graphics standards: IGES, DXF, STEP, STL, etc.
2.	**Computer Aided Manufacture (CAM)** Introduction: NC, CNC, DNC, Modes, NC Elements, Advantages and Limitations of NC, CNC. Functions of computers in DNC. NC and CNC machine tools: CNC tooling, Tool presetting, ATC, Work holding, Overview of different CNC machining centers, CNC Turning centers, High speed machine tools. CNC Programming: Part program fundamentals, Steps involved in development of a part program, Manual part programming, CAPP: APT Programming in Drilling, Milling & Turning. Introduction to 3 axis and 5 axis CNC machines programming.
3.	**Computer Integrated Manufacture (CIM)** Introduction to Manufacturing Systems, Material handling Systems - AGV, Robots, AS & RS, Group Technology and Cellular Manufacturing, Flexible Manufacturing Systems (FMS).

4.	**Basics of Finite Element Analysis** Introduction, basic concepts, discretization, element types, nodes & degrees of freedom, mesh generation, constraints, loads, preprocessing, application to static analysis.
5.	**Robotics** Fundamentals of robotics, control systems in robotics, robotic end effectors and sensors, robot programming techniques, applications of robotic system.
	Text Books
1.	I. Zeid and R. Sivasubramanian: CAD/CAM Theory and Practice, Tata McGraw Hill.
2.	P.N.Rao: CAD/CAM Principles and Applications, Tata McGraw Hill.
	References
1.	N. Chougule: CAD/CAM/CAE, SciTech Publications.
2.	P.N. Rao, and T. Kundra: Computer Aided Manufacturing, TMH.
3.	Mikell Groover: Automation, Production Systems and Computer Integrated Manufacturing, Prentice -Hall.
4.	J. Reddy: An Introduction to the Finite Element Method, McGraw Hill, New York.
5.	S. Rao: The Finite Element Method in Engineering, Pergamum press, Oxford England.

Programme	B. Tech (Production Engineering)	**Semester -** VI
Course Code	R4PE3011S	
Course Title	MIS and ERP	
Prerequisites	None	

Course Outcomes: On the completion of this course, the learner will able to

1. Demonstrate understanding the role and functions of ERP in carrying out business processes in an industry.
2. Develop the ability to integrate various resources for optimization in the industry as well as for strategic utilization of IT enabled services and functions.
3. Report on the reasons for the success (or failure) of a business strategy in a competitive environment.

Syllabus

1.	**Organizations and Computing** Introduction, Modern Organization-IT enabled- Networked-Dispersed- Knowledge Organization, Information Systems in Organizations- what are information systems?, Brief history of computing-ENIAC: Way to commercial computers- Advent of artificial intelligence- advent of personal computing-Free Software Movement- Advent of Internet, The role of internet- Internet and Web: they are different-the internet changes everything.
2.	**Managing Information Systems in Organizations** Introduction, Managing in the Internet Era, Managing Information Systems in Organization-the IT interaction model, Challenges for the manager-what information to build?-how much to spend on information systems?-what level of capabilities should be created with information systems?-how centralized should the services be?-what security levels are required?-what is technology road map for the organization?
3.	**Data and Information** Introduction, data and information- measuring data, information as a resource, information in organizational functions, types of information technology, types of information systems-transaction processing systems-management information systems
4.	**Decision Making and Communication** Introduction, Decision making with MIS-Tactical decisions-operational decisions-strategic decisions, communication in organizations- types of communication- examples of communications in organizations- decision making with communication technology

5.	**Decision Support Systems** Introduction, Understanding DSS- MIS and DSS-Decision making-types of decisions, Analytics and Business Intelligence- BI techniques
6.	**Managing Data Resources** Introduction , The Need for Data Management- History of data use, Challenges of Data Management- data independence- reduced data redundancy- data consistency- data access- data administration- managing concurrency-managing security- recovery from crashes-application development, Database Concepts- fields, records and files- basic architecture, Data Warehouses-data mining uses
7.	**Managing IT Function** Introduction, Challenges of Managing the IT function- Modern IT environment-Centralization versus Decentralization-IT security-Technology selection, Vendor Management- vendor selection-vendor contracts and service levels-Ongoing relationship management- vendor retention or termination.
8.	**ERP Systems** Overview of enterprise systems – Evolution - Risks and benefits -Fundamental technology - Issues to be consider in planning design and implementation of cross functional integrated ERP systems. Overview of ERP software solutions- Small medium and large enterprise vendor solutions, BPR, Business Engineering and best Business practices - Business process Management. Overview of ERP modules -sales and Marketing, Accounting and Finance, Materials and Production management.
10.	**ERP Implementations** Planning Evaluation and selection of ERP systems- Implementation life cycle - ERP implementation, Methodology and Frame work-Training – Data Migration. People Organization in implementation-Consultants, Vendors and Employees. Maintenance of ERP- Organizational and Industrial impact; Success and Failure factors of and ERP Implementation Emerging Trends in ERP Systems: Extended ERP systems and ERP add-ons - CRM, SCM, Business analytics etc. - Future trends in ERP systems-web enabled, Wireless technologies so on. Case studies on successful and failed ERP implementation.
	Text Books
1.	K. Laudon, C. Traver: Management Information Systems, Prentice Hall Publications.
2.	Alexis Leon: ERP Demystified, Tata McGraw-Hill.

	References
	Management Information Systems by Jaiswal and Mittal, Oxford University Press
	Decision Support Systems and Intelligent Systems by Turban and Aronson, Pearson Education Asia

Programme	B. Tech (Production Engineering)	**Semester -** VI
Course Code	R4PE3008P	
Course Title	Metal Casting and Welding Technology Laboratory	
Prerequisites	Manufacturing Technology	

	Course outcomes: On the completion of this course, the learner will able to 1. Ability to identify, formulate and model a casting. 2. Identify proper material for a casting based upon requirements. 3. Identification of best joining methods for particular application
	List of Experiments/Assignments
1.	Nondestructive testing: Magnetic Inspection Testing
2.	Nondestructive testing: Ultrasonic testing
3.	Temperature measurement using Data logger
4.	Arc welding
5.	Chemical welding process
6.	Various types of joints requirements for welding
7.	Study on plastic Moulding
8.	Assignments based on the topics covered in the theory course
	Text Books
1.	P. Rao, Manufacturing Technology - Foundry, Forming and Welding – Vol - I, McGraw Hill Publications.
2.	P. Jain: Principles of Foundry Technology, Tata McGraw Hill Publications.
3.	B. Ravi: Metal casting Technology, PHI Publication.
	References
1.	ASM: Handbook Vol. XV
2.	Foundrymen's Handbook: The Penton Publishing Company

Programme	B. Tech. [Production Engineering]	**Semester -** VI
Course Code	R4PE3009P	
Course Title	Mechatronics and Automation Lab	
Prerequisites	Fluid Mechanics and Machinery	

	Course outcomes: On the completion of this course, the learner will able to 1. Draw, simulate and troubleshoot various pre-designed industrial circuit using simulation software like Automation Studio and Festo. 2. Test basic circuits on trainers. 3. Write and understand Assembly Language Programming for given applications. 4. Automate the different manual applications.
	List of Experiments
1.	Design and testing of electro-pneumatic circuits using a trainer.
2.	Design and testing of electro-pneumatic circuits using a simulator.
3.	Design and testing of pneumatic circuits using a trainer.
4.	Design and testing of pneumatic circuits using a simulator.
5.	Design and testing of hydraulic circuits using a trainer.
6.	Design and testing of electro-hydraulic circuits using a trainer.
7.	Design and testing of Stability of industrial automatic control.
8.	Testing assembly programming on 8085 µp /8051 µc
9.	Design and testing of PLC ladder logic diagram.
	Assignments
1.	Drawing of at least five industrial circuits.
2.	Stability analysis of industrial automatic control.
3.	Numerical problems based on above topics.
4.	Industrial visit report.

	Training Kits and Simulators
1.	Vickers Hydraulics trainer and simulator.
2.	Festo Pneumatic and PLC trainer and simulator.
3.	Automation Studio Simulator.
4.	8085 µp /8051 µc Kits.
5.	Control Engineering Problem Solver.

Programme	B. Tech. (Production Engineering)	**Semester -** VI
Course Code	R4PE3010P	
Course Title	CAD CAM CIM Lab	
Prerequisites	Manufacturing Technology	

Course outcomes: On the completion of this course, the learner will able to

1. Become an expert user of an advanced CAD/CAM system (Pro-E) the student will be able to efficiently use the system to conduct an entire product development process of middle to large scale project from the very early conceptual design till the final machining G-code generation or rapid prototyping operation, in a team work environment.
2. The student will have a thorough understanding of the fundamental mathematical theories and computer algorithms underlying CAD/CAM/CAE software tools.
3. Attain proficiency in drawing complex components and assembly using software available in markets so that students can use this knowledge directly on employment.

	Syllabus
1.	**Computer Aided Design (CAD)** Create solid components, Assembly, drawing (Drafting) of given components by using Modeling software like Pro-E. Also prepare and present report on it. Write and run a program to draw an entity like line, circle, etc. using DDA algorithm and Bresenham's algorithm. Assignment on 2D, 3D Geometric transformation & Projection transformation. Assignment on geometric design of planar curves and surfaces. Assignment on Product Data Exchange Standards.
2.	**Computer Aided Manufacture (CAM)** Develop CNC program & APT program for given components. Create tool path generation using any CAM package. Assignment on Rapid Prototyping.
3.	**Computer Aided Engineering (CAE)** Analysis exercises using any CAE package.

Professional Elective 1

Programme	B. Tech (Production Engineering)	**Semester** - VI
Course Code	R4PE3101S	
Course Title	Artificial Intelligence and Expert Systems	
Prerequisites	Mathematics for Production Engineers	

Course Outcomes: On the completion of this course, the learner will able to

1. Acquire knowledge of expert system capabilities
2. Develop capability in formulating and solving problems using AI techniques
3. Acquire competency in knowledge representation and inference
4. Demonstrate expertise in machine learning techniques

Syllabus

1.	**Introduction to AI and Production Systems** Introduction to AI-Problem formulation, Problem Definition -Production systems, Control strategies, Search strategies. Problem characteristics, Production system characteristics -Specialized production system- Problem solving methods - Problem graphs, Matching, Indexing and Heuristic functions -Hill Climbing-Depth first and Breath first, Constraints satisfaction - Related algorithms, Measure of performance and analysis of search algorithms.
2.	**Representation of Knowledge** Game playing - Knowledge representation, Knowledge representation using Predicate logic, Introduction to predicate calculus, Resolution, Use of predicate calculus, Knowledge representation using other logic-Structured representation of knowledge.
3.	**Knowledge Inference** Knowledge representation -Production based system, Frame based system. Inference - Backward chaining, Forward chaining, Rule value approach, Fuzzy reasoning - Certainty factors, Bayesian Theory-Bayesian Network-Dempster - Shafer theory.
4.	**Planning and Machine Learning** Basic plan generation systems - Strips -Advanced plan generation systems – K strips -Strategic explanations -Why, Why not and how explanations. Learning- Machine learning, adaptive Learning.

5.	**Expert Systems** Expert systems - Architecture of expert systems, Roles of expert systems - Knowledge Acquisition –Meta knowledge, Heuristics. Typical expert systems - MYCIN, DART, XOON, Expert systems shells.
	Text Books
1.	Kevin Night and Elaine Rich, Nair B., Artificial Intelligence (SIE), Mc Graw Hill
2.	Dan W. Patterson, “Introduction to AI and ES”, Pearson Education, 2007.
	References
1.	Peter Jackson: Introduction to Expert Systems, Pearson Education.
2.	Stuart Russel and Peter Norvig: AI – A Modern Approach, Pearson Education.
3.	Deepak Khemani: Artificial Intelligence, Tata McGraw Hill Education.
4.	http://nptel.ac.in

Programme Name	B. Tech (Production Engineering)	**Semester –** VI
Course Code	R4PE3102S	
Course Title	Dynamics of Machinery	
Prerequisites	Theory of Machines, Strength of Materials	

Course Outcomes:

1. Understand the force-motion relationship in components subjected to external forces.
2. Analyze balancing problems in rotating and reciprocating machinery.
3. Model a physical system of vibration.
4. Estimate and evaluate response for the system.
5. Analyze and design governors and dynamometers.

Syllabus

1. **Force Analysis**

Static Analysis- Static equilibrium, Equilibrium of two and three force members, Members with two forces and torque, Free body diagrams, Principle of virtual work.

Dynamic Analysis- D' Alembert's principle, Equivalent offset inertia force, Dynamic analysis of four bar mechanism, Dynamic Analysis of reciprocating engines - Piston effort, Crank effort, turning moment on crankshaft, Inertia of connecting rod, Inertia force in reciprocating engines (Graphical method).

2. **Balancing**

Static and Dynamic balancing of rotating masses, balancing of reciprocating masses, Balancing of locomotives, Partial balancing of reciprocating masses, Multi cylinder Inline and radial engines. Inertia effect of crank and connecting rod, single cylinder engine, balancing in multi cylinder-inline engine (primary & secondary forces), V-type engine; Radial engine – Direct and reverse crank method.

3. **Single Degree Free Vibration**

Basic features of vibration system, Degrees of freedom, static equilibrium position, longitudinal, Transverse, and torsional vibrations, Equation of Motion, Natural frequency, Different types of damping, Effect of damping on vibrations, Damped Vibration, conversion of multi springs - multi masses - multi dampers into single spring mass and dampers with linear or rotational co-ordinate system, logarithmic decrement.

4.	**Forced Vibration** Sources of Excitation, Response of one-degree freedom systems to periodic forcing, response of unbalance rotating and reciprocating masses, Support motion – absolute motion, relative motion, forced vibration with damping, transmissibility, Vibration isolation, vibration measurement, Vibration sensors: seismometer and Accelerometers, Introduction to FFT analyzer, Whirling of shafts with single rotor.
5.	**Multi Degree Vibration** Vibration of undamped two degrees system, Concepts of normal mode vibrations, natural frequencies, mode shapes, nodes, Dunkerley's method, Rayleigh's method, Holzer Method, Eigen values, Eigen vectors, Matrix method, Orthogonality principle, Matrix Iteration Method, Torsional Vibration of two - three – multi rotor system.
6.	**Governors** Introduction, types of governors, characteristics of centrifugal governors, gravity controlled and spring controlled centrifugal governors, hunting of centrifugal governors, inertia governors. Dynamometers: types of dynamometers, Prony brake, rope brake and band brake dynamometers, belt transmission dynamometer, torsion dynamometer, hydraulic dynamometer.
	Text Books
1.	P.L. Ballaney: Theory of Machines and Mechanisms, Khanna Publications.
2.	Sadhu Singh: Theory of Machines, Pearson Publications
3.	G. K. Grover: Mechanical Vibrations, Nem chand and Bros.
4.	S.S. Rattan: Theory of Machines, McGraw-Hill Education (India) Private Limited.
	References
1.	S. Graham Kelly: Schaum's Outline of Theory and Problems of Mechanical Vibrations, Tata McGraw-Hill Publication.
2.	Thomas Bevan: Theory of Machines, CBS Publishers and Distributors.
3.	Amitabha Ghosh and A. Mallick: Theory of Mechanisms and Machines, Affiliated East-West Pvt. Ltd., New Delhi.
4.	Joseph Shigley, G.R Pennock and John Uicker: Theory of Machines, Oxford University Press.
5.	Robert L. Norton: Dynamics of Machinery, Tata McGraw Hill Publications.
6.	John Hannah and Stephens: Mechanics of Machines, Viva Low-Prices Student Edition.

Programme	B. Tech (Production Engineering)	**Semester -** VI
Course Code	R4PE3103S	
Course Title	Automobile Engineering	
Prerequisites	Engineering Mechanics**,** Applied Thermodynamics	

Course Outcomes: On the completion of this course, the learner will able to

1. Development of understanding of functioning of spark and compression ignition engines
2. To impart the functioning of fuel injection systems
3. Knowledge of different joints used in power transmission
4. Importance of aerodynamics in automobile designs

Syllabus

1. **Introduction**

Introduction, Broad classification of Automobiles, Vehicle Layout & its types, Types of bodies. Engine-parameters, construction, operating cycles. 2-stroke & 4-stroke cycle engines, SI & CI engines, Engine performance & efficiency, valve timing & port timing diagrams

2. **Fuel System**

Conventional fuels, alternative fuels, normal and abnormal combustion, cetane and octane numbers, Fuel mixture requirements for SI engines, Fuel Cell, types of carburetors, multi-point and single point fuel injection systems, fuel transfer pumps, Fuel filters, fuel injection pumps and injectors

3. **Transmission System**

General arrangement of clutch, types & working, Principle of friction clutches, Constructional details, Fluid flywheel, Single plate, multi-plate and centrifugal clutches.

Gear box: Necessity for gear ratios in transmission, synchromesh gear boxes, 3, 4 and 5 speed gear boxes.

Principle of operation of automatic transmission, torque converter. Construction and working of Propeller shaft, Universal joint, Final drive, Differential,

Rear axles.

4.	**Suspension and Steering System** Suspension requirements, Sprung and Un sprung mass, Types of automotive suspension. Systems. Conventional and Independent, Shock absorber, Types of springs, Hotch- kiss and Torque tube drive, Reaction members -Radius rods, Stabilizer bar, Air suspension System. Function of steering, Steering system layout, Automotive steering mechanism, Types of steering gear boxes, Condition for true rolling, Steering geometry-Camber, Caster, King pin inclination, Toe-in and Toe-out, Wheel alignment, Slip angle, Under steer & over steer conditions, Introduction of power steering.
5.	**Braking and Electrical System** Purpose & principle of automotive brake system, types of braking system, disc & drum brakes; Mechanical, Hydraulic & Air brake system, Calculation of braking force required, stopping distance and dynamic weight transfer. Automotive batteries, Automotive lighting system, Starting system, Charging system, Voltage and current regulator, Electric horn, Dash board gauges, Wiper & side indicator circuit, Engine electronic control modules-operating modes
6	**Recent Trends in Automobiles** NVH, Automotive emission controls, emission norms, Principle of operation construction-working & application of different types of sensors, Safety in Automobiles, Testing and certification of vehicles. Aerodynamics and ergonomics in automobile designs
	Text Books
1.	Kirpal Singh: Automobile Engineering (Vol I & II), Standard Publishers and Distributors
2.	Joseph Heitner: Automotive Mechanics- Principles & Practices, , CBS Publisher.
	References
1	Donald Anglin and William Crouse: Automotive Mechanics, TMH.
2.	T.R. Banga and Nathu Singh: Automobile Engineering, Khanna Publications
3.	Harbans Singh Reyat: The Automobile, S. Chand Limited
4.	Tom Denton: Automobile Electrical and Electronic Systems, Taylor& Francis

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Programme	B. Tech (Production Engineering)	**Semester:** VI
Course Code	R4PE3104S	
Course Title	Plastics Processing Technology	
Prerequisites	Metal Casting Technology	

Course Outcomes: On the completion of this course, the learner will able to

1. Develop capability to apply knowledge of plastic materials and their properties in selecting the plastics for given applications and working conditions.
2. Select an appropriate, feasible and economical manufacturing process for a given product
3. Acquire competency in select optimal process and parameters and design tooling for manufacturing a given part economically.
4. Demonstrate expertise in construction, service and maintenance of plastics moulding machines.

Syllabus

1. **Overview**

Definition, composition, resins, additives and fillers chemistry of resins; types, chemical, physical, processing and engineering properties of plastics. Manufacturing processes of resins and plastics, raw materials finished forms. Contribution and comparatives performance of plastics in various sectors of business and economy.

2. **Processing of Plastics**

Processes based on type of material, industrial product design and production volume. Casting processes gravity, still casting, continuous casting, and Centrifugal casting. Moulding processes: injection, compression, transfer. Miscellaneous processes: foaming, thermoforming, laminating etc. Joining processes: sealing, welding, adhesive bonding. Continuous extrusion processes for films, sheets, sections, calendaring, laminating etc. Finishing processes: printing, embossing, etc.

3. **Processing Equipment**

For moulding, extrusion, blowing, calendaring, welding, etc; construction, major units, operational and control features, specifications.

4.	**Design of Moulds** For injection, compression and transfer moulding; feeding system, overflows, breathers and vents, cooling/heating of moulds, locking, ejection, mounting of moulds; construction and manufacturing aspects; two / three plate moulds, inserts, mould materials, machining, fabricating of moulds, polishing of cavities. Design of extrusion dies for different shapes, die materials, manufacture, mounting, heating / cooling of dies.
5.	**Product Design** Process, materials and tooling related aspects; specific beneficial (or otherwise) design features vis-à-vis other materials.
	Text Books
1.	R. J. Crawford: Plastics Engineering, Butterworth-Heinemann.
2.	F.W. Billmeyer: Text Book of Polymer Science, John Wiley and Sons.
	References
1.	A.S. Athalye: Plastics Materials Handbook, Multi-tech Publishing Co., Mumbai.
2.	M.V. Joshi: Dies for Plastics Extrusion: Principles of Design and Construction, Macmillan India Publication.
3.	E.C. Berhard: Processing of Thermoplastic Materials, Von Nostrand Reinhold Co.
4.	A.L.Griff: Plastics Extrusion Technology, Von Nostrand Reinhold Co. NY.
5.	I.V. Rubin: Injection Moulding Theory and Practice, John Wiley and Sons.
6.	Butler: Compression and Transfer Moulding, Ilifee and Sons.

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Programme	B. Tech. (Production Engineering)	**Semester - VI**
Course Code	R4PE3105S	
Course Title	Industrial Robotics	
Prerequisites	Theory of Machines	

Course outcomes: On the completion of this course, the learner will able to

1. Discuss the history, concepts and key components of robotics technologies.
2. Describe and compare various robot sensors and their perception principles that enable a robot to analyze their environment, reason and take appropriate actions toward the given goal.
3. Analyze and solve problems in spatial coordinate representation and spatial transformation, robot locomotion, kinematics, motion control, localization and mapping, navigation and path planning.
4. Apply and demonstrate the learned knowledge and skills in practical robotics applications.

Syllabus

1.	**Introduction** Introduction -- brief history, types, classification and usage, Science and Technology of robots, Some useful websites, textbooks and research journals.
2.	**Elements of robots – links, joints, actuators, and sensors** Position and orientation of a rigid body, Homogeneous transformations, Representation of joints, link representation using D-H parameters, Examples of D-H parameters and link transforms, different kinds of actuators – stepper, DC servo and brushless motors, model of a DC servo motor, Types of transmissions, Purpose of sensors, internal and external sensors, common sensors – encoders, tachometers, strain gauge based force-torque sensors, proximity and distance measuring sensors, and vision.
3.	**Kinematics of serial robots** Introduction, Direct and inverse kinematics problems, Examples of kinematics of common serial manipulators, workspace of a serial robot, Inverse kinematics of constrained and redundant robots. Solution procedures using theory of elimination, Inverse kinematics solution for the general 6R serial manipulator.
4.	**Kinematics of parallel robots** Degrees-of freedom of parallel mechanisms and manipulators, Active and passive joints, Constraint and loop-closure equations, Direct kinematics problem, Mobility of parallel manipulators, Closed-from and numerical solution, Inverse kinematics of parallel manipulators and mechanisms, Direct kinematics of Gough-Stewart platform.

5.	**Velocity and static analysis of robot manipulators** Linear and angular velocity of links, Velocity propagation, Manipulator Jacobians for serial and parallel manipulators, Velocity ellipse and ellipsoids, Singularity analysis for serial and parallel manipulators, Loss and gain of degree of freedom, Statics of serial and parallel manipulators, Statics and force transformation matrix of a Gough-Stewart platform, Singularity analysis and statics.
6.	**Dynamics of serial and parallel manipulators** Mass and inertia of links, Lagrangian formulation for equations of motion for serial and parallel manipulators, Generation of symbolic equations of motion using a computer, Simulation (direct and inverse) of dynamic equations of motion, Examples of a planar 2R and four-bar mechanism, Recursive dynamics, Commercially available multi-body simulation software (ADAMS) and Computer algebra software Maple.
7.	**Motion planning and control** Joint and Cartesian space trajectory planning and generation, Classical control concepts using the example of control of a single link, Independent joint PID control, Control of a multi-link manipulator, Nonlinear model based control schemes, Simulation and experimental case studies on serial and parallel manipulators, Control of constrained manipulators, Cartesian control, Force control and hybrid position/force control, Advanced topics in non-linear control of manipulators.
8	**Advances in robotics** Introduction to chaos, Non-linear dynamics and chaos in robot equations, Simulations of planar 2 DOF manipulators, Analytical criterion for unforced motion. Gough-Stewart platform and its singularities, use of near singularity for fine motion for sensing, design of Gough-Stewart platform based sensors. Over-constrained mechanisms and deployable structures, Algorithm to obtain redundant links and joints, Kinematics and statics of deployable structures with pantographs or scissor-like elements (SLE's).
	Text Books
1.	Ashitava Ghoshal: Robotics - Fundamental Concepts and Analysis, OUP.
2.	Spong, Hutchinson, and M. Vidyasagar: Robot Modelling and Control, Wiley.
	References
1.	Craig, J. J.: Introduction to Robotics: Mechanics and Control, Addison-Wesley
2.	Murray Li., and Sastry S.S: A Mathematical Introduction to Robotic Manipulator, CRC Press.
3.	Siciliano, B., and Khatib, O. (Editors), Handbook of Robotics, Springer, 2008.

Programme	B. Tech. [Production Engineering]	**Semester -** VI
Course Code	R4PE3106S	
Course Title	Business Analytics	
Prerequisites	Applied Probability and Statistics	

	Course outcomes: On the completion of this course, the learner will able to 1. Impart the knowledge of data processing techniques 2. Develop a deeper understanding of work study through implementation of method study and work measurement 3. Apply the ergonomic principles for workplace design 4. Formulate and solve business problems and to support managerial decision making
	Syllabus
1.	**Overview of Business Analysis** Origins of business analysis, development of business analysis, scope of business analysis work, holistic approach, role and responsibilities of a business analyst, Competencies of a Business Analyst, visualization
2.	**Predictive Modeling** Classification and predictive modeling, Decision trees as classification tools, Regression Models (Linear & Logistic), Cluster Analysis, Market Basket Analysis
3.	**Statistics for Analytics** Qualitative data and analytics, Multi-Variant Data Analytics, Using SPSS for Data Analytics
4.	**Introduction to Decision Modeling** Role of Optimization to solve business problems (like marketing mix, capital budgeting, portfolio optimization), Use of Simulation Decision Making under Uncertainty (Types of problems: inventory management, capital investment analysis, market share estimation, sensitivity analysis), Heuristics & Meta-Heuristics techniques, Multi-Criteria Decision Systems, Group Decision Support Systems, Analytics in Supply Chain Management
5.	**Data Mining** Introduction to Data Mining, Data Warehousing and OLAP concepts, Data Mining Process, Data mining tool XL Miner, Classification and Regression Trees, Case studies like Market Basket Analysis, Web & Social Media, E- Commerce etc.

6	**Advances in Business Analytics** Tools and technologies for Big data, Internet of Technology (IoT), Cloud Computing. Software tools for analytics like HADOOP, R, Weka, SAS Enterprise Miner, IBM Watson, Tableau etc.
	Text Books
1	Debra Paul, Donald Yeats: Business Analysis, BCS Publishers.
2	Shmueli, Patel, and Bruce: Data Mining for Business Intelligence: Concepts, Techniques, and Applications, Wiley Publications.
3	Shmueli, Bruce, Stephens and Patel: Data Mining for Business Analytics: Concepts, Techniques, and Applications, Wiley Publications.
4	Jay Liebowitz: Business Analytics An Introduction, CRC Press.

Programme	B. Tech [Production Engineering]	**Semester:** VI
Course Code	R4PE3107S	
Course Title	Procurement and Inventory Management	
Prerequisites	Applied Probability and Statistics	

Course Outcomes: On the completion of this course, the learner will able to

1. Appreciate the importance of inventory & the role it plays in the profitability of the company with acquisition of basic knowledge of Materials Management, Inventory Control and Warehousing for both service as well as manufacturing sector
2. Apply practical know-how in application of these concepts in real-time functioning of a firm for cost analysis, decision-making, quality management and value analysis.
3. Use deterministic and probabilistic inventory models to optimize the investment in inventory
4. Employ computers in managing the inventory and global purchasing.

Syllabus

1. **Introduction**

Stocks and inventories. Role of materials management in productivity and value improvement. Purchasing – cost reduction and value analysis, choice and rationalization of materials, purchasing research. Material classification (single- and multi-dimensional), codification and standardization. Simplification for variety reduction. Vendor selection, development, rating; negotiations and purchase, price analysis, organization of purchasing function, product explosion. Buyer supplier relationship. Role of materials management in production organizations.

2. **Procurement System**

Strategic outsourcing: Make or buy decision. Sourcing. Pre-purchase System. Ordering. Post purchase activity. Price forecasting and analysis. Total cost of ownership. Purchasing under uncertainty vendor development and evaluation. Purchase negotiation and pricing. Purchasing of Capital Equipment. Tendering. Purchase Vs Lease. Equipment procurement Import Substitution. Import Regulations and procedures Legal aspects of purchasing.

E-commerce: exchanges, hubs and market places.

Materials Control: Acceptance sampling, vendor certification plans, vendor reliability

3.	**Public Buying** Buying procedures related to various Governmental organizations like D.G.S&D Registration of suppliers. Rate and Running Contracts. Indenting procedures Materials Planning: Make or buy decision.
4.	**Warehousing and Stores Management** Purchase of Stores location and layout. Various types of stores. Stores Procedures. Stores Accounting and Stock checking Management of Scrap: Obsolete, damaged & unwanted stocks.
5.	**Inventory Management for Independent Demand** Sources of information and demand forecasting and estimation. Selective inventory management techniques (ABC, FSN, SDE etc). Classification of inventory models. Periodic and continuous review system. Relevant cost and optimization models – Models for independent demand-known demand and single item – EOQ, EBQ, EPQ with and without stockout. Models with quantity discount. Safety stock calculations with positive LT and two bin systems. Models for coordinated delivery system. Inventory models with uncertain demand – models in probabilistic, fuzzy demand environment. Newsvendor model with extensions.
6	**Inventory Management for Dependent Demand** Production schedule. Bill of materials (BOM).Materials requirement planning. Just in Time and Kanban.
7	**Logistics Management** Introduction, evolution of Logistics Elements of Logistics Management. Customer Order Processing, Transportation Management: Distribution Strategies – Cross Docking, Milk Runs, Direct Shipping, Hub and Spoke Model, Pool Distribution. Packaging for Logistics: Concept, Requirements, Trends of Packaging, Functionality Participants, Transportation Formats, Private Fleet, Modes of transportation, Decision Factors, Transport Documentation. Service innovation, Inter-modal Transportation Mode, Containerization, RFID Third – Party Logistics (TPL/3PL), Operations of Indian 3PLs Fourth-Party Logistics (4PL)
	Text Books
1.	K.S. Menon: Purchasing and Materials Management, A.H. Wheeler Publications.
2.	David Burt, Donald Dobbler and Stephen Starling: World Class Supply Management, TMH

	References
1.	Donald Bowersox, David Closs, and Bixby Cooper: Supply Chain Logistics Management, McGraw Hill Publishing.
2.	Gopalakrishnan: Purchasing and Materials Management, Prentice Hall India (PHI).
3.	Gopalakrishnan and Sudarshan: Materials Management –an Integrated Approach, PHI
4.	Donald Waters: Inventory control and management, John Wiley and Sons.
5.	Logistics Management: James Stock and Douglas Lambert. McGraw Hill International
6.	Axsäter Sven: Inventory Control, Springer International Publishing.
7.	Paul Zipkin: Foundations of Inventory Management, McGraw-Hill Higher Education
8.	Tony Arnold, Stephen Chapman and Lloyd Clive: Introduction to Materials Management, Pearson Learning
9.	John Toomey: Inventory management- principles, concepts, techniques, Springer US.

Open Elective 1

Programme	B. Tech (All Branches)	**Semester** - VI
Course Code	R4PE3601S	
Course Title	Project Management	
Prerequisites	None	

	Course Outcomes: On the completion of this course, the learner will able to 1. Demonstrate the fundamental principles of project management. 2. Analyse the feasibility of project. 3. Apply the software tools for project implementation. 4. Evaluate the performance of the project.
	Syllabus
1.	**Background of Project Management** Elements of project, project tasks, evolution of project management, the need of project management, characteristics of projects, characteristics of project management, Projects in contemporary organizations, phases of projects. Project success criteria, skills of project managers.
2.	**Project Selection and Appraisal** Brainstorming and concept evolution, Project selection and evaluation, Selection criteria and models, Types of appraisals, SWOT analysis, Cash flow analysis, Payback period, and Net present value. Project risk analysis.
3.	**Project Organization and Planning** Project manager, Cross-functional team, Dedicated project organization, Influence project organization, Matrix organization, Advantages and disadvantages of project organizations, Selection of project organization, Work Breakdown Structure (WBS), Integration of project organization and WBS, WBS and responsibility matrix. Project scheduling, project monitoring.
4.	**Project Scheduling and Resource Management** Gantt chart, Milestone chart, Network techniques: PERT and CPM, AON and AOA representation, Three time estimates, Using probability distributions for time computation, Probability of project completion, Time scale version of network, Early start and late start schedules, Resource allocation, Resource loading and levelling, Constrained resource scheduling, Multi-project scheduling and resource allocation, Crashing a project. Procurement in projects.

5.	**Project Risk Analysis** Different methods of project risk evaluation and analysis.
6.	**Project Cost and Financing** Controlling of project cost, project financing, financial control of projects, project termination, conflict resolution and application of ICT in project management.
7.	**Computerized Project Management** Computerized PMIS, Choosing software for project management, using software for project management. Case studies in project management in specific industries such as Electrical industry, Electronics industry, IT/ITeS industry, Manufacturing industries, fashion industries, infrastructure sector, etc.
	Text Books
1.	John Nicholas, Project Management for Business and technology: Principles and Practice. Pearson Prentice Hall, New Delhi.
2.	Shtub, Bard and Globerson : Project Management: Engineering, Technology, and Implementation, PHI.
	References
1.	A Guide to the Project Management Body of Knowledge (PMBOK Guide) Latest Edition. PMI.
2.	Horald Kerzner : Project Management - A Systemic Approach to Planning, Scheduling and Controlling, CBS Publishers.
3.	L.S. Srinath: PERT and CPM: Principles and Applications, Affiliated East West Press Ltd.
4.	Choudhury: Project Scheduling and Monitoring in Practice.
5.	K. Joy: Total Project Management: The Indian Context, Macmillan India Ltd.