
Dr. Babasaheb Ambedkar Technological University, Lonere

Dr. Babasaheb Ambedkar Technological University (Established as University of Technology in
the State of Maharashtra)

(Under Maharashtra Act No. XXIX of 2014)

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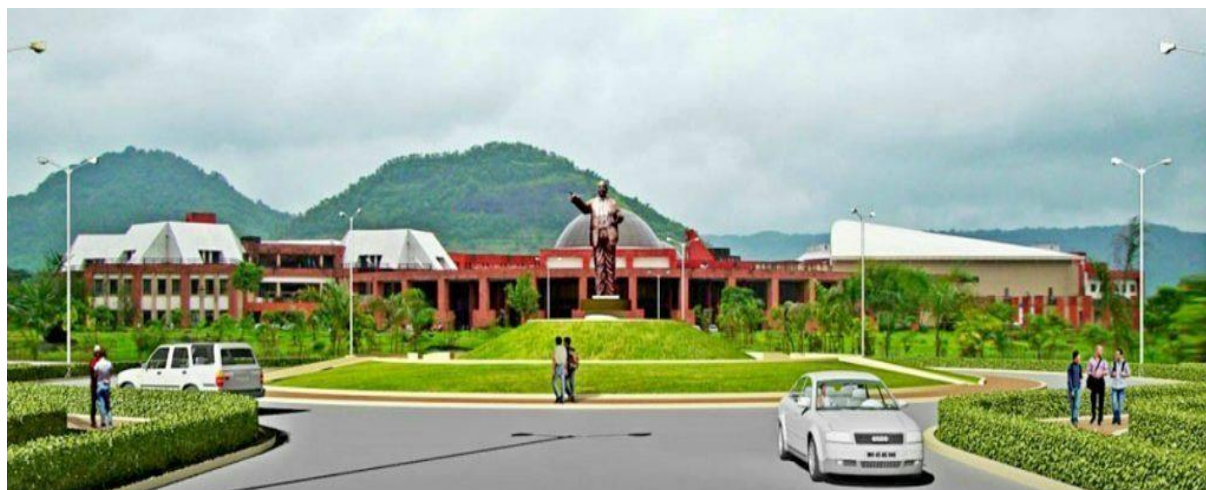
CURRICULUM

UNDER GRADUATE PROGRAMME

B.TECH

2nd and 3rd year PRODUCTION ENGINEERING

ACADEMIC YEAR
2022-2023



Abbreviations

BSC: Basic Science Course

ESC: Engineering Science Course

PCC: Professional Core Course

PEC: Professional Elective Course

OEC: Open Elective Course

HSSMC: Humanities and Social Science including Management Courses

PROJ: Project work, seminar and internship in industry or elsewhere

**Course Structure for Semester III
B.Tech in Production Engineering
(2022-23)**

Semester III										
Course Category	Course Code	Course Title	Teaching Scheme			Evaluation Scheme				Credit
			L	T	P	CA	MSE	ESE	Total	
BSC7	BTBS301	Engineering Mathematics – III	3	1	-	20	20	60	100	4
PCC 1	BTMC302	Fluid Mechanics	3	1	-	20	20	60	100	4
PCC 2	BTAC303	Engineering Thermodynamics and heat transfer	3	1	--	20	20	60	100	4
ESC10	BTMES304	Materials Science and Metallurgy	3	1	-	20	20	60	100	4
PCC3	BTMCL305	Machine Drawing and CAD Lab	-	-	4	60	-	40	100	2
PCC4	BTPCL306	Production Engineering Lab I	-	-	6	60	-	40	100	3
PROJ-2	BTES209P (IT – 1)	IT – 1 Evaluation	-	-	-	-	-	100	100	1
Total			12	4	10	200	80	420	700	22

Semester IV

**Course Structure for Semester IV
B.Tech in Production Engineering
(2022-23)**

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Course Category	Course Code	Course Title	Teaching Scheme			Evaluation Scheme				Credit
			L	T	P	CA	MSE	ESE	Total	
PCC 5	BTPC401	Casting & Moulding Technology	3	1	-	20	20	60	100	4
PCC 6	BTPC402	Theory of Machines	3	1	-	20	20	60	100	4
HSSMC3	BTHM403	Basic Human Rights	3	-	-	20	20	60	100	3
ESC11	BTMES404	Strength of Materials	3	1	-	20	20	60	100	4
PEC 1	BTMPE405	Elective-I	3	-	-	20	20	60	100	3
PCC7	BTPCL406	Production Engineering Lab II	-	-	4	60	-	40	100	2
PROJ-3	BTPI407 (IT – 2)	Field Training / Industrial Training (minimum of 4 weeks which can be completed partially in third semester and fourth semester or in at one time).	-	-	-	-	-	-	-	Credits to be evaluated in V Sem.
Total			15	3	6	220	100	380	700	21

Elective I

Sr. No.	Course code	Course Name
1	BTMPE405A	Numerical Methods in Mechanical Engineering
2	BTMPE405B	Sheet Metal Engineering
3	BTMPE405C	Fluid Machinery

Course Structure for Semester V B.Tech in Production Engineering (2022-23)

Semester V										
Course Category	Course Code	Course Title	Teaching Scheme			Evaluation Scheme				Credit
			L	T	P	CA	MSE	ESE	Total	

Dr. Babasaheb Ambedkar Technological University, Lonere

PCC 8	BTPC501	Design of Machine Elements	3	1	--	20	20	60	100	4
PCC 9	BTPC502	Metal Forming Processes	3	1	--	20	20	60	100	4
PCC 10	BTPC503	Joining Technology	3	1	-	20	20	60	100	4
PEC 2	BTMPE504/ BTAPE504	Elective-II	3	-	-	20	20	60	100	3
OEC 1	BTMOE505	Open Elective-I	3	-	-	20	20	60	100	3
PCC11	BTPC6	Metrology and Quality control	3	1	-	20	20	60	100	4
PCC12	BTPCL507	Production Engineering Lab III	-	-	4	60	-	40	100	2
PROJ-3	BTPI407 (IT – 2)	IT – 2 Evaluation	-	-	-	-	-	100	100	1
Total			18	4	4	180	120	500	800	25

Elective II

Sr. No.	Course code	Course Name
1	BTMPE504A	Refrigeration and Air conditioning
2	BTMPE504C	Engineering Tribology
3	BTAPE504A	Fundamental of Automobile Design
4	BTAPE504D	Automobile Engineering

Open Elective I

Sr. No.	Course code	Course Name
1	BTMOE505A	Solar Energy
2	BTMOE505B	Renewable Energy Sources
3	BTMOE505C	Human Resource Management
4	BTMOE505D	Product Design Engineering

Course Structure for Semester VI B.Tech in Production Engineering (2022-23)

Semester VI					
Course	Course Code	Course Title	Teaching Scheme	Evaluation Scheme	Credit

Dr. Babasaheb Ambedkar Technological University, Lonere

Category			L	T	P	CA	MSE	ESE	Total	
PCC 12	BTPC601	Machine Tools and Metal Cutting	3	1	--	20	20	60	100	4
PCC 13	BTPC602	CAD/CAM/CIM	3	1	--	20	20	60	100	4
PEC 3	BTPPE603 BTMPE603 BTAPE603	Elective-III	3	-	-	20	20	60	100	3
PEC 4	BTPPE604 BTMPE604 BTAPE604	Elective-IV	3	-	-	20	20	60	100	3
OEC 2	BTMOE605	Open Elective-II	3	-	-	20	20	60	100	3
PCC14	BTPCL606	Production Engineering Lab IV	-	-	4	60	-	40	100	2
PROJ-4	BTPS607	B Tech Seminar	-	-	2	60	-	40	100	1
PROJ-5	BTPP608	Mini Project – 2	-	-	2	60	-	40	100	1
PROJ-6	BTPI609 (IT – 3)	Field Training / Industrial Training (minimum of 4 weeks which can be completed partially in third semester and fourth semester or in at one time).	-	-	-	-	-	-	-	Credits To be evaluated in VII Sem.
Total			15	2	8	280	100	420	800	21

Elective III:

Sr. No.	Course code	Course Name
1	BTPPE603A	Robotics & Automation
2	BTPPE603B	Assembly Planning & Management
3	BTMPE603A	IC Engines
4	BTMPE603B	Mechanical Vibrations
5	BTMPE603C	Machine Tool Design
6	BTAPE603C	Automobile Body Design (Pre-requisite: Automobile Design)

Elective IV:

Sr. No.	Course code	Course Name
1	BTPPE604A	Production Planning and Control

2	BTPPE604B	Flexible Manufacturing Systems
3	BTMPE604A	Process Equipment Design
4	BTMPE604B	Product Life Cycle Management
5	BTMPE604C	Finite Element Method
6	BTAPE604B	Computational Fluid Dynamics

Open Elective II:

Sr. No.	Course code	Course Name
1	BTMOE605A	Quantitative Techniques and Project Management
2	BTMOE605B	Nanotechnology
3	BTMOE605C	Energy Conservation and Management
4	BTMOE605D	Wind Energy
5	BTMOE605E	Introduction to Probability Theory and Statistics

Semester III Engineering Mathematics-III

BTBS301	BSC 7	Engineering Mathematics-III	3-1-0	4 Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week Tutorial: 1hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	
CO2	
CO3	
CO4	
CO5	
CO6	
CO7	

CO8	
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Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												
CO7												
CO8												

Course Contents:

Unit 1: Laplace Transform

Definition – conditions for existence ; Transforms of elementary functions ; Properties of Laplace transforms - Linearity property, first shifting property, second shifting property, transforms of functions multiplied by t^n , scale change property, transforms of functions divided by t , transforms of integral of functions, transforms of derivatives ; Evaluation of integrals by using Laplace transform ; Transforms of some special functions- periodic function, Heaviside-unit step function, Dirac delta function.

[09 Hours]

Unit 2: Inverse Laplace Transform

Introductory remarks ; Inverse transforms of some elementary functions ; General methods of finding inverse transforms ; Partial fraction method and Convolution Theorem for finding inverse Laplace transforms ; Applications to find the solutions of linear differential equations and simultaneous linear differential equations with constant coefficients.

[09 Hours]

Unit 3: Fourier Transform

Definitions – integral transforms ; Fourier integral theorem (without proof) ; Fourier sine and cosine integrals ; Complex form of Fourier integrals ; Fourier sine and cosine transforms ; Properties of Fourier transforms ; Parseval’s identity for Fourier Transforms.

[09 Hours]

Unit 4: Partial Differential Equations and Their Applications

Formation of Partial differential equations by eliminating arbitrary constants and functions; Equations solvable by direct integration; Linear equations of first order (Lagrange’s linear equations); Method of separation of variables – applications to find solutions of one dimensional heat flow equation $\left(\frac{\partial u}{\partial t} = c^2 \frac{\partial^2 u}{\partial x^2}\right)$, and one dimensional wave equation (i.e. $\frac{\partial^2 y}{\partial t^2} = c^2 \frac{\partial^2 y}{\partial x^2}$).

[09 Hours]

Unit 5: Functions of Complex Variables

Analytic functions; Cauchy- Riemann equations in Cartesian and polar forms; Harmonic functions in Cartesian form; Cauchy's integral theorem; Cauchy's integral formula; Residues; Cauchy's residue theorem (All theorems without proofs). **[09 Hours]**

Text Books

1. Higher Engineering Mathematics by B. S. Grewal, Khanna Publishers, New Delhi.
2. Higher Engineering Mathematics by H. K. Das and Er. Rajnish Verma, S. Chand & CO. Pvt. Ltd., New Delhi.
3. A course in Engineering Mathematics (Vol III) by Dr. B. B. Singh, Synergy Knowledgeware, Mumbai.
4. Higher Engineering Mathematics by B. V. Ramana, Tata McGraw-Hill Publications, New Delhi.

Reference Books

1. Advanced Engineering Mathematics by Erwin Kreyszig, John Wiley & Sons, New York.
2. A Text Book of Engineering Mathematics by Peter O' Neil, Thomson Asia Pte Ltd. , Singapore.
3. Advanced Engineering Mathematics by C. R. Wylie & L. C. Barrett, Tata McGraw-Hill Publishing Company Ltd., New Delhi.
4. Integral Transforms and their Engineering Applications by Dr. B. B. Singh, Synergy Knowledgeware, Mumbai.
5. Integral Transforms by I. N. Sneddon, Tata McGraw-Hill, New York.

General Instructions:

1. The tutorial classes in Engineering Mathematics-III are to be conducted batchwise. Each class should be divided into three batches for the purpose.
2. The internal assessment of the students for 20 marks will be done based on assignments, surprise tests, quizzes, innovative approach to problem solving and percentage attendance.
3. The minimum number of assignments should be eight covering all topics.

Fluid Mechanics

BTMC302	PCC 1	Fluid Mechanics	3-1-0	4 Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03 hrs)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Define fluid, define and calculate various properties of fluid
CO2	Calculate hydrostatic forces on the plane and curved surfaces and explain stability of floating bodies
CO3	Explain various types of flow. Calculate acceleration of fluid particles
CO4	Apply Bernoulli's equation and Navier-Stokes equation to simple problems in fluid mechanics
CO5	Explain laminar and turbulent flows on flat plates and through pipes
CO6	Explain and use dimensional analysis to simple problems in fluid mechanics
CO7	Understand boundary layer, drag and lift

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1							1
CO2	3	3	1	1	1							1
CO3	3	3	1	1	1							1
CO4	3	3										1
CO5	3	3										1
CO6	2	3										1
CO7	2	3										1

Course Contents:

Unit 1: Basics [06 Hours]

Definition of fluid, fluid properties such as viscosity, vapour pressure, compressibility, surface tension, capillarity, Mach number etc., pressure at a point in the static mass of fluid, variation of pressure, Pascal's law, pressure measurement by simple and differential manometers using manometric expression.

Unit 2: Fluid Statics [06 Hours]

Hydrostatic forces on the plane and curved surfaces, centre of pressure, Buoyancy, centre of buoyancy, stability of floating bodies, metacentre and metacentric height its application in shipping.

Unit 3: Fluid Kinematics [08 Hours]

Velocity of fluid particle, types of fluid flow, description of flow, continuity equation, Coordinate freeform, acceleration of fluid particle, rotational and irrotational flow, Laplace's equation in velocity potential and Poisson's equation in stream function, flownet.

Unit 4: Fluid Dynamics [10 Hours]

- a) Introduction to boundary layer theory and its analysis.
- b) Momentum equation, development of Euler's equation, Introduction to Navier-Stokes equation, Integration of Euler's equation to obtain Bernoulli's equation, Bernoulli's theorem, Application of Bernoulli's theorem such as venturimeter, orificemeter, rectangular and triangular notch, pitot tube, orifices, etc.
- c) Laminar Flow- Flow through circular pipe, between parallel plates, Power absorbed in viscous flow in bearings, loss of head due to friction in viscous flow.

Unit 5: Turbulent Flow and Dimensional Analysis [10 Hours]

- a) Turbulent Flow: Reynolds's experiment, frictional loss in pipe flow, shear stress in turbulent flow, major and minor losses, HGL and TEL, flow through series and parallel pipes.
- b) Dimensional Analysis: Dimensional homogeneity, Raleigh's method, Buckingham's theorem, Model analysis, similarity laws and dimensionless numbers.
- d) Forces on Submerged bodies: Drag, lift, Drag on cylinder, Development of lift in cylinder.

Texts:

1. P. N. Modi, S. M. Seth, “Fluid Mechanics and Hydraulic Machinery”, Standard Book House, 10th edition, 1991.
2. Robert W. Fox, Alan T. McDonald, “Introduction to Fluid Mechanics”, John Wiley and Sons, 5th edition.

References:

1. V. L. Streeter, K. W. Bedford and E. B. Wylie, “Fluid Dynamics”, Tata McGraw-Hill, 9th edition, 1998.
2. S. K. Som, G. Biswas, “Introduction to Fluid Mechanics and Fluid Machines”, Tata McGraw Hill, 2nd edition, 2003.

Engineering Thermodynamics & Heat Transfer

BTAC303	Thermodynamics & Heat Transfer	PCC 2	3L-1T-0P	4 Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week Tutorial: 1 hrs/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Course Contents:

Unit 1: Elementary Thermodynamics [08 Hours]

Basics of Thermodynamics, Ideal gas Laws, First Law of Thermodynamics, Steady Flow Energy Equation, Carnot Cycle, reverse Carnot Cycle, Second Law of Thermodynamics, Concept of refrigeration, Heat Pump and Heat Engine.

Unit 2: Vapor Power Cycles [08 Hours]

Vapour power cycles Steam Generation and its properties, Measurement of dryness fraction, Carnot Cycle, Application of Gas laws to vapour processes. Ideal Rankine Cycle, Calculation of Thermal Efficiency, Specific Steam Consumption, Work ratio.

Steam Turbines: Types, construction, working, compounding, velocity diagram, & diagram efficiency (No numerical).

Unit 3: Fuels and Fundamentals of Combustion[08 Hours]

Solid, Liquid and gaseous fuels, Combustion equations, analysis of product of combustion, gravimetric and volumetric analysis, theoretical air, excess air and exhaust gas produced.

Unit 4: I. C. Engines[08 Hours]

Air standard Otto, Diesel cycles(Elementary Numerical treatment), classifications of ICE and systems of I.C. engines such as fuel supply system for SI & CI engines, ignition system, cooling system, lubrication system, Performance of IC Engine –Indicated power, Brake power, Thermal efficiency, Specific fuel consumption(Elementary Numerical).

Unit 5: Heat Transfer[08 Hours]

Introduction and Basic Concepts of Conduction: Application areas of heat transfer in manufacturing and machine tools, Modes and Laws of heat transfer, thermal conductivity, thermal diffusivity, Heat conduction in plane wall, composite slab, composite cylinder, composite sphere, electrical analogy, concept of thermal resistance, overall heat transfer coefficient, conduction, critical radius of insulation for cylinders and spheres, economic thickness of insulation. (Elementary numerical)

Fundamentals of convection: Concept Laminar and turbulent flow, Reynold Number, Prandlt number, Grashoff number, Nusselt Number. Mechanism of natural and forced convection, local and average heat transfer coefficient, concept of velocity & thermal boundary layers.

Fundamentals of Radiation: Fundamental concepts of radiation, different laws of radiation, Concept of: shape factor, radiation between two black and diffuse gray surfaces and radiation shields. (No numerical)

Texts:

1. R.K. Rajput, “Thermal Engineering”, Laxmi Publications.
2. R. S. Khurmi and Gupta, “Thermal Engineering”, S. Chand Publication.

References:

1. S.P. Sukhatme, “Heat Transfer”, Orient Longman.
2. Y.A. Cengel, “Thermodynamics – an Engineering approach” Tata McGraw Hill.
3. Eastop, A. Mc’conkey, “Applied Thermodynamics”, Pearson Publishers.
4. Holman J.P., “Heat Transfer”, Tata McGraw Hill.

Material Science and Metallurgy

BTMES304	ESC10	Materials Science and Metallurgy	3-1-0	4 Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03 hrs)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Study various crystal structures of materials
CO2	Understand mechanical properties of materials and calculations of same using appropriate equations
CO3	Evaluate phase diagrams of various materials
CO4	Suggest appropriate heat treatment process for a given application
CO5	Prepare samples of different materials for metallography

CO6	Recommend appropriate NDT technique for a given application
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Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1									
CO2	3	2	2	3	2							
CO3	2	1	2	1	1							
CO4	1	2	2	1	2	1	2	1	1	1		
CO5	1	1	1	3	2		1		1			
CO6	1	1	2	2	2	1	2		1	1		

Course Contents:

Unit 1: Fundamentals

a) Structure of Materials [15 Hours]

Crystal structures, indexing of lattice planes, Indexing of lattice directions, Imperfections in crystals-point defects, line defects, surface and bulk defects, Mechanism of plastic deformation, deformation of single crystal by slip, plastic deformation of polycrystalline materials.

b) Mechanical Properties and their Testing

Tensile test, engineering stress-strain curve, true stress-strain curve, types of stress-strain curves, compression test, bend test, torsion test, formability, hardness testing, different hardness tests-Vickers, Rockwell, Brinell, Impact test, fatigue test, creep test.

Unit 2: Equilibrium Diagrams [09 Hours]

Definitions of terms, rules of solid-solubility, Gibb's phase rule, solidification of a pure metal, plotting of equilibrium diagrams, lever rule, Iron-iron carbide equilibrium diagram, critical temperatures, solidification and microstructure of slowly cooled steels, non-equilibrium cooling of steels, property variation with microstructures, classification and application of steels, specification of steels, transformation products of austenite, TTT diagram, critical cooling rate, CCT diagram.

Unit 3: Heat Treatment [07 Hours]

Heat treatment of steels, cooling media, annealing processes, normalizing, hardening, tempering, quenching and hardenability, surface hardening processes-nitriding, carbo-nitriding, flame hardening, induction hardening.

Unit 4: Metallography [08 Hours]

Microscopy, specimen preparation, polishing abrasives and cloths, specimen mounting, electrolytic polishing, etching procedure and reagents, electrolytic etching, optical metallurgical microscope, macroscopy, sulphur printing, flow line observations, examination of fractures, spark test, electron microscope.

Unit 5: Strengthening Mechanisms and Non-destructive Testing [08 Hours]

Refinement of grain size, cold working/strain hardening, solid solution strengthening, dispersion

strengthening, Precipitation hardening. Magnetic particle inspection, dye Penetrant inspection, ultrasonic inspection, radiography, eddy current testing, acoustic emission inspection.

Texts:

1. V. D.Kodgire, S.V.Kodgire, “Material Science and Metallurgy for Engineers”, Everest Publishing House, Pune, 24thedition, 2008.
2. W. D.Callister, “Materials Science and Engineering: An Introduction”, John Wiley and Sons, 5thedition,2001.
3. V.Raghvan, “Material Science Engineering”, Prentice Hall of India Ltd., 1992.

References:

1. V. B.John, “Introduction to Engineering Materials”, ELBS, 6thedition, 2001.
2. G. F.Carter, D. E.Paul, “Materials Science and Engineering”, ASM International, 3rd edition, 2000.
3. T. E.Reed-Hill, R.Abbaschian, “Physical Metallurgy Principles”, Thomson, 3rdedition

Machine Drawing and Computer Aided Drafting Lab

BTMCL305	PCC3	Machine Drawing and Computer-aided Drafting Lab	0-0-4	2 Credits
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Practical Scheme:	Examination Scheme:
Practical: 4 hrs/batch	Continuous Assessment: 60 Marks External Exam: 40 Marks

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Draw Conventional representation of standard machine components, welds, material etc.
CO2	Draw sectional view of a given machine component.
CO3	Develop Assemble view from details of given component i.e. valve, pump, machine tool part, etc.
CO4	Combine details of given machine component and draw assembled view.
CO5	Use various Auto-Cad commands to draw orthographic projection

CO6	Draw sectional view from pictorial view of given machine component using Auto-Cad
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Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1		1				1			
CO2	2	1	1		1				1			1
CO3	3	1	1		1				2	1		2
CO4	3	1	1		1				2	1		1
CO5	2	1	1		2				2	2		1
CO6	1	1	1		1				1	1		1

Course Contents:

Unit 1: Sectional Views [04 Hours]

Full section, half section, partial section, off-set section, revolved sections, removed sections, auxiliary section, guidelines for hatching, examples on all above types of sections of machine elements.

Unit 2: Study of Machine Elements [04 Hours]

Study of simple machine elements and components such as screwed fasteners, shaft couplings, pipe joints, riveted and welded joints, bearings, gears, etc.

Unit 3: Interpenetration of Surfaces (Emphasis on Applied Cases)[04 Hours]

Line or curve of intersection of two penetrating cylinders, Cone and cylinder, prism and a cylinder, cone and prism, Forged ends, etc.

Unit 4: Drawing of Assembly and Details [04 Hours]

Part drawing of standard machine components such as valves, components of various machine tools, pumps, shaft couplings, joints, pipe fittings, engine parts, etc.

Production Drawing and Reading Blue Prints [04 Hours]

Types of production drawings, size, shape and description; limits, fits and tolerances, surface roughness and surface roughness symbols, reading the blue prints.

Unit 5: Computer Aided Drafting [04 Hours]

Introduction to Computer Aided Design and Drafting, Advantages of CADD, study of preliminary AutoCAD commands like drawing, dimensioning, viewing commands. Drawing 3D views in AutoCAD, Introduction to AutoLISP programming.

List of Practical's/ Experiments/ Assignments (minimum six assignments should be completed)

1. One full imperial drawing sheet consisting the drawing/sketches of representation of standard components, symbols of pipe joints, weld joints, rivet joint etc., surface finish symbols and grades, limit, fit and tolerance sketches.
2. Two full imperial drawing sheets, one consisting of assembly and the other consisting of details of any one standard component such as valves, components of various machine tools, pumps, joints, engine parts, etc.
3. Two assignment of AutoCAD: Orthographic Projections of any one simple machine component such as bracket, Bearing Housing or Cast component for Engineers such as connecting rod, Piston, etc.; with dimensioning and detailing of three views of components.
4. 3-D model at least one simple machine component.

Texts:

1. N. D. Bhatt, "Engineering Drawing", Charotar Publishing House, Anand, India.
2. N. D. Bhatt, "Machine Drawing", Charotar Publishing House, Anand, India.
3. Ajeet Singh, "Working with AutoCAD 2000", Tata McGraw Hill, New Delhi.
4. George Omura, "ABC of AutoLISP", BPB Publications, New Delhi.

References:

1. Narayana, Kannaiah, Reddy, "Machine Drawing", New Age International Publishers.
2. AutoCAD and AutoLISP manuals from Autodesk Corp. U.S.A.
3. ISCode: SP46-1988, Standard Drawing Practices for Engineering Institutes.

Production Engineering Lab I

BTPCL306	PCC4	Production Engineering Lab I	0-0-6	3Credit
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Practical Scheme:	Examination Scheme:
Practical: 6hrs/batch	Continuous Assessment: 60 Marks External Exam: 40 Marks

List of Practical's/ Experiments/ Assignments (Any 4 from Group-A, Any 3 from Group-B and Any 3 from Group-C)

Group-A (Fluid Mechanics)

1. Flow visualization technique: characteristics of laminar and turbulent flow patterns using Helleshaw Apparatus.
2. Verification of Bernoulli's theorem
3. Determination of Critical Reynolds number using Reynolds Apparatus
4. Determination of pressure drop in pipes of various cross-sections

5. Determination of pressure drops in pipes of various pipe fittings etc.
6. Viscosity measurement using viscometer(at least one type)
7. Verification of momentum equation using impact of jet apparatus
8. Determination of metacentric height of a floating body
9. Calibration of a selected flow measuring device and Bourdon pressure gauge
10. Gauge and differential pressure measurements using various types of manometers, Bourdon type pressure gauge.
11. Demonstration of measurement using these instruments Lab.
12. Experiment to study hydraulic jump.

Group-B (Material Science and Metallurgy Lab)

1. Brinell Hardness Test
2. Rockwell Hardness test
3. Erichson Cupping Test
4. Magnaflux Test
5. Dye Penetrant Test
6. Specimen Preparation for Microscopy
7. Sulphur Print Test
8. Spark Test
9. Study and drawing of microstructures of plain carbon steels of varying carbon percentage
10. Study and drawing of microstructures of heat treated steels
11. Jominy End Quench Test
12. Study and drawing of microstructures of cast irons
13. Study and drawing of microstructures of non-ferrous alloys
14. Hardening of steels of varying carbon percentage

Group-C (Thermal Engineering Lab)

1. Determination of dryness fraction of steam.
2. Trial on bomb calorimeter.
3. Study of MPFI and Bosh fuel injection pump

4. Study of High Pressure Boilers.
5. Test on Diesel/Petrol engine to determine BP, bsfc, Brake thermal efficiency.
6. Trial on reciprocating air compressor.
7. Determination of thermal conductivity of insulating material.
8. Test on parallel & counter flow heat exchanger.
9. Determination of Emissivity of a Test Plate.

IT – 1 Evaluation

BTES209P (IT – 1)	Internship – 1 Evaluation	PROJ-1	OL-OT-OP	1 Credits
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Teaching Scheme: Lecture: --	Examination Scheme: Continuous Assessment: -- Mid Semester Exam: -- End Semester Exam: 100 Marks
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Semester-IV

Casting and Moulding Technology

BTPC401	PCC 5	Casting and Moulding Technology	3-1-0	4Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03 hrs)

Objectives: To make students aware of different casting and moulding processes, foundry practices to design casting for different components.

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Classify different casting processes, advantages and limitations.
CO2	Identify various patterns and sand moulding processes.
CO3	Outline special casting processes, their advantages and limitations.
CO4	Select pouring and feeding methods of casting.
CO5	Design gating and risering system of casting.
CO6	Identify casting defects and various casting inspection and testing methods.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	1				1							
CO2	1				1							
CO3	1				1							
CO4	1		1		1							
CO5	1		1		1							
CO6	1				1					1		1

Course Contents:

Unit 1: Introduction to casting processes [06 Hours]

Classification, advantages, limitations, applications of casting, casting terms, sand mold making procedure

Unit 2: Technology of patternmaking, moulding and core making [06 Hours]

Pattern materials, pattern making tools, types of patterns, pattern allowances, methods of Constructing patterns, color coding, tools and equipment's, types of modeling sands, sand Additives, properties of molding sand and testing, molding processes: green sand, dry sand Molding: advantages, limitations and applications core materials, core prints, core boxes, core making, and chaplets.

Unit 3: Special casting processes [06 Hours]

Shell molding, investment molding, full molding process, CO₂ molding, permanent mold Casting, die casting, centrifugal casting and continuous casting, advantages, limitations and applications

Unit 4: Melting, pouring and feeding [06 Hours]

Introduction of furnaces for ferrous and non-ferrous casting, use, construction, charging and other furnaces

Unit 5: Gating and risering of castings [06 Hours]

Gating system, gates, gating ratio, casting yield and gating system design
Risering of casting: Function, shape, types, location, feeding distance, and its design parameters.

Design considerations and inspection of casting [06 Hours]

Designing for economical molding and eliminating defects, defects in casting, inspection
Methods: visual, dimensional, mechanical, metallurgical and NDT

Texts/References:

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

Theory of Machines

BTPC402	Theory of Machines	PCC 6	3L-1T-0P	4 Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3hrs/week Tutorial: 1hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03 hrs)

Pre-Requisites: Applied Mechanics and Engineering Graphics

Course Outcomes:At the end of the course, students will be able to

CO1	Select appropriate mechanism to design and develop a machine for an application
CO2	Analyze the mechanisms to determine velocity and acceleration of various links of the mechanism
CO3	Design and draw profile of the cam to obtain specified follower motion for an application
CO4	Analyze the governor to determine its height for the corresponding change in speed and sleeve displacement
CO5	Explain lower pair mechanisms and select them to meet the need where they are suitable
CO6	Explain and apply friction concepts in automotive and mechanical applications.

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2		2	1								
CO2	1	2			1	1						
CO3	1		1	1								
CO4	1	2	1		1	1						
CO5	2											
CO6	2		2		2			1				

Course Contents:

Unit 1 [06 Hours]

Definition of link, pair, kinematics chain, inversions, inversions of single and double slider crank chain, kinematic diagrams of mechanisms, equivalent linkage of mechanism, degree of freedom, Study of various mechanisms, Steering system & mechanism, suspension.

Unit 2[06 Hours]

Velocity and acceleration analysis and its purpose, velocity and acceleration diagrams using relative velocity method, Corioli's component of acceleration, Velocity and acceleration analysis by vector methods, coordinate system, Loop closure equation, Chase solutions, velocity and acceleration by vector and complex algebra.

Velocity and acceleration of slider crank mechanism by analytical method and Klein's construction.

Unit 3[06 Hours]

Classification of gears, Terminology of spur gears, Conjugate action, Involute and cycloidal profile. Path of contact, contact ratio, Interference, Undercutting, Internal gears. Helical gear terminology, Normal and transverse module, Torque transmitted by helical gears, Spiral gears, Efficiency of spiral gears, Worm and Bevel gear terminology.

Gear Trains: Velocity ratios, Types of gear trains, Tooth load, Torque transmitted and holding torque.

Unit 4[06 Hours]

Cams and Followers: Types of cams and followers, Analysis of motion, Jump and ramp of cam, Determination of cam profiles for a given follower motion.

Flywheel: Turning moment diagram, Fluctuation of energy and speed, Determination of flywheel size for different types of prime movers and machines.

Governors: Function of governor, Inertia and centrifugal type of governors, Controlling force analysis, Governor Effort and governor power, Sensitivity, stability, Isochronisms and Hunting, Friction insensitiveness.

Gyroscope: Principles of gyroscopic action, Precession and gyroscopic acceleration, gyroscopic couple, Effect of the gyroscopic couple on ships, aeroplanes and vehicles, inclined rotating discs, gyroscopic stabilization.

Unit 5 [10 Hours]

Friction Clutches: Principle, Functions, General requirements, Torque capacity, Types of clutches, Cone clutch, Single-plate clutch, Diaphragm spring clutch, Multi-plate clutch, Centrifugal clutch, Electromagnetic clutch, Lining materials, Over-running clutch, Clutch control systems.

Brakes & Braking System : Function and requirements of braking system, Types of brakes, Elementary theory of shoe brake, drum brake arrangement, disc brake arrangement, self-energizing, brake friction material. brake linkages, hydraulic brake system and components, hydraulic brake fluids, air brakes, vacuum servo assisted brake, engine exhaust brake, parking brakes, dual power brake system, regenerative brake system, fail-safe brake, anti – lock brakes, anti-skid brakes, brake efficiency and testing, weight transfer, braking ratio, ABS System.

Belt and Rope Drives: Flat belts, Effect of slip, Centrifugal tension, crowing of pulley, Initial tension in belts. V-Belts Geometric relationship, analysis of belt tensions, condition for maximum power, Selection of flat and V-belts from manufacturer's catalogue, Adjustment of belt tensions.

Text Books:

1. A.Ghosh and, A.K.Malik, "Theory of Mechanisms and Machines", Affiliated East-West Press Pvt. Ltd., New Delhi.
2. S. S. Rattan, "Theory of Machines", Tata-McGraw Hill, New Delhi.

Reference Books:

1. Thomas Beven, "Theory of Machines", CBS Publishers and Distributors", Delhi.
2. J.E.Shigely and J.J. Uicker, "Theory of Machines and Mechanisms", McGraw Hill, New York, International Student Edition, 1995

Basic Human Rights

BTHM403	HSSMC3	Basic Human Rights	3-0-0	3 Credits
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Teaching Scheme: Lecture: 3 hrs/week	Examination Scheme: Audit Course
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Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the history of human rights.
CO2	Learn to respect others caste, religion, region and culture.
CO3	Be aware of their rights as Indian citizen.
CO4	Understand the importance of groups and communities in the society.
CO5	Realize the philosophical and cultural basis and historical perspectives of human rights.
CO6	Make them aware of their responsibilities towards the nation.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						2						

CO2												
CO3												
CO4									3			
CO5								2		2		
CO6												1

Course Contents:

Unit 1: The Basic Concepts, Fundamental Rights and Economic Program [08 Hours]

Individual, group, civil society, state, equality, justice. Human Values, Human rights and Human Duties: Origin, Contribution of American bill of rights, French revolution. Declaration of independence, Rights of citizen, Rights of working and exploited people

Society, religion, culture, and their inter-relationship. Impact of social structure on human behavior, Social Structure and Social Problems: Social and communal conflicts and social harmony, rural poverty, unemployment, bonded labour.

Unit 2: Workers and Human Rights [04 Hours]

Migrant workers and human rights violations, human rights of mentally and physically challenged. State, Individual liberty, Freedom and democracy.

Unit 3: NGOs and Human Rights in India [04 Hours]

Land, Water, Forest issues.

Unit 4: Human Rights in Indian Constitution and Law [04 Hours]

- i) The constitution of India: Preamble
- ii) Fundamental rights.
- iii) Directive principles of state policy.
- iv) Fundamental duties.
- v) Some other provisions.

Unit 5: UDHR and Indian Constitution [04 Hours]

Universal declaration of human rights and provisions of India; Constitution and law; National human rights commission and state human rights commission.

References:

1. Shastry, T. S. N., "India and Human Rights: Reflections", Concept Publishing Company India (P Ltd.), 2005.
2. C. J. Nirmal, "Human Rights in India: Historical, Social and Political Perspectives (Law in India)", Oxford India.

Strength of Materials

BTMES404	ESC11	Strength of Materials	3-1-0	4 Credits
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Teaching Scheme: Lecture: 3 hrs/week Tutorial: 1 hr/week	Examination Scheme: Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03 hrs)
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Pre-Requisites: Engineering Mechanics

Course Outcomes: At the end of the course, students will be able to:

CO1	State the basic definitions of fundamental terms such as axial load, eccentric load, stress, strain, E, μ , etc.
CO2	Recognize the stress state (tension, compression, bending, shear, etc.) and calculate the value of stress developed in the component in axial/eccentric static and impact load cases.
CO3	Distinguish between uniaxial and multiaxial stress situation and calculate principal stresses, max. Shear stress, their planes and max. Normal and shear stresses on a given plane.
CO4	Analyze given beam for calculations of SF and BM
CO5	Calculate slope and deflection at a point on cantilever /simply supported beam using double integration, Macaulay's , Area-moment and superposition methods
CO6	Differentiate between beam and column and calculate critical load for a column using Euler's and Rankine's formulae

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

Course Contents:

Unit 1: Simple Stresses and Strains [12 Hours]

Mechanical properties of materials, analysis of internal forces, simple stresses and strains, stress-strain curve, Hooke's law, modulus of elasticity, shearing, thermal stress, Hoop stress, Poisson's ratio, volumetric stress, bulk modulus, shear modulus, relationship between elastic constants.

Principal Stresses and Strains

Uni-axial stress, simple shear, general state of stress for 2-D element, ellipse of stress, principal stresses and principal planes, principal strains, shear strains, strain rosettes, Mohr's circle for stresses and strains

Unit 2: Strain energy, resilience and Combined Stresses [10 Hours]

Strain energy, resilience: Combined axial and flexural loads, middle third rule, kernel of a section, load applied off the axes of symmetry.

Shear and Moment in Beams: Shear and moment, interpretation of vertical shear and bending moment, relations among load, shear and moment.

Unit 3: Stresses in Beams [08 Hours]

Moment of inertia of different sections, bending and shearing stresses in a beam, theory of simple bending, derivation of flexural formula, economic sections, horizontal and vertical shear stress, distribution shear stress for different geometrical sections-rectangular, solid circular, I-section, other sections design for flexure and shear.

Unit 4: Torsion [08 Hours]

Introduction and assumptions, derivation of torsion formula, torsion of circular shafts, stresses and deformation indeterminate solid/homogeneous/composite shafts, torsional strain energy.

Columns and Struts: Concept of short and long Columns, Euler and Rankine's formulae, limitation of Euler's formula, equivalent length, eccentrically loaded short compression members.

Unit 5: Beam Deflections [08 Hours]

Differential equation of deflected beam, slope and deflection at a point, calculations of deflection for determinate beams by double integration, Macaulay's method, theorem of area-moment method (Mohr's theorems), moment diagram by parts, deflection of cantilever beams, deflection in simple supported beams, mid-span deflection, conjugate beam method, deflection by method of superposition.

Texts:

1. S. Ramamrutham, “Strength of Materials”, Dhanpat Rai and Sons, New Delhi.
2. F. L. Singer, Pytle, “Strength of Materials”, Harper Collins Publishers, 2002.
3. S. Timoshenko, “Strength of Materials: Part-I (Elementary Theory and Problems)”, CBS Publishers, New Delhi.

References:

1. E. P. Popov, “Introduction to Mechanics of Solid”, Prentice Hall, 2nd edition, 2005.
2. S. H. Crandall, N. C. Dahl, T. J. Lardner, “An introduction to the Mechanics of Solids”, Tata McGraw Hill Publications, 1978.
3. S. B. Punmia, “Mechanics of Structure”, Charotar Publishers, Anand.

Numerical Methods in Mechanical Engineering

BTMPE405A	PEC 1	Numerical Methods in Engineering	3-0-0	3 Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week Tutorial: 0 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03 hrs)

Course Outcomes: At the end of the course, students will be able to:

CO1	Describe the concept of error
CO2	Illustrate the concept of various Numerical Techniques
CO3	Evaluate the given Engineering problem using the suitable Numerical Technique
CO4	Develop the computer programming based on the Numerical Techniques

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3		1	3							
CO2	3	3		1	3							
CO3	3	3		1	3							
CO4	3	3		1	3							

Course Contents:

Unit1: Error Analysis [06 Hours]

Significant figures, round-off, precision and accuracy, approximate and true error, truncation error and Taylor series, machine epsilon, data uncertainties, error propagation, importance of errors in computer programming.

Unit2: Roots of Equations [06 Hours]

Motivation, Bracketing methods: Bisection methods, Open methods: Newton Raphson method, Engineering applications.

Unit3: Numerical Solution of Algebraic Equations [06 Hours]

Motivation, Cramer's rule, Gauss- Elimination Method, pivoting, scaling, engineering applications.

Unit4: Numerical Integration and Differentiation [06 Hours]

Motivation, Newton's Cotes Integration Formulas: Trapezoidal Rule, Simpson's rule, engineering applications Numerical differentiation using Finite divide Difference method

Unit5: Curve, Fitting and Interpolation and Computer Programming [12 Hours]

Motivation, Least Square Regression: Linear Regression, Polynomial regression.

Interpolation: Newton's Divide Difference interpolation, engineering applications.

Solution to Ordinary Differentiation Equations: Motivation, Euler's and Modified Euler's Method, Heun's method, Runge-Kutta Method, engineering applications.

Computer Programming

Overview of programming language, Development of at least one computer program based on each unit.

Texts:

1. Steven C Chapra, Raymond P. Canale, "Numerical Methods for Engineers", Tata McGraw Hill Publications, 2010.
2. E. Balagurusamy, "Numerical Methods", Tata McGraw Hill Publications, 1999.

References:

1. V. Rajaraman, "Fundamental of Computers", Prentice Hall of India, New Delhi, 2003.
2. S. S. Sastri, "Introductory Methods of Numerical Methods", Prentice Hall of India, New Delhi, 3rd edition, 2003.
3. K. E. Atkinson, "An Introduction to Numerical Analysis", Wiley, 1978.
4. M.J. Maron, "Numerical Analysis: A Practical Approach", Macmillan, New York, 1982

Sheet Metal Engineering

BTMPE405B	PEC 1	Sheet Metal Engineering	3-0-0	3 Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3hrs/week Tutorial: 0 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Recognize common manufacturing processes of Sheet Metal Fabrication
CO2	Understand the principles of design and fabricate of sheet metal products and recognize common material used in the industry
CO3	Distinguish Shearing, Drawing and Pressing etc. processes.
CO4	Know types of dies and formability.
CO5	Select mechanical or hydraulic presses for the given process

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	3	2				2	1		1

CO2	3			1	3	2	3					2
CO3	1	1		3	3	2	1		3		1	3
CO4	3	3	1	1	3		1	1	1			
CO5	3	2			3	3	2				1	3

Course Contents:

Unit1: Introduction

Importance of sheet metal engineering, materials used, desirable properties of materials in sheet metal products

Unit2: Basic Applications

Shearing processes like blanking, piercing, and punching.

Unit3: Drawing Processes

Shallow and deep drawing of cylindrical and rectangular bodies, forming and bending including spring-back.

Unit4: Types of Dies and Mechanical Presses

Dies: Compound dies, progressive dies, and combination dies

Mechanical Presses

Mechanical and hydraulic presses, modern developments in press tools, formability.

Unit 5: Case Studies

Case studies for manufacturing of sheet metal products in various engineering applications

Texts:

1. Donaldson et al., "Tool Design", Tata McGraw-Hill Publications, New Delhi, 1998.

References:

1. P.N.Rao, "Manufacturing Technology, Foundry, Forming and Welding", Vol.I, Tata McGraw Hill Publishing Co.Ltd, New Delhi, 3rd edition, 2004.
2. ASM Handbook, "Metal Forming", Vol.XV, ASM Publication, Metals Park, Ohio, 10th edition, 1989.
3. A. S.Deshpande, "Die Design Handbook", ASTME.
4. Sheet Metal Engineering Notes, IIT Bombay, 1999.

Fluid Machinery

BTMPE405C	PEC 1	Fluid Machinery	3-0-0	3 Credits
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Teaching Scheme: Lecture: 3hrs/week Tutorial: 0 hr/week	Examination Scheme: Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)
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Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand and apply momentum equation
CO2	Understand and explain Hydrodynamic Machines
CO3	Explain difference between impulse and reaction turbines
CO4	Find efficiencies, draw velocity triangles
CO5	Explain governing mechanisms for hydraulic turbines
CO6	Explain working of various types of pumps, draw velocity diagrams, do simple calculations
CO7	Design simple pumping systems

Mapping of course outcomes with program outcomes

Course	Program Outcomes
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Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1									1
CO2	3		3				2					1
CO3	3	2										1
CO4	3	3	2									1
CO5			3									1
CO6	3	3	3	1	1							1
CO7	3	3		3								1

Course Contents:

Unit 1: Momentum Equation and its Applications

Impulse momentum, Principle, Fixed and moving flat inclined plates, Curved vanes, Series of plates and vanes, Velocity triangle and their analysis, Water wheels. Hydrodynamic Machines: Classification, General theory, Centrifugal head, Fundamental equations, and Euler's equation, Degree of reaction, Head on machine, various efficiencies, Condition for maximum hydraulic efficiency.

Unit 2: Impulse and Reaction Turbines

Impulse principle, Construction of Pelton wheel, Velocity diagrams and its analysis, Number of buckets, Jets, Speed ratio, Jet ratio.

Reaction Turbines: Constructional details of Francis, Kaplan and Propeller turbine, Deciaz turbine, and Draft tube types, Efficiencies, Cavitation.

Unit 3: Governing of Turbines

Methods of governing, Performance characteristics, Safety devices, Selection of turbines, Unit quantities, Specific speed, Principles of similarity and model testing.

Unit 4: Centrifugal Pump

Construction, Classification, Terminology related to pumps, Velocity triangle and their analysis, Cavitation, NPSH, Thoma's cavitation factor, Priming, Methods of priming, Specific speed, Performance characteristics, Actual thrust and its compensation, Troubleshooting.

Multistage Pumps: Pump H-Q characteristics and system H-Q Characteristics, Series and parallel operation of pumps, Systems in series and parallel, Principle of model testing and similarity.

Unit 5: Special Purpose Pumps

Chemical pumps, nuclear pumps, Sewage pumps, Submersible deep well pumps, Pump installation, Energy efficient pumps.

Failure of Pumping System: Pump failures, Remedies, Source failure, Causes and remedies, Trouble shooting.

Miscellaneous Pumps: Reciprocating pump, Gear pump, Vane pump, Lobe pump, etc., Application field (no mathematical treatment).

Texts:

1. P. N. Modi, S. M. Seth, "Hydraulics and Fluid Mechanics including Hydraulic Machines", Standard Book House, Rajsons Publications Pvt. Ltd., 20th edition.

2. R. K. Bansal, “A Text Book of Fluid Mechanics and Hydraulic Machines”, Lakshmi Publications Pvt. Ltd., 9th edition.

References:

1. Yunus A. Çengel, John M. Cimbala, Fluid Mechanics: Fundamentals and Applications”, McGraw Hill, 3rd edition, 2014.

Production Engineering Lab-II

BTPCL406	PCC7	Production Engineering Lab II	0-0-4	2Credit
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Practical Scheme:	Examination Scheme:
Practical: 4hrs/batch	Continuous Assessment: 60 Marks External Exam: 40 Marks

List of Practical's/Experiments/Assignments (Any 5 from Group-A and Any 5 from Group-B)

Group-A (Theory of Machines):

1. Determination of Moment of Inertia of rigid bodies by bifilar or trifilar suspension method.
2. Compound Pendulum.
3. Experimental Verification of displacement relation for different shaft angles for single Hook's Joint.
4. Developing a computer program for velocity and acceleration of slider crank mechanism.

5. Graphical solution of problems on velocity & acceleration in mechanisms by Relative velocity & relative acceleration method including problem with Corioli's component of acceleration.
6. Graphical solution of problems on velocity in mechanisms by ICR method.
7. Klein's constructions for slider crank mechanism.
8. Inertia force analysis with graphical methods.
9. Straight line motion mechanisms.

Group-B (Strength of Material):

1. Tension test on ferrous and non-ferrous alloys (mild steel/cast iron/aluminum, etc.)
2. Compression test on mild steel, aluminum, concrete, and wood
3. Shear test on mild steel and aluminum (single and double shear tests)
4. Torsion test on mild steel and cast iron solid bars and pipes
5. Flexure test on timber and cast iron beams
6. Deflection test on mild steel and wooden beam specimens
7. Graphical solution method for principal stress problems
8. Impact test on mild steel, brass, aluminum, and cast iron specimens
9. Experiments on thermal stresses
10. Strain measurement in stress analysis by photo-elasticity
11. Strain measurement involving strain gauges/ rosettes
12. Assignment involving computer programming for simple problems of stress, strain computations

Semester V

Design of Machine Elements

BTPC501	Design of Machine Elements	PCC 8	3L-1T-0P	4 Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Objectives: To understand material properties, design process and various theories of failures in order to design various basic machine components and new components based on design principles.

Pre-Requisites: Strength of Materials

Course Outcomes: At the end of the course, students will be able to:

CO1	Formulate the problem by identifying customer need and convert into design specification
CO2	Understand component behavior subjected to loads and identify failure criteria
CO3	Analyze the stresses and strain induced in the component
CO4	Design of machine component using theories of failures
CO5	Design of component for finite life and infinite life when subjected to fluctuating load
CO6	Design of components like shaft, key, coupling, screw and spring

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1						1				1
CO2	3	2		1		1		1		1		1
CO3	1	1				1		1		1		1

CO4	3	3	2	1		2		1		1		1
CO5	1	1				1		1		1		1
CO6	2	2	2	1		1		1		1		1

Course Contents:

Unit1:

Mechanical Engineering Design Process

Traditional design methods, general industrial design procedure, design considerations, phases in design, creativity in design, use of standardization, preferred series, introduction to ISO 9000, use of design data book, aesthetic and ergonomic considerations in design.

Theories

Failure: Maximum normal stress theory, Maximum shear stress theory, Maximum distortion energy theory, comparison of various theories of failure,

Unit2: Design of Machine Elements

I. Against Static Loading

Direct loading and combined loading, Joints subjected to static loading e.g. cotter and knuckle joint, turnbuckle, etc. introduction to fluctuating loads.

II: Against Fluctuating Loads

Stress concentration, stress concentration factors, fluctuating stresses, fatigue failure, endurance limit, notch sensitivity, approximate estimation of endurance limit, design for finite life and finite life under reversed stresses, cumulative damage in fatigue, Soderberg and Goodman diagrams, fatigue design under combined stresses.

Unit 3: Design of Shafts, Keys, Couplings and Bearings

Various design considerations in transmission shafts, splined shafts, spindle and axle strength, lateral and torsional rigidity, ASME code for designing transmission shaft.

Types of Keys: Classification and fitment in keyways, Design of various types of keys.

Couplings: Design consideration, design of rigid, muff and flange type couplings, design of flexible couplings.

Bearings: Types, Constructional details of roller contact and sliding contact bearings, Static and dynamic load carrying capacities, Stribeck's Equation, Equivalent load, load and life relationship, selection of bearing life, Load factor, selection of bearing from manufacturer's catalogue, Lubrication and bearing materials.

Unit 4: Design of Threaded Joints

Stresses in screw fasteners, bolted joints under tension, torque requirement for bolt tightening, preloading of bolt under static loading, eccentrically loaded bolted joints.

Power Screws: Forms of threads used for power screw and their applications, torque analysis for square and trapezoidal threads, efficiency of screw, collar friction, overall efficiency, self-locking in power screws, stresses in the power screw, design of screw and nut, differential and compound screw, re-circulating ball screw.

Welded

Type of welded joints, stresses in butt and fillet welds, strength of welded joints subjected to bending moment

Joints:

nts.

Mechanical Springs

Stressdeflectionequationforhelicalspring, Wahl'sfactor, styleofends, designofhelicalcompression, tensionandtorsionalspringunderstaticloads, constructionanddesignconsiderationinleafsprings, nipping

Unit 5: Design of Gears and Drives

Geardrives, Classification ofgears, Lawofgearing, Terminologyofspurgear, Standard system of gear tooth force analysis, gear tooth failures, material selection, Numberofteeth, Facewidth, Beamstrengthequation, Effectiveloadongear tooth, Estimation of module based on beam strength.

Design formaximumpowercapacity, Lubricationofgears.

HelicalGears:

Terminology, Virtualnumberofteeth, Toothproportions, Forceanalysis, Beamstrengthequation, Effectiveloadongear tooth, Wearstrengthequation.

BevelGears: Typesofbevelgears, Terminologyofstraightbevel, forceanalysis, BeamandWearstrengthequation, Effectiveloadongear tooth.

WormGears: Terminology, Proportions, Forceanalysis, Frictioninwormgears, Vector method, Selectionofmaterials, Strengthandwearrating, Thermalconsiderations

Texts:

1. V. B.Bhandari, "DesignofMachineElements", TataMcGrawHill Publications, NewDelhi, 2008.
2. R. L.Nortan, "MachineDesign: AnIntegratedApproach", PearsonEducationSingapore, 2001.

References:

1. R. C.Juvinall, K. M.Marshek, "Fundamentalofmachinecomponentdesign", John Wiley&SonsInc., NewYork, 3rdedition, 2002.
2. B. J. Hamrock, B. JacobsonandSchmidSr., "FundamentalsofMachineElements", InternationalEdition, NewYork, 2ndedition, 1999.
3. A. S.Hall, A. R.Holowenko, H. G.Langhlin, "TheoryandProblemsofMachineDesign", Schaum'sOutlineSeries, Tata McGrawHillbookCompany, NewYork, 1982.
4. J. E.ShigleyandC.Mischke, "MechanicalEngineeringDesign", Tata McGrawHill Publications, 7thedition, 2004.
5. M. F.Spotts, "DesignofMachineElements", PrenticeHallofIndia, NewDelhi.

Metal Forming Processes

BTPC502	PCC 9	Metal Forming Processes	3-1-0	4Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03 hrs)

Objectives: To apply basic of metal forming processes to shape products to their desired forms without any defects.

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Define basic stress strain relationship and failure criteria.
CO2	Identify effect of temperature, strain rate and microstructure on formability.
CO3	Calculate the roll separating force, pressure and power required for rolling.
CO4	Determine forces and power required in forging and extrusion.
CO5	Estimate bending force, spring back, effect in bending and forces in wire drawing.
CO6	Classify various advanced forming processes.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1				1							
CO2	1				1							
CO3	1		1	1	1							
CO4	1		1	1	1							
CO5	1		1	1	1							
CO6	1				1							

Course Contents:

Unit 1: Stress and Strain

Review of the theory of stress and Strain – transformation laws –principal stress and strain – Mohr’s circle, Stress strain relations, Material properties, Theory of plasticity, Behaviour of metals under uni-axial tension and compression — true stress-true strain relations — effect of work hardening, Empirical stress-strain relations for work hardening materials. Representation of Tresca and von-Mises criterion –yield surface for work hardening materials, Stress strain relations in the plastic range

Unit 2: Metal Forming Processes

Effect of temperature, strain rate, metallurgical microstructure, chemical composition and mechanical properties, Classification of material forming process, Hot forming/ Cold forming, Concept of Formability, formability limits and formability diagram.

Unit 3: Mechanics of Rolling Process

Rolling, process parameters, pressure distribution and roll separating force, rolling pressure, driving torque and power requirements. Defects in rolling. Automatic gauge control- Roll pass classification & design.

Unit 4: Forging and Extrusion

Forging: Determination of forces in strip forging and disc forging, defects in forged components.

Extrusion: Process, parameters, determination of work load from stress analysis and energy considerations, power loss, hydrostatic extrusion, pressure required to extrude, variables affecting the process.

Unit 5: Bending, Punching and Blanking

Bending: Bendability, determination of work load and spring back.

Punching & Blanking: Two-dimensional deformation model and fracture analysis, determination of working force.

Introduction rod and wire drawing machines - construction and working. Preparation of stock for wire drawing. Wire drawing dies, material and design. Patenting heat treatment. Variables in wire drawing, Maximum reduction in wire in one pass, forces required in drawing.

Advanced metal forming processes

High velocity forming- principles, comparison of high velocity and conventional Forming processes. Explosive forming, Magnetic pulse forming, Electro hydraulic Forming, Microforming, Microcoining, microextrusion, Microbending, Stretch forming, coining embossing, curling spinning, flow forming advantages, limitations and application of the process.

Texts:

1. P.N.Rao, “Manufacturing Technology, Foundry, Forming and Welding” Vol.1, 3rd edition, Tata McGraw Hill Publishing Co. Ltd, New Delhi, 2004

References:

1. ASM Handbook, Vol. 15 Metal Forming, ASM International, Metals Park, Ohio, 1989.
2. Die Design Handbook, ASTM, 1989.
3. A.S. Deshpande, "Sheet Metal Engineering Notes", IIT Bombay, 1999.

Joining Technology

BTPC503	PCC 10	Joining Technology	3-1-0	Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Objectives: To apply the basics of metal joining processes to join different metals with appropriate technique for joining suitable materials.

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Classify various joining processes and identify welding symbols, joints and edge preparation.
CO2	Identify various arc welding methods, equipment's and electrodes.
CO3	Outline gas welding and their equipment's and classify resistance welding processes.
CO4	Define various solid state welding processes, thermal cutting and their working principles.
CO5	Outline welding defects and their causes, destructive and non-destructive testing of welds.
CO6	Choose suitable welding fixtures, estimate cost of welding.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1				1							
CO2	1				1							
CO3	1				1							
CO4	1				1							

CO5	1				1							1
CO6	1		1		1		1					

Course Contents:

Unit 1: Fundamentals and Classification of Welding Processes

Introduction, classification of Welding processes. Comparison with other joining processes, advantages, disadvantages, practical applications. Welding symbols, Basic & supplementary weld symbols, types of weld Joints, Selection of Weld Joint, and edge preparation.

Unit 2: Arc Welding Processes and Equipments

Definition, types of processes, Carbon Arc Welding, Flux Shielded Metal Arc Welding, Submerged Arc Welding, Tungsten Inert Gas Welding, Metal Inert Gas Welding, Electroslag Welding, Electro Gas Welding, Plasma Arc Welding , Arc Welding equipments, Electrodes Types, classification and coding of electrodes.

Unit 3: Welding, Soldering and Brazing

Principle of operation, types of flames, Gas welding Techniques, filler material and fluxes, Gas welding equipments, advantages and applications

Resistances welding: Definition, Fundamentals, variables advantages and application, Spot Welding, Heat Shrinkage, Heat Balance Methods, Equipment, Electrodes, Seam, Projection Butt (up sets and flash), Percussion Welding – Definition, Principle of Operation, equipment, Metal Welded, advantages and application.

Soldering and Brazing: Definition, Comparison of Soldering, Brazing and Welding, principle, joint design, filler alloy, fluxes, processes and application.

Unit 4: Solid State Welding Processes

Cold Welding, Diffusion Welding, Ultrasonic Welding, Explosive Welding, Friction Welding, Inertia and Forge Welding – Definition, principle of operation advantages, limitation and application.

Thermal Cutting of Metal: Oxy-Fuel, Oxygen-Lance, Metal Powder, Chemicals Flux Cutting, Arc Cutting- Metallic, Air Carbon, Tungsten Arc, Plasma Arc Cutting

Unit 5: Weld Defects and Inspection

Weldability: Definition, effect of alloying elements, Purpose and types of tests, Hot Cracking, Root Cracking and Cold Cracking Tests. Common Weld defects, Causes and remedies. Concept of distortion, Types of distortion, Control of welding distortion

Destructive testing of weld – Tensile, Bend, Impact, Nick Break, Hardness, Etch Tests, Non Destructive Testing of Welds – Visual, Leak, X- ray and Gamma ray Radiography, Magnetic Particle Inspection, Dye, Fluorescent Penetrant Tests, Ultrasonic Inspection & Eddy Current Testing

Welding Automation and Robotics

Introduction, Automation options, Simple Mechanization, Dedicated and Special Purpose Automation, Robotic welding, Modular Automation, Programmable control, Remote Control Slave and Automated Systems

Welding Fixtures: Introduction, welding fixtures, their characteristics, classification and selection considerations, Principles governing design of good welding fixtures, various types of welding fixtures.

Estimation of Welding Cost: Introduction, main components costs of welding processes, factors involved in welding costs, basic costing procedure for arc welding, basic costing procedure for gas welding, factors affecting welding costs.

Texts:

1. O.P. Khanna, “Welding Technology” Khanna Publisher
2. Richard Little, “Welding & Welding Technology” TMH
3. N. K. Srinivasan, “Welding Technology” Khanna Publisher
4. Dr. R.S.Parmar, “Welding Processes and Technology” Khanna Publisher

References:

1. Md. Ibrahim Khan, “Welding Science & Technology” New Age International
2. V. M. Radhakrishnan, “Welding Technology & Design” New Age International Publisher
3. James E Brambaugh, “Welding Guide and Handbook” Taraporwala Mumbai
4. A.L. Davies, “Welding” Cambridge University Press
5. P. T. Houlcroft, “Welding Process Technology” Cambridge University Press
6. L.M.Gourd, “Principles of Welding Technology” ELBS

Refrigeration and Air Conditioning

BTMPE504A	PEC 2	Refrigeration and Air Conditioning	3-0-0	3 Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3hrs/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Unit 1: Introduction

History, Fundamentals of refrigeration, Unit, Applications, Methods of producing cooling, Refrigeration systems, Thermodynamics of refrigeration, Primary and secondary refrigeration, Heat Pump

Unit 2: Vapour Compression System

Thermodynamics analysis, theoretical and actual cycle, Use of P-h and T-s diagram for problem solving, COP, Effect of evaporator and condenser temperature on cycle performance, Effects of suction superheating

Liquid sub-cooling, liquid-vapour heat exchanger, estimation of compressor displacement, COP and power requirement, waste heat recover opportunities

Unit 3:

Compound Vapour Compression System: Multi-evaporator, multi-compressor systems, cascade system (no mathematical treatment)

Vapour Absorption System: Aqua-ammonia system, lithium bromide-water system, Electrolux refrigerator, comparison with vapour compression cycle (descriptive treatment only), P-T- ξ chart, thermodynamic analysis, and capacity control, solar refrigeration system

Unit 4:

Refrigerant for Vapour Compression System: Desirable Properties, Selection, Zeotropes and Azeotropes, Necessity for replacement of CFC refrigerants, natural refrigerants

Air Conditioning: Psychrometry, properties of moist air, psychrometric charts.

Thermal comfort: Heat transfer from human body by sensible and latent heat transfer, metabolic heat generation, steady state model for heat transfer, effect of clothing and definition of effective temperatures, comfort conditions, human comfort, comfort chart.

Unit 5: Air Conditioning Process Calculation

Sensible and latent heat loads, SHF, GSHF, RSHF, outside conditions, indoor conditions, estimation of coil capacity required, bypass factor, evaporative cooling

Principle of air distribution, duct design methods, friction chart, duct materials, methods of noise control

All air system, all water system, unitary systems; window air-conditioner, split air-conditioners, refrigeration and air-conditioning controls.

Texts:

1. Arora, C.P., Refrigeration and Air Conditioning, Tata McGraw Hills, New Delhi, Second Edition, 2000.
2. Stoeker, W.F. and Jones, J.P., Principles of Refrigeration and Air Conditioning, McGraw Hill, New York, Second Edition, 1982.

References:

1. ASHRAE Handbook – Fundamentals and Equipment, 1993.
2. ASHRAE Handbook – Applications, 1961.
3. ISHRAE Handbook
4. NPTEL Lectures by Prof. RamGopal, IIT Kharagpur
5. Carrier Handbook
6. Jord R.C., and Priester, G.B., Refrigeration and Air Conditioning, Prentice - Hall of India Ltd., New Delhi, 1969.
7. Threlkeld, J.L., Thermal Environmental Engineering, Prentice Hall, New York, 1970.

BTMPE504C	PEC2	Engineering Tribology	3-0-0	Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the basic concepts and importance of tribology.
CO2	Evaluate the nature of engineering surfaces, their topography and surface characterization techniques
CO3	Analyze the basic theories of friction and frictional behavior of various materials
CO4	Select a suitable lubricant for a specific application
CO5	Compare different wear mechanisms
CO6	Suggest suitable material combination for tribological design.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2	2	1	2	2		1						
CO3	2	3	1	2	1	1	1					
CO4	2	2	2		1	1	2		1		1	
CO5	1	1	1	1	1							
CO6	2	2	2		2	2	2		1	1	1	

Course Contents:

Unit1: Introduction

Definition of tribology, friction, wear and lubrication; importance of the tri-biological studies.
Surface Topography: Methods of assessment, measurement of surface roughness-different statistical parameters (R_a, R_z, R_{max} , etc.), contact between surfaces, deformation between single and multiple asperity contact, contact theories involved

Unit2: Friction

Coulomb laws of friction, its applicability and limitations, comparison between static, rolling and kinetic friction, friction theories, mechanical inter locking, molecular attraction, electrostatic forces and welding, shearing and ploughing, models for asperity deformation.

Unit3: Lubrication

Types of lubrication, viscosity, characteristics of fluids as lubricant, hydrodynamic lubrication, Reynold's equation, elasto-hydrodynamic lubrication: partial and mixed, boundary lubrication, various additives, solid lubrication.

Unit4: Wear Sliding wear: Abrasion, adhesion and galling, testing method spin-on-disc, block-on-ring, etc., theory of sliding wear, un-lubricated wear of metals, lubricated wear of metals, fretting wear of metals, wear of ceramics and polymers.

Wearing by plastic deformation and brittle fracture. Wear by hard particles: Two-body abrasive wear, three-body abrasive wear, erosion, effects of hardness shape and size of particles.

Unit5: Wear and Design and Materials for Bearings

Introduction, estimation of wear rates, the systems approach, reducing wear by changing the operating variables, effect of lubrication on sliding wear, selection of materials and surface engineering. Principles and applications of tribo design

Materials for Bearings

Introduction, Rolling bearings, Fluid film lubricated bearings, marginally lubricated and dry bearings, gas bearings.

Texts:

1. I. M. Hutchings, "Tribology, Friction and Wear Engineering Materials", Edward Arnold, London.
2. R. C. Gunther, "Lubrication", Baily Brothers and Swinfen Limited.
3. F. T. Barwell, "Bearing Systems, Principles and Practice", Oxford University Press.

References:

1. B. C. Majumdar, "Introduction to Tribology of Bearings", A. H. Wheeler & Co. Private Limited, Allahabad.
2. D. F. Dudley, "Theory and Practice of Lubrication for Engineers", John Wiley and Sons.
3. J. Halling, "Principles of Tribology", McMillan Press Limited.
4. Cameron Alas Tair, "Basic Lubrication Theory", Wiley Eastern Limited.
5. M. J. Neale, "Tribology Handbook", Butterworth's.
6. D. D. Fuller, "Lubrication".

Dr. Babasaheb Ambedkar Technological University, Lonere

BTAPE504A	Automobile Design (Product Design, PLM, CAE, Catia)	PEC 2	3L-0T-0P	3 Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3hrs/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	
CO2	
CO3	
CO4	
CO5	
CO6	

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												

Course Contents:

Domain related training (Approx. 20 Hrs)

Unit 1:

Introduction to Styling, Basic of Design - Introduction to Design, Good Design & it's Examples of All Time, Industrial Design & its use. Design Process - Typical Product Life Cycle, Automotive Design Process (for production release), Design Studio (Automotive studio) Process or Product Conceptualization Process, Case Study. CAS Surfaces or Digital Clay Models, Class A Surfaces - Role of Class A surface Engineer, Requirements for a Surface to fulfill " Class A Surface" Standards, Case Studies for Class A Surfaces, Class A Surface Creation for Bonnet

Unit 2:

Introduction to Body In White: Introduction & familiarization to Body In White (BIW), various type of BIW, Types of BIW sub system, various aggregates of BIW. Bonnet Design Case Study:Function of Bonnet, Defined Input to Bonnet, Intended Input to Bonnet Design. Steps in Bonnet design, Study of Class A Surfaces, Hood Package Layout , Typical Sections, Block Surfaces in 3D, Dynamic Clearance Surfaces in 3D, Hood Structural Members, CAE 1(Durability, Crash), Panel Detail Design, Body Assembly Process, CAE 2(Durability, crash, individual panel level), Design Updating & Detailing Prototypes, Design Updating & Production

Release

Unit 3:

Introduction to CAE & its importance in the PLM, Introduction to FEA & its applications (NVH, Durability & Vehicle Crashworthiness). Introduction of Pre-Processor, Post-Processor & Solvers. Importance of discretization & Stiffness Matrix (for automobile components). Importance of oil canning on an automobile hood with Case study related to Durability Domain. Modal analysis on the hood (Case Study related to NVH Domain). Introduction of vehicle crashworthiness & Bio-mechanics (Newtonian laws, energy management, emphasis of impulse in car crashes). Head impact analysis as a Case study on the hood of an automobile (EuroNCAP test regulation). Importance of Head performance criteria (HPC). Introduction to failure criteria (By explaining the analogy of using uni-axial test results for predicting tri-axial results in reality), Mohr's Circle, Von-Mises stress criteria, application of various failure criteria on brittle or ductile materials

Unit 4:

Introduction to CAD,CAM & CAE, FEA - Definition, Various Domains – NVH, Dura, Crash, Occupant Safety, CFD. Implicit vs. Explicit Solvers, Degree of Freedom, Stiffness Matrix, Pre-Post & Solver; Types of solvers, Animation. Durability -Oil Canning, Oil Canning on Hood, Scope of work, Loading, Boundary Conditions, Results & Conclusions. NVH – Constrained Modal Analysis, Constrained Modal Analysis on Hood, Scope of work, Loading, Boundary Conditions, Results & Conclusions. Crash – Vehicle Crashworthiness, Energy Management, Biomechanics, Head Impact Analysis on Hood, Importance of Failure Criteria, Von-Mises Stress

Unit 5:

Sheet metal design & Manufacturing Cycle, Simultaneous Engineering (SE) feasibility study, Auto Body & its parts, Important constituents of an automobile, sheet metal, sheet metal processes. Type of draw dies, Draw Model development & its considerations. Forming Simulations, Material Properties, Forming Limit Curve (FLD), Pre Processing, Post-Processing, Sheet metal formability- Simulation

Die Design –Sheet metal parts, Sheet metal operations (Cutting, Non-Cutting etc.), Presses, Various elements used in die design, Function of each elements with pictures, Types of dies, Animation describing the working of dies, Real life examples of die design. **Fixture Design** - Welding (Spot/Arc Welding), Body Coordinates, 3-2-1 principle, Need for fixture, Design considerations, Use of product GD&T in the fixture design, fixture elements. Typical operations in Sheet metal Fixture (Manual/Pneumatic/Hydraulic fixture), Typical unit design for sheet metal parts (Rest/Clamp/Location/Slide/Dump units/Base), Types of fixture (Spot welding/ Arc welding/ Inspection fixture/Gauges)

Tools related training (Approx. 20 Hrs):

Depending on the tools available in the college, the relevant tool related training modules shall be enabled to the students.

AutoCAD, AutoCAD Electrical, AutoCAD Mechanical, AutoCAD P&ID, Autodesk 3ds Max, Autodesk Alias, Autodesk SketchBook, Automotive, CATIA V5, CATIA V6, FEA, Autodesk Fusion 360, Autodesk Inventor, Autodesk Navisworks, Autodesk Ravit, Autodesk Showcase, Autodesk Simulation, PTC Creo, PTC ProENGINEER, Solid Edge,

SOLIDWORKS.

Texts:

1. Notes of TATA Technologies
2. Curt Larson, “ Datum Principles: Flexible Parts: Applications for Automotive Body-in-White and Interior Trim (Dimensional Management Series Book 1)”, Right Tech, Inc., Kindle Edition.
3. Curt Larson, “ Datum Principles: Flexible Parts: Applications for Automotive Body-in-White and Interior Trim (Dimensional Management Series Book 2)”, Right Tech, Inc., Kindle Edition.
4. VukatoBoljanovic, “Sheet Metal Forming Processes and Die Design”, Industrial press Inc., Kindle Edition.

References:

1. IbrahimZeid, “CAD/CAM TheoryandPractice”, TataMcGrawHillPublication,
2. Mikell P. Grover “Automation, Production Systems and Computer-Integrated Manufacturing”, Pearson Education, New Delhi.
3. P. Radhakrishnan& S. Subramanyan “CAD/CAM/CIM” Willey Eastern Limited New Delhi.
4. Onwubiko, C., “Foundation of Computer Aided Design”, West Publishing Company. 1989
5. R.W.Heine, C. R.Loper and P.C.Rosenthal, *Principles of Metal Casting*, McGraw Hill, Newyork, 1976.
6. J. H.Dubois And W. I.Pribble, *Plastics Mold Engineering Handbook*, Van NostrandReihnhold, New York, 1987.
7. N. K. Mehta, Machine tool design, Tata Mcgraw-hill, New Delhi, 1989.
8. Geoffrey Boothroyd, Peter Dewhurst and Winston Knight, Product Design for Manufacturing and Assembly, 2nd Edition
9. C. Howard, *Modern Welding Technology*, Prentice Hall, 1979.
10. Grieves, Michael, Product Lifecycle Management, McGraw-Hill, 2006. ISBN 0071452303
11. Stark, John. Product Lifecycle Management: Paradigm for 21st Century Product Realization, SpringerVerlag, 2004. ISBN 1852338105

Automobile Engineering

BTAPE504D	PEC2	Automobile Engineering	3-0-0	
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Teaching Scheme	Examination Scheme
Lecture: 3 Hrs/week	Continuous Assessment: 20 Marks Mid semester examination: 20 Marks End Semester Exam: 60 Marks (3

	hrs duration)
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Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to :

CO1	Identify the different parts of the automobile.
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CO2	Explain the working of various parts like engine, transmission, clutch, brakes etc.,
CO3	Demonstrate various types of drive systems.
CO4	Apply vehicle troubleshooting and maintenance procedures.
CO5	Analyze the environmental implications of automobile emissions. And suggest suitable regulatory modifications.
CO6	Evaluate future developments in the automobile technology.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
O1	2	1										
CO2	1	2		2		1						
CO3	1	1		1	1							
CO4	2			3	1							
CO5		2			1	1	2					
CO6	1		2			2						

Course Contents:

Unit1: Introduction

Vehicle specifications, Classifications, Chassis layout, Frame, Main components of automobile and articulated vehicles; Engine cylinder arrangements, Power requirements, Tractive efforts and vehicle performance curves.

Unit2: Steering and Suspension Systems

Steering system; Principle of steering, Centre point steering, Steering linkages, Steering geometry and wheel alignment, power steering.

Suspension system: its need and types, Independent suspension, coil and leaf springs, Suspension systems for multi-axle vehicles, troubleshooting and remedies.

Unit3: Transmission System

Clutch: its need and types, Gearboxes: Types of gear transmission, Shift mechanisms, Over running clutch, Fluid coupling and torque converters, Transmission universal joint, Propeller shaft, Front and rear axles types, Stub axles, Differential and its types, Four wheel drive.

Unit4: Brakes, Wheels and Tyres

Brake: its need and types: Mechanical, hydraulic and pneumatic brakes, Disc and drum type: their relative merits, Brake adjustments and defects, Power brakes
Wheels and Tyres: their types; Tyre construction and specification ; Tyre wear and causes; Wheel balancing.

Unit5: Electrical Systems

Construction, operation and maintenance of lead acid batteries, Battery charging system, Principle and operation of cutout and regulators, Starter motor, Bendix drive, Solenoid drive, Magneto-coil and solid stage ignition systems, Ignition timing.

Vehicle Testing and Maintenance

Need of vehicle testing, Vehicle test standards, Different vehicle tests, Maintenance: trouble shooting and service procedure, over hauling, Engine tune up, Tools and equipment for repair and overhauling, Pollution due to vehicle emissions, Emission control system and regulations.

Texts:

1. Kripal Singh, “Automobile Engineering”, Vol.I and II, Standard Publishers.
2. G.B.S.Narang, “Automobile Engineering”, Dhanpat Rai and Sons.

References:

1. Joseph Heitner, “Automotive Mechanics”, East-West Press.
2. W.H.Crouse, “Automobile Mechanics”, Tata McGraw Hill Publishing Co.

Open Elective-I

Solar Energy

BTMOE505A	OEC1	Solar Energy	3-0-0	3 credits
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Teaching Scheme: Lecture: 3 hrs/week	Examination Scheme: Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)
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Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Describe measurement of direct, diffuse and global solar radiations falling on horizontal and inclined surfaces.
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CO2	Analyze the performance of flat plate collector, air heater and concentrating type collector.
CO3	Understand test procedures and apply these while testing different types of collectors.
CO4	Study and compare various types of thermal energy storage systems.
CO5	Analyze payback period and annual solar savings due to replacement of conventional systems.
CO6	Design solar water heating system for a few domestic and commercial applications.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1											
CO2	1	2				1						
CO3	2			1	1		2					
CO4	1	1										
CO5		2			1							
CO6			2	3		1	1					

Course Contents

Unit 1: Solar Radiation

Introduction, spectral distribution, solar time, diffuse radiation, Radiation on inclined surfaces, measurement of diffuse, global and direct solar radiation.

Unit 2: Liquid Flat Plate Collectors

Introduction, performance analysis, overall loss coefficient and heat transfer correlations, collect or efficiency factor, collect or heat removal factor, testing procedures.

Unit 3: Solar Air Heaters

Introduction, types of air heater, testing procedure.

Unit 4: Concentrating Collectors

Types of concentrating collectors, performance analysis

Unit 5: Thermal Energy Storage and Economic Analysis

Introduction, sensible heat storage, latent heat storage and thermochemical storage

Solar Pond: Solar pond concepts, description, performance analysis, operational problems.

Economic Analysis

Definitions, annular solar savings, payback period.

Texts:

1. J. A. Duffie, W. A. Beckman, "Solar Energy Thermal Processes", John Wiley, 1974.
2. K. Kreith, J. F. Kreider, "Principles of Solar Engineering", Tata McGrawHill Publications, 1978.

References:

1. H. P. Garg, J. Prakash, "Solar Energy: Fundamentals and Applications", Tata McGraw Hill Publications, 1997.
2. S. P. Sukhatme, "Solar Energy Principles of Thermal Collection and Storage", Tata McGraw Hill Publications, 1996.

Renewable Energy Sources

BTMOE505B	OEC1	Renewable Energy Sources	3-0-0	Credits
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Teaching Scheme: Lecture: 3 hrs/week	Examination Scheme: Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)
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Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Explain the difference between renewable and non-renewable energy
CO2	Describe working of solar collectors

CO3	Explain various applications of solar energy
CO4	Describe working of other renewable energies such as wind, biomass

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	3		2	3	3	3	2	2		2
CO2	1	1	3	1	2	3	3	3	2	2		2
CO3	2	1	1				3	2		1		2
CO4	3	3			2	3	3	2				1

Course Contents:

Unit1: Introduction

Energy resources, Estimation of energy reserves in India, Current status of energy conversion technologies relating to nuclear fission and fusion, solar energy.

Unit2: Solar Radiations

Spectral distribution, solar geometry, Attenuation of solar radiation in Earth's atmosphere, Measurement of solar radiation, Properties of opaque and transparent surfaces.

Unit3: Solar Collectors

Flat Plate Solar Collectors: Construction of collector, material, selection criteria for flat plate collectors, testing of collectors, Limitation of flat plate collectors, Introduction to ETC.

Concentrating type collectors: Types of concentrator's advantages, paraboloid, parabolic trough, Heliostat concentrator, Selection of various materials used in concentrating systems, tracking.

Unit4: Solar Energy Applications

Air/ Water heating, Space heating/cooling, solar drying, and solar still, Photo-voltaic conversion.

Unit5: Wind Energy and Biomass and Other Renewable Energy Sources

Types of wind mills, Wind power availability, and wind power development in India. Evaluation of sites for bio-conversion and bio-mass, Bio-mass gasification with special reference to agricultural waste.

Other Renewable Energy Sources: Tidal, Geo-thermal, OTEC; Mini/micro hydro-electric, Geo-thermal, Wave, Tidal System design, components and economics.

Texts:

1. Chetansingh Solanki, "Renewable Energy Technologies", Prentice Hall of India, 2008.

References:

1. S. P. Sukhatme, "Solar Energy: Principles of Thermal Collection and Storage", Tata McGraw Hill Publications, New Delhi, 1992.

2. G. D.Rai, “SolarEnergyUtilization”,KhannaPublisher,Delhi,1992.

Human Resource Management

BTMOE505C	OEC1	Human Resource Management	3-0-0	3 Credits
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Teaching Scheme: Lecture: 3 hrs/week	Examination Scheme: Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03 hrs)
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Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Describe trends in the labor force composition and how they impact human resource management practice.
CO2	Discuss how to strategically plan for the human resources needed to meet organizational goals

	and objectives.
CO3	Define the process of job analysis and discuss its importance as a foundation for human resource management practice
CO4	Explain how legislation impacts human resource management practice.
CO5	Compare and contrast methods used for selection and placement of human resources.
CO6	Describe the steps required to develop and evaluate an employee training program
CO7	Summarize the activities involved in evaluating and managing employee performance.
CO8	Identify and explain the issues involved in establishing compensation systems.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1					2						1	
CO2											3	
CO3										2		
CO4								2		2		
CO5									2	3		
CO6										1		3
CO7										2	2	
CO8											2	

Course Contents:

Unit1: Introduction to Human Resource Management

Concept of management, concept of human resource management, personnel to human resource management, human resource management model, important environmental influences like government regulations, policies, labor laws and other legislation. Acquisition of human resources: Human resource planning, Demand for man power, Weaknesses of manpower planning, job analysis, job specification, recruitment sources, recruitment advertising, the selection process, selection devices, equal opportunities: Indian and foreign practices, socializing then ewmployee

Unit2: Development of Human Resources

Employee Training and Management Development: Training, Training and Learning, Identification of training needs, training methods, Manager Development, Methods for developing managers, evaluating training effectiveness
 Career Development: Concept of career, value of effective career development, external versus internal dimensions to a career, career stages, linking career dimensions with stages

Unit3: Motivation of Human Resources

Definition of motivation, Nature and Characteristics of Motivation, Theories of motivation: Maslow's Need Hierarchy Theory, Drucker Theory, Likert Theory, Herzberg Two Factor Theory, McClell and Theory, McGregor Theory X and Y, etc., Psychological approach.
 Job Design and Work Scheduling: Design, Scheduling and Expectancy Theory, Job characteristics model, job enrichment, job rotation, work modules, flex-time, new trends in work scheduling.

Unit4: Performance Appraisal

Performance appraisal and expectancy theory; appraisal process, appraisal methods, factors that can destroy appraisal.
 Rewarding the Productive Employee: Rewards and expectancy theory, types of rewards, qualities of effective rewards, criteria for rewards.

Unit5: Maintenance of Human Resources and Labor Relations

Compensation Administration: Concept of Compensation Administration, Job evaluation, Pay structures, Incentives compensation plans.

Benefits and Services Benefits: Something for everybody, Services, Trends in benefits and services.

Discipline: Concept of Discipline, types of discipline problems, general guidelines, disciplinary action, employment-at-will doctrine, disciplining special employee groups Safety and Health: safety programs, health programs, stress, turn out.

Labor Relations

Unions, Major labor legislation, goals of group representation.

Collective Bargaining: Objectives, scope, participants of collective bargaining, process of collective bargaining, trends in collective bargaining

Research and the future: What is research? Types of research, why research in human resource management, Secondary sources: where to look it up, Primary sources: relevant research methods, current trends and implications for human resource management.

Texts:

David A. DeCenzo, Stephen P. Robbins,

“Personnel/Human Resources Management”, Prentice Hall of India Pvt. Ltd, 3rd edition, 2002.

Trevor Bolton, “An Introduction to Human Resource Management”, Infinity Books, 2001.

References:

Ellen E. Kossek, “Human Resource Management – Transforming the Workplace”, Infinity Books, 2001.

G.S. Batra, R.C. Dangwal, “Human Resource Management New Strategies”,

Deep and Deep Publications Pvt. Ltd., 2001.

D.M. Silvera, “HRD: The Indian Experience”, New India Publications, 2nd edition, 1990.

Product Design Engineering

BTMOE505D	OEC1	Product Design Engineering – I	3-0-0	3 Credits
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Teaching Scheme: Lecture: 3hr/Week	Examination Scheme: Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)
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- **Pre-requisites:** Knowledge of Basic Sciences, Mathematics and Engineering Drawing

Course Outcomes: At the end of the course, students will be able to

1. Understand the need for product design
2. Apply various methods of idea generation
3. Understand various types of prototypes and testing methods
4. Understand the product economics at production scale
5. Appreciate the environmental concerns in product lifecycle

Course Contents:

Unit 1: Introduction to Engineering Product Design

[07 Hours]

Trigger for Product/Process/System, Problem solving approach for Product Design, Disassembling existing product(s) and understanding relationship of components with each other, identifying materials and their processing for final product, fitting of components, understanding manufacturing as scale of the components, Reverse engineering concept,

Unit 2: Ideation & Conceptualization

[07 Hours]

Generation of ideas, funneling of ideas, Short-listing of ideas for product(s) as an individual or group of individuals, Market research for need, competitions, Product architecture, Designing of components, Drawing of parts and synthesis of a product from its component parts, 3-D visualization,

Unit 3: Testing and Evaluation Prototyping:

Design Automation, Prototype testing and evaluation, Working in multidisciplinary teams, Feedback to design processes, Process safety and materials, Health and hazard of process operations.

Unit 4: Manufacturing

[07 Hours]

Design models and digital tools, Decision models, Prepare documents for manufacturing in standard format, Materials and safety data sheet, Final Product specifications sheet, Detail Engineering Drawings (CAD/CAM programming), Manufacturing for scale, Design/identification of manufacturing processes

Unit 5: Environmental Concerns

[07 Hours]

Product life-cycle management, Recycling and reuse of products, Disposal of product and waste. Case studies.

Reference:

1. Model Curriculum for “Product Design Engineer – Mechanical”, NASSCOM (Ref. ID: SSC/Q4201, Version 1.0, NSQF Level: 7)
2. Eppinger, S., & Ulrich, K.(2015). Product design and development. McGraw-Hill Higher Education.
3. Green, W., & Jordan, P. W. (Eds.).(1999).Human factors in product design: current practice and future trends. CRC Press.

4. Sanders, M. S., & McCormick, E. J. (1993). Human factors in engineering and design. McGRAW-HILLbookcompany.
5. Roozenburg, N. F., & Eekels, J. (1995). Product design: fundamentals and methods (Vol. 2). John Wiley & Sons Inc.
6. Lidwell, W., Holden, K., & Butler, J. (2010). Universal principles of design, revised and updated: 125 ways to enhance usability, influence perception, increase appeal, make better design decisions, and teach through design. Rockport Pub.

Metrology and Quality Control

BTPC6	PCC 11	Metrology and Quality Control	3-1-0	4 Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Identify techniques to minimize the errors in measurement
CO2	Identify methods and devices for measurement of length, angle, and gear and thread parameters, surface roughness and geometric features of parts.
CO3	Choose limits for plug and ring gauges.
CO4	Explain methods of measurement in modern machineries
CO5	Select quality control techniques and its applications
CO6	Plot quality control charts and suggest measures to improve the quality of product and reduce cost using Statistical tools.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1				3								2
CO2		2	2		2							
CO3			2	3	2							
CO4						3						
CO5	1					2		3	3		3	2

CO6	1					2		3	3		2	2
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Course Contents:

Unit 1: Measurement Standard and Comparators [07 Hours]

Measurement Standard, Principles of Engineering Metrology, Line end, wavelength, Traceability of Standards. Types and Sources of error, Alignment, Slip gauges and gauge block, Linear and Angular Measurement (Sine bar, Sine center, Autocollimator, Angle Décor and Dividing head), Calibration. Comparator: Mechanical, Pneumatic, Optical, Electronic (Inductive), Electrical (LVDT).

Unit 2: Interferometry and Limits, Fits, Tolerances [07 Hours]

Principle, NPL Interferometer, Flatness measuring of slip gauges, Parallelism, Laser Interferometer, Surface Finish Measurement: Surface Texture, Measuring Surface Finish by Stylus probe, Tomlinson and Talysurf, Analysis of Surface Traces: Methods. Design of Gauges: Types of Gauges, Limits, Fits, Tolerance; Terminology for limits and Fits. Indian Standard (IS 919-1963) Taylor's Principle.

Unit 3: Metrology of Screw Thread [07 Hours]

Gear Metrology: Gear error, Gear measurement, Gear Tooth Vernier; Profile Projector, Tool marker's microscope. Advancements in Metrology: Co-ordinate Measuring Machine, Universal Measuring Machine, Laser in Metrology.

Unit 4: Introduction to Quality and Quality Tools [07 Hours]

Quality Statements, Cost of Quality and Value of Quality, Quality of Design, Quality of Conformance, Quality of Performance, Seven Quality Tools: Check sheet, Flow chart, Pareto analysis, cause and effect diagram, scatter diagram, Brain storming, Quality circles.

Unit 5: Total Quality Management and Statistical Quality Control [07 Hours]

Quality Function Deployment, 5S, Kaizan, Kanban, JIT, Poka yoke, TPM, FMECA, FTA, Zero defects. Statistical Quality Control: statistical concept, Frequency diagram, Concept of Variance analysis, Control chart for variable & attribute, Process Capability. Acceptance Sampling: Sampling Inspection, sampling methods. Introduction to ISO 9000: Definition and aims of standardizations, Techniques of standardization, Codification system.

Texts:

1. I. C. Gupta, "Engineering Metrology", Dhanpatand Rai Publications, New Delhi, India.
2. M. S. Mahajan, "Statistical Quality Control", Dhanpat and Rai Publications.

References:

1. R. K. Jain, "Engineering Metrology", Khanna Publications, 17th edition, 1975.
2. K. J. Hume, "Engineering Metrology", McDonald Publications, 1st edition, 1950.
3. A. W. Judge, "Engineering Precision Measurements", Chapman and Hall, London, 1957.

4. K. L. Narayana, "Engineering Metrology", Scitech Publications, 2nd edition.
 5. J. F. Galyer, C. R. Shotbolt, "Metrology for Engineers", Little-hampton Book Services Ltd., 5th edition, 1969.
 6. V. A. Kulkarni, A. K. Bewoor, "Metrology & Measurements", Tata McGraw Hill Co. Ltd., 1st edition, 2009.
 7. AmitavaMitra, "Fundamental of Quality Control and Improvement", Wiley Publication.
 8. V. A. Kulkarni, A. K. Bewoor, "Quality Control", Wiley India Publication, 01st August, 2009.
 9. Richard S. Figliola, D. E. Beasley, "Theory and Design for Mechanical Measurements", Wiley India Publication.
 10. E. L. Grant, "Statistical Quality Control", Tata McGraw Hill Publications.
- J. M. Juran, "Quality Planning and Analysis", Tata McGraw Hill Publications.

Production Engineering Lab-III

BTPCL506	PCC11	Production Engineering Lab III	0-0-4	2Credit
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Practical Scheme: Practical: 4hrs/batch	Examination Scheme: Continuous Assessment: 60 Marks External Exam: 40 Marks
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List of Practical's/Experiments/Assignments (Any 6 from Group-A and Any 4from Group-B)

Group-A (Production Process Lab)

1. Making a job with a process plan involving plain, step and taper turning as well thread cutting as operations on a Centre lathe.
2. Preparation of process planning sheet for a job including operations such as milling, drilling and shaping.
3. Making a spur gear using universal dividing head on milling machine.
4. Making a simple component by sand casting using a split pattern.
5. Cutting of a steel plate using oxyacetylene flame cutting /plasma cutting.
6. Making a butt joint on two stainless steel plates using TIG/MIG Welding.
7. An experiment on shearing operation.
8. An experiment on blanking operation.
9. An experiment on drawing operation

10. Arc Welding.
11. Non Destructive Testing: Magnetic Inspection Testing
12. Non Destructive Testing: Ultrasonic Testing
13. Determine Roll pass scheduling for Blooming Mill and Drawing of Grooved Rolls.
14. Design Simple Die for Cutting Operation.
15. Design and Drawing of Bending/Forming/Coining Dies.
16. Assignment on Sand Casting.
17. Design of Forging Dies.
18. Assignment on Extrusion Process.

Group-B (Design of Machine Element Practice)

1. The term work shall consist of two design projects based on the syllabus of Design of machine Element. Each design project shall consist of two imperial size sheets- one involving assembly drawings with a part list and overall dimensions and other sheet involving drawings of individual components. Manufacturing tolerances, surface finish symbols and geometric tolerances should be specified, wherever necessary, so as to make it working drawing
2. A design report giving all necessary calculations for the design of components and assembly should be submitted in a separate file.

Two assignments based on topics of syllabus of Design of machine Element.

IT – 2 Evaluation

PROJ-2	BTPI408 (IT – 2)	IT – 2 Evaluation	-	-	-	-	-	100	100	1
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Semester-VI

Machine Tools and Metal Cutting

BTPC601	PCC 12	Machine Tools and Metal Cutting	3-1-0	4Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03 hrs)

Objectives: To make student aware of tool geometry, tool signature, and mechanics of chip formation, types of chip, tool wear, and surface finish and need of cutting fluids, machinability of the materials. Study of various features and capabilities of various machine tools, machining time calculation will help in selection of appropriate machine tool for a particular application.

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Classify various machine tools and estimate machining time.
CO2	Calculate the cutting forces in orthogonal and oblique cutting.
CO3	Evaluate the machinability of materials.
CO4	Identify the abrasive processes.
CO5	Classify the different precision machining processes.
CO6	Design jigs and fixtures for given application.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	1				1							
CO2	1			1	1							
CO3	1			1	1							
CO4	1				1							
CO5	1				1							
CO6	1		1		1							1

Course Contents:

Unit1: Classification of Metal Removal Processes and Machine Tools

Introduction to Manufacturing and Machining, Basic working principle, configuration, specification and classification of machine tools, Construction, working principle and applications of shaping, planning and slotting machines, Use of various attachments in Machine Tools, Estimation of machining time

Unit2: Mechanics of Machining (Metal Cutting)

Geometry of single point cutting tools, Mechanism of chip formation, Orthogonal and oblique cutting, Use of chip breaker in machining, Machining forces and Merchant's Circle Diagram (MCD), Analytical and Experimental determination of cutting forces, Dynamometers for measuring cutting Forces, Cutting temperature: causes, effects, assessment and control, Control of cutting temperature and cutting fluid application

Unit3: Machinability

Concept of Machinability and its improvement, Failure of cutting tools and tool life, Cutting Tool Materials of common use, Advanced Cutting Tool Materials

Unit4: Abrasive Processes (Grinding and Super Finishing)

Basic principle, purpose and application of grinding, Selection of wheels and their conditioning, Classification of grinding machines and their uses, Super finishing processes, Honing, Lapping and Super finishing

Unit5: Gear and thread manufacturing

Production of screw threads by Machining, Rolling and Grinding, Manufacturing of Gears, Broaching – Principles and Applications

Introduction to Jigs and Fixtures

Role and importance of jigs and fixture, Principle of location and clamping, Locating, Supporting and clamping elements, Application of typical jigs and fixtures.

Texts:

1. P.N.Rao, "Manufacturing Technology- Metal Cutting and Machine Tools", Vol. II, Tata McGraw Hill Publishing Co. Ltd, New Delhi, 2nd edition, 2002.

2. Amitabha Bhattacharyya, G. C. Sen, “Principle of MetalCutting”, New Central Book Agency,1969.
3. M.C.Shaw,“TheoryofMetalCutting”,OxfordandI.B.H.Publishing,1st edition,1994.
4. P.H.Joshi,“JigsandFixtures”,TataMcGrawHillPublishingCo., NewDelhi.

References:

1. MilkellP.Groover,“FundamentalsofModernManufacturing: Materials,Processes, andsystems”,JohnWileyandSons,NewJersey, 4th edition,2010.
2. SeropeKalpakjianandStevenR.Schmid,“ManufacturingEngineeringandTechnology”, AddisonWesleyLongman(Singapore)Pte.IndiaLtd., 4thedition,2000.
3. GeoffreyBoothroyd,WinstonKnight,“FundamentalsofMachiningandMachineTools”, TaylorsandFrancis,3rd edition,2006.
4. EdwardG.Hoffman,“JigsandFixturesDesign”,CengageLearning,5th edition,2004.
5. Paul DeGarmo, J.T. Black, RonaldA. Kohser, “Materials and Processes in Manufacturing”,Wiley,10th edition,2007.
6. www.nptel.com, IIT Kharagpur, Manufacturing ProcessesI.

CO4	3											1
CO5	1	3	3		1							1
CO6	3	1	1		1							1
CO7	3											1
CO8	3	1	2	3	1							1
CO9	2	1										1

Course Contents:

Unit1: ComputerAidedDesign(CAD)

Hardware requiredforCAD:Interactiveinput output devices,Graphicssoftware:general requirementsandgroundrules,2 –DcurveslikeLine,Circle,etc.andtheiralgorithms, 2-D and 3-DtransformationsuchasTranslation,Scaling,RotationandMirror

Unit2: BezierandB-splinesCurves

EquationsandApplications, window andviewportclippingalgorithms,3-Dgeometries, CSG, B-rep, wireframe,surfaceandsolidmodelingandtheirrelativeadvantages,limitationsandapplications.

Unit3: ComputerAidedManufacturing(CAM)

NumericalControl, ElementsofaNCsystem,StepsinNCbasedmanufacturing,Point to point,straightlineandcontouringcontrol,ManualandComputerAssistedPartProgramming,NCand APT programming, Adaptive control, Distributed Numerical Control.

Unit4: FiniteElementMethods

Introduction,Typesofelements,Degreesoffreedom,Fieldvariable,Shapefunction, Boundary conditions,Meshing,Nodaldisplacements,Plainstressandplainstrain problems,1-D,2-Dand3-Dproblems,Static,dynamicandthermalanalysis,Preprocessors –solvers–postprocessor.

Unit5: FlexibleManufacturingSystem

Introduction,ComponentsofFMS,GroupTechnology,Partclassificationandfamilies,Compositepart ,Typesof FMSlayouts,AdvantagesofFMS

Robotics:Robotconfigurations,

Drivesforrobots,Sensorsusedinrobotics,Programmingtechnique,Programminglanguages,Applications,Latestdevelopmentinrobotics

ComputerAidedProcessPlanning

Introduction, RetrievalandGenerativeCAPPsystems, generationofMachiningData.

ComputerIntegratedManufacturing:

Introduction,Typesofdata,Typesofinterfaces,Computernetworkstructures, Computerizedproductionmanagementsystems,Inventorymanagement,MRP,Operationscheduling, Processmonitoring,Computeraidedqualitycontrol,Testing/Inspectionmethods.

Texts:

IbrahimZeid,“CAD/CAMTheoryandPractice”, TataMcGrawHillPublication,

M. P. Grover,Zimmer,“CAD/CAM/CIM”, PrenticeHallIndia.

Elective-III

Robotics & Automation

BTPPE603A	PEC3	Robotics& Automation	3-1-0	4Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	List the various components of a typical Robot, grippers, sensors, drive system and describe their functions
CO2	Calculate the world to joint and joint to world coordinates using forward and reverse transformations
CO3	Calculate the gripper forces, drive sizes, etc.
CO4	Develop simple robot program for tasks such as pick and place, arc welding, etc. using some robotic language such as VAL-II, AL, AML, RAIL, RPL, VAL
CO5	Evaluate the application of robots in applications such as Material Handling, process operations and Assembly and inspection
CO6	Discuss the implementation issues and social aspects of robotics

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

Course Contents:

Unit 1: Introduction

Various basic components of a Robotic system, various configurations, work envelopes, Manipulators, sensors, controllers, etc.

Unit 2: Mechanical System in Robotics

Motion conversion, Kinematic chains, position analysis, forward and backward transformations, natural and joints pace coordinates.

Unit 3: Drives for Robot

Electrical drives, Stepper motor, DC motors, AC motors, hydraulic and pneumatic drives, hybrid drives, drive selection for robotics joints.

Unit 4: Sensors in Robotics

Position sensor, velocity sensor, proximity sensors, touch sensors, force sensors, etc.

Robot Programming

Path planning, Leadthrough(manual and powered) programming, teach pendant mode, programming languages, AL, AML, RAIL, RPL, VAL pmentin robotics

Unit 5: Artificial Intelligence for Robots: Knowledge Representation, Problem representation and problem solving, search techniques in problem solving

Robot Applications

Application of robot in: Material handling, assembly and inspection, process operations, etc.

Texts:

1. M. P. Grover, "Industrial Robotics: Technology, Programming and Applications", Tata McGraw Hill Publication.

References:

1. Saeed B. Niku, "Introduction to Robotics, Analysis, Systems, Applications", Pearson Education.
2. Richard D. Klafter, "Robotic Engineering: An Integrated Approach", Prentice Hall of India.

Assembly Planning and Management

BTPPE603B	PEC3	Assembly Planning and Management	3-1-0	4Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03 hrs)

Objectives: To gain an understanding and interest in the assembly line design practices prevalent in industry and ability to recognize situations in an assembly system environment those suggest the use of certain quantitative methods to assist in decision making. To learn how to think about, approach, analyze, and solve assembly system problems using people skills (predominantly) and technology.

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Illustrate key characteristics and types of assembly.
CO2	Classify the various methods of assembly sequence planning.
CO3	Outline the concept of assembly line design.
CO4	Solve simple assembly line balancing problems.
CO5	Formulate and solve generalized assembly line balancing problems.
CO6	Illustrate need and approaches for reconfiguration of assembly lines.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1				1							
CO2	1				1							
CO3	1	1			1							
CO4	1				1		1					
CO5	1				1		1					
CO6	1				1	1						

Course Contents:

Unit 1: Introduction to Assembly Planning

Assembling a product, manual and automatic assembly, robotic assembly, Liaison diagram, assembly process, key characteristics of assembly, variation risk and its management.

Unit 2: Assembly Sequence Planning

Introduction, assembly sequence design process, Bourjault method of generating all feasible sequences, cutest method, stability of subassemblies, softwares

Unit 3: Assembly Line Design

Process of Assembly Line Design (ALD), components of ALD, consideration of equipment's, buffers etc. Introduction to assembly line balancing and defining assembly line balancing problem using precedence diagrams.

Unit 4: Simple Assembly Line Balancing Problem (SALBP)

Performance Characteristics, types of SALBP, optimal solution methods for SALBP, heuristics and meta-heuristics, introduction to Genetic Algorithm, applying simple genetic algorithmic approach to SALBP.

Unit 5: Generalized Assembly Line Balancing Problem (GALBP)

Considerations leading to GALBP, formulation and solution approaches for a few types of GALBP such as assignment restrictions, mixed model ALBP, U-line ALBP, parallelization, etc.

Reconfiguration

Need and importance of reconfiguration/rebalancing, approaches for reconfiguration.

Texts and References:

1. Daniel E. Whitney, "Mechanical Assemblies", Oxford University Press, 2004
2. Mikell P. Groover, "Automation: Production Systems and Computer Integrated Manufacturing", Second edition, Prentice Hall of India, 2002

IC Engines

BTMPE603A	PEC3	IC Engines	3-0-0	3Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: Applied Thermodynamics – I

Course Outcomes: At the end of the course, students will be able to

CO1	
CO2	
CO3	
CO4	
CO5	
CO6	

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

Course Contents:

Unit 1: Fundamentals of IC Engines

Applications, nomenclature, engine components, Engine classification, two and four stroke cycle engines; fundamental difference between SI and CI engines; valve timing diagrams.

Power Cycles: Air standard Otto, Diesel and Dual cycles; Valve timing diagrams, Fuel-Air cycles and deviation of actual cycles from ideal cycles.

Unit 2: Combustion

Introduction, important qualities and ratings of SI Engines fuels; qualities and ratings of CI Engine fuels.

Combustion in S.I. Engines, flame speed, ignition delay, normal and abnormal combustion, effect of engine variables on flame propagation and ignition delay, Combustion in C.I. Engines, combustion of a fuel drop, stages of combustion, ignition delay, combustion knock; types of SI and CI Engine combustion chambers.

Unit 3: Various Engine Systems and Engine Testing and Performance

Starting systems, fuel supply systems, engine cooling system, ignition system, engine friction and lubrication systems, governing systems.

Engine Testing and Performance of SI and CI Engines

Parameters, Type of tests and characteristic curves.

Super charging in IC Engine: Effect of attitude on power output, types of supercharging.

Engine Emissions and control: Pollutants from SI and CI engines and their control, emission regulations such as Bharat and Euro.

Unit 4: Alternate fuels

Need for alternative fuels, applications, various alternate fuels etc

Gaseous Fuels, Alcohols, Biodiesels, vegetable oil extraction, Trans-esterification process, properties of alternative fuels and fuel blends.

Fuel Cell Technology: Operating principles, Types, construction, working, application, advantages and limitations.

Unit 5: Layout of Electric vehicle and Hybrid vehicles

Advantages and drawbacks of electric and hybrid vehicles, System components, Electronic control system – Different configurations of Hybrid vehicles, Power split device. High energy and power density batteries – Basics of Fuel cell vehicles

Texts&References:

1. V. Ganeshan, "Internal Combustion Engines", Tata McGraw Hill Publications, New Delhi, 3rd edition.
2. J. B. Heywood, "Internal Combustion Engine Fundamentals", Tata McGraw Hill Publications, New York, International Edition, 1988.
3. "Alternative Fuels", Dr. S. S. Thipse, Jaico publications.
4. "IC Engines", Dr. S. S. Thipse, Jaico publications.
5. "Engine Emissions, pollutant formation", G. S. Springer and D.J. Patterson, Plenum Press.
6. ARAI vehicle emission test manual.
7. Gerhard Knothe, Jon Van Gerpen, Jargon Krahl, "The Biodiesel Handbook", AOCS Press
8. Champaign, Illinois 2005.
9. Richard L Bechtold P.E., Alternative Fuels Guide book, Society of Automotive Engineers,
10. 1997, ISBN 0-76-80-0052-1.

Transactions of SAE on Biofuels (Alcohols, vegetable oils, CNG, LPG, Hydrogen, Biogas etc.

Mechanical Vibration

BTMPE603B	PEC3	Mechanical Vibration	3-0-0	Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: Theory of Machines - II

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the cause and effect of vibration in mechanical system
CO2	Formulate governing equation of motion for physical system
CO3	Understand role of damping, stiffness and inertia in mechanical system
CO4	Analyze rotating system and calculate critical speeds
CO5	Estimate the parameters of vibration isolation system
CO6	Estimate natural frequencies and mode shapes of continuous system

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	2	1	1					2
CO2	3	3	2	1	1							2
CO3	3	2	2	1	1							2
CO4	3	3	2	2	2							2
CO5	3	3	2	2	2		3					2
CO6	3	3	3	2								2

Course Contents:

Unit 1: Single DOF- Free Vibrations

Basic concepts: Causes and effect of vibrations, practical applications, harmonic and periodic motions, vibration terminology, vibration model, Equation of motion -natural frequency, Energy method, Rayleigh method, principle of virtual work, damping model, viscously damped free vibration, Oscillatory, non-oscillatory and critically damped motions, logarithmic decrement. Coulomb's damping.

Unit 2: Single DOF- Forced Vibrations

Analysis of linear and torsional system subjected to harmonic force excitation, force transmissibility, Magnification factor, motion transmissibility, vibration isolation, typical isolator and mounts, critical speed of single rotor, undamped and damped.

Unit 3: Two DOF Systems

Introduction, formulation of equation of motion, equilibrium method, lagrangian method, free vibration response, Eigen values and eigen vector, Normal mode and mode superposition, Coordinate coupling, decoupling equation of motion.

Unit 4: Torsional Vibration

Simple system with one or two rotor masses, Multi DOF system: transfer matrix method, geared system, and branched system.

Unit 5: Multi Degree of Freedom System and Continuous Systems

Formulation of equation of motion, free vibration response, natural mode and mode shapes, orthogonality of model vectors, normalization of model vectors, decoupling of modes, model analysis, mode superposition technique. Free vibration response through model analysis. DF

Continuous Systems

Vibration of strings, longitudinal and transverse vibration of rods, transverse vibrations of beams, equation of motions and boundary conditions, transverse vibration of beams, natural frequencies and mode shapes.

Texts:

1. L. Meirovich, "Elements of Vibration Analysis", Tata McGraw Hill.

References:

1. S. S. Rao, "Mechanical Vibrations", Pearson education.
2. W. T. Thompson, "Theory of Vibration", CBS Publisher.

Machine Tool Design

BTMPE603C	PEC3	Machine Tool Design	3-0-0	3Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 2 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: Machine design and Manufacturing processes-I

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand basic motion involved in a machine tool.
CO2	Design machine tool structures for conventional and CNC machines.
CO3	Design and analyze system for specified speeds and feeds.
CO4	Understand control strategies for machine tool operations.
CO5	Design of rotary and linear drive for machine tools.
CO6	Analyze machine tool structure for design accuracy.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2	1	1	1				1	1	1
CO2	3	1	3	1	2	1	1		1	1	1	1
CO3	2	1	2	1	1	1			1	1	1	1
CO4	2	1	1	1	1	1	1			1	1	1
CO5	3	1	3	1	1	1	1		1	1	1	1
CO6	2	1	2	1	1	1	1		1	1	1	1

Course Contents:

Unit 1: Introduction

Kinematics of different types of machine tools, selection of cutting conditions and tools, calculations of cutting force on single point and multipoint tools, hole machining, calculation of power, accuracy requirements and standards.

Unit 2: Design of Rotary Drives

Design of spindle drives, AC motors with stepped drive, DC and AC variable speed drive motor characteristics and selection, principle of speed controllers, timing belts and other types of transmission belting, closed loop operation of mail drives, rotary indexing drives.

Unit 3: Design of Feed Drives

Feed drive using feed boxes, axes feed drive of CNC drives, DC and AC servomotors, characteristics controllers and their selection, Ball screws and friction guide ways, linear motion systems, design calculation of drives, closed loop operations of feed drive, linear indexing drives.

Unit 4: Control Elements

Single and multi-axis CNC controllers, hydraulic control, Pneumatic control limit switches, proximity switches, sequencing control using hardwired and PLC systems.

Design of machine tool structures: Static and dynamic stiffness, dynamic analysis of cutting process, stability, forced vibration, ergonomics and aesthetics in machine tool design.

Unit 5: Design of Spindle and Spindle Supports and Design of Special Purpose Machines

Function of spindles, design requirements, standard spindle noses, design calculation of spindles, bearing selection and mounting.

Finite elements analysis of machine tool structures: Examples of static, dynamic and thermal analysis and optimization of typical machine tool structure like column and using a finite element analysis package.

Design of Special Purpose Machines

Modular design concepts, standard modules, example of design of typical SPM with CNC, transfer machines.

Texts:

1. N. K. Mehta, "Machine Tool Design", Tata McGraw Hill Book Co., 1991.
2. P.C. Sharma, "A Textbook of Machine Tools and Tool Design", S. Chand & Co. Ltd., 1 January 2005.
3. Sen and Bhattacharya, "Principles of Machine Tools", 1 Jan 2009.
4. YoramKoren, "Computer control of manufacturing systems", Tata McGraw Hill Education, 2009.

References:

1. Aacherkan, "Machine Tool Design", Vol. I and Vol. III, Mir Publishers, Moscow,1970.
2. W. L. Cheney, "Details of Machine Tool Design (Classic Reprint)", Forgotten Books, 20 Sep 2016.
3. Central Machine Tool Institute, "Machine Tool Design Handbook", Tata McGraw Hill Education, 1st Edition, 16 June 2001.

Course Contents:

Domain Related Training (Approx. 40 hrs)

Unit 1:

BIW : Requirement Specification in the Pre-Program Stage, Product Life Cycle & Important Gateways for BIW, Identification of Commodities for BIW, Design Concept & Considerations in BIW, BIW Materials & Grades, GD & T for BIW.

Unit 2:

Sheet Metal Joining – Welds, Adhesives, TWBs. DFMEA, Design Verification – CAE Methods & Gateway supports Part A & B, CAE Analysis – NVH, Crash & Durability, Test Validation & Assessment.

Unit 3:

Manufacturing – Sequence, Welding & Assembly, Future Trends in BIW, BIW: Examples & Case Studies.

Unit 4:

Trims: Requirement Specification in the Pre-Program Stage, Product Life Cycle & Important Gateways for Trims, Identification of Commodities for Trims, Design Requirements & Considerations, Trim Materials in Automotive.

Unit 5:

Design of Plastic Part, DFMEA, Design Verification – CAE Methods & Gateway supports, CAE Analysis – Moldflow, Crash & Durability, Test Validation & Assessment.

Manufacturing Process, Assembly Sequence, Future Trends & Future Material for Trims, Trims: Examples & Case Studies.

Texts:

1. Notes of TATA Technologies
2. Curt Larson, “ Datum Principles: Flexible Parts: Applications for Automotive Body-in-White and Interior Trim (Dimensional Management Series Book 1)”, Right Tech, Inc., Kindle Edition.
3. Curt Larson, “ Datum Principles: Flexible Parts: Applications for Automotive Body-in-White and Interior Trim (Dimensional Management Series Book 2)”, Right Tech, Inc., Kindle Edition.

References:

1. VukatoBoljanovic, “Sheet Metal Forming Processes and Die Design”, Industrial press Inc., Kindle Edition.
2. R. D. Cook, Concepts and Applications of Finite Element Analysis; John Wiley and Sons, second edition, 1981.
3. K.J. Bathe, Finite Element Method and Procedures; Prentice hall, 1996.
4. IbrahimZeid, “CAD/CAM Theory and Practice”, Tata McGraw Hill Publication,
5. J. H. Dubois And W. I. Pribble, *Plastics Mold Engineering Handbook*, Van NostrandReihnhold, New York, 1987.

6. Geoffrey Boothroyd, Peter Dewhurst and Winston Knight, Product Design for Manufacturing and Assembly, 2nd Edition
7. C. Howard, *Modern Welding Technology*, Prentice Hall, 1979.
8. Jesper Christensen and Christophe Bastien, "Nonlinear Optimization of Vehicle Safety Structures: Modeling of Structures Subjected to Large Deformations, Butterworth-Heinemann, Kindle Edition
9. Grieves, Michael, Product Lifecycle Management, McGraw-Hill, 2006. ISBN 0071452303
10. Stark, John. Product Lifecycle Management: Paradigm for 21st Century Product Realization, SpringerVerlag, 2004. ISBN 1852338105

Elective-IV

Production Planning and Control

BTPPE604A	PEC4	Production Planning and Control	3-1-0	4Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03 hrs)

Objectives: To gain an understanding and appreciation of the fundamental principles and methodologies relevant to planning, design, operation, and control of production systems. To reinforce analytical skills already learned, and build on these skills to further increase ones "portfolio" of useful analytical tools. To gain ability to recognize situations those suggest the use of certain quantitative methods to assist in decision making and learn how to think about, approach, analyze, and solve production system problems using both technology and skill people.

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Illustrate functions of PPC and basic concepts of product analysis.
CO2	Estimate output for a given data using various forecasting methods.
CO3	Determine the optimal production order quantity for a given data.

CO4	Estimate the machine output and process capacities in a multi-product system.
CO5	Solve the sequencing problems for the given data.
CO6	Estimate the inventory level by various methods for given data.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1				1							
CO2	1			1	1							
CO3	1			1	1						1	
CO4	1			1	1						1	
CO5	1			1	1							
CO6	1			1	1							

Course Contents:

Unit 1: Product Development and Design

Introduction: Functions of PPC, types of production, production consumption cycle, coordination of production decisions. Product Design and Company Policy, Product Analysis: Marketing Aspect, Product Characteristics, Economic Analysis, production Aspect.

Unit 2: Forecasting and Facility Layout

Introduction, Time Series Methods, Casual Methods, Forecast Errors. Facility Layout: Introduction, Flow Systems, Types of Layout: Product, Process, Group Layout, Computerized Layout Planning

Unit 3: Production Order

Purpose of production order, procedure for formulating production order, process outlines, process and activity charts, production master program, operation and route sheet, production order. Batch Production: Quantities in batch production, criteria for batch size determination, minimum cost batch size, production range, maximum profit batch size, maximum return and maximum rate of return economic batch size

Unit 4: Machine Output

Machine output, multi-machine supervision by one operator, machine interference, balancing of machine lines, analysis of process capacities in a multi-product system

Unit 5: Production and Operations Planning

Aggregate Planning, Strategies and techniques for Aggregate Planning, Production Planning in Mass Production Systems and Assembly Line Balancing, Sequencing problems such as 1

machine n jobs, 2 machines n jobs & its extension, m machines 2 jobs, scheduling jobs with random arrivals

Inventory Control

Inventory and its purpose, the relevant costs, selective inventory analysis (ABC analysis), Classical Inventory Model, EOQ with quantity discounts, EOQ for multiple items with constraints on resources, Safety Stock, determining safety stock when usage and lead time vary, Fixed Order Period Inventory Control System

Texts:

1. D.Bedworth and J.E Bailey, "Integrated Production Control: System-management, Analysis and Design", John Wiley, 1983.
2. A.Elsayed and T.O. Boucher, "Analysis and Control of Production Systems", Prentice Hall, 1985.
3. J. R. King, "Production Planning and Control", Pergamon Press, Oxford, 1975.

References:

1. P.F.Bestwick and K.Lockyer, "Quantitative Production Management", Pitman Publications, 1982.
2. A.C.HaxandD.Candea, "Production and Inventory Management", Prentice-Hall, 1984.
3. M.G.Korgaokar, "JIT Manufacturing", Macmillan, 1992.

Flexible Manufacturing Systems

BTPPE604B	PEC4	Flexible Manufacturing Systems	3-1-0	Credits
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Teaching Scheme: Lecture: 3hrs/week Tutorial: 1 hr/week	Examination Scheme: Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03 hrs)
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Objectives: To understand Flexible Manufacturing Systems, Configurations, Workstations, Control systems, applications and benefits.

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Define FMS, its need, benefits and limitations.
CO2	Outline layout, configuration and optimization of FMS.
CO3	Outline the process of installation, interfacing and monitoring of FMS.
CO4	Propose suitable FMS configuration for a given application.
CO5	Identify AGV, ASRS, transfer and feeding mechanisms in FMS.
CO6	Summarize tool management and monitoring strategies in FMS.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1				1							
CO2	1				1	1						
CO3	1				1	1						
CO4	1				1		1					
CO5	1				1				1			
CO6	1				1				1			1

Course Contents:

Unit 1: Overview of FMS

An overview, need for FMS, classification, benefits and limitations, components of FMS, Flexibility in manufacturing, Building blocks of FMS, FMS control, FMC Vs FMS.

Unit 2: Implementation of FMS

FM system development and implementation of an FMS, planning, description, layout and configuration, analysis and optimization of FMS, organization and information processing in manufacturing.

Unit 3: Software for FMS

Concepts of distributed numerical control, programmable controller's hardware configurations, FMS software, FMS instillation, and computer control of work center and assembly lines, functions of computers, computer process interface, and computer process monitoring.

Unit 4: Modeling and Simulation of FMS

Modeling, simulation and analysis of FMS design, Scheduling and loading of FMS, network, Economic considerations.

Unit 5: Automation in FMS

Automated material handling and storage, automated storage, automated flow lines, methods of work-part transport, transfer mechanisms, auxiliary support equipment, automation of machining operations, introduction and design of automated assembly systems, part feeding devices, automated inspection and testing, contact and noncontact inspection methods.

Tool Management

FMS fixtures, tool management, tool strategies, tool monitoring and fault detection, analysis methods for FMS, FMS development towards factories of the future

Texts/References:

1. D.J.Parish, Flexible Manufacturing Systems, Butter Worth-Heinemann Ltd., Oxford, 1993.

2. M.P.Groover, Automation, Production Systems and Computer Integrated Manufacturing, Prentice Hall of India Ltd., 1989.
3. A.Kusiak, Intelligent Manufacturing Systems, Prentice Hall, Englewood Cliffs, New Jersey, 1990.
4. D.M.Considine, G.D.Considine, Standard Handbook of Industrial Automation, Chapman and Hall, London, 1986.
5. N.Viswanadhan, Y.Narhari, Performance Modeling of Automated Manufacturing Systems, Prentice Hall of India Ltd., 1992.
6. P.G.Ranky , The Design and Operation of FMS, IFS Publishers. UK, 1988.
7. W.W.Luggen , Flexible Manufacturing Cells and Systems, Prentice Hall, Englewood Cliffs, New Jersey, 1991.

Process Equipment Design

BTMPE604A	PEC4	Process Equipment Design	3-0-0	Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 2 hrs/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the factors influencing design of pressure vessel
CO2	Calculate thickness and thickness variation for cylindrical storage tank
CO3	Estimation of thickness for thin and thick wall pressure vessels
CO4	Design of flange and gasket selection for cylindrical pressure vessels
CO5	Selection of various blade and baffle arrangement for agitators
CO6	Design of support for horizontal and vertical vessel

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1		1			1	1	1				1
CO2	2	2	1			1	1	1				1
CO3	2	2	2			1	1	1				1
CO4	2	2	2			1	1	1				1
CO5	2	2	1			1	1	1				1

CO6	2	2	2			1	1	1				1
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Course Contents:

Unit 1: Design Considerations for Pressure Vessel

Selection of type of vessel, Methods of fabrication, Effect of fabrication methods, various criteria in vessel design, Economic considerations, Types of process equipment, Constructional requirement and applications. Fabrication and testing, Inspection and non-destructive testing of equipment.

Unit 2: Storage Vessel

Design methods of atmospheric storage vessel: storage of fluids, storage of non-volatile liquids, storage of volatile liquids, storage of gases, Optimum tank proportion, Bottom design, Shell design, Wind girder for open top tank, Rub curb angle, Self-supported roof, Design of rectangular tank,

Unit 3: Pressure Vessel

Unfired process vessel with internal and external pressure, Operating condition, Selection of material, Design condition, Stresses, Design criteria, Design of shell subjected to internal and external pressure, Cylindrical vessel under combined loading, Design of heads and closures: flat head and formed heads for vessel. Design consideration for reactors and chemical process vessels. Flange facings, Gaskets, Design of flanged joint, Flange thickness, and Blind flanges.

Unit 4: High Pressure Vessel

Design of thick walled high-pressure vessel, Constructional features, Materials for high-pressure vessels, Multilayer vessel with shrink fit construction, Thermal expansion for shrink fitting, stress in multi shell or shrink fit construction, auto fretting, Pre-stressing. Tall vessels and their design, Stress in shell, Determinations of longitudinal stresses, Longitudinal bending stresses due to eccentric loads, Determination of resultant longitudinal stresses.

Unit 5: Agitated Vessel and Support for Pressure Vessel

Type of agitators, Baffling, Power requirement for agitation, Design based on torque and bending moment, Design based on critical speed, Blade design, Hub and key design, Stuffing box and gland design, Turbine agitator design,

Support for Pressure Vessel

Bracket or lug support: Thickness of the base plate, Thickness of web (gusset) plate, Column support for bracket base plate for column or leg support. Skirt Support: Skirt design, Skirt bearing plate, and Anchor bolt design, Design of bolting chair. Saddle Support: Longitudinal bending moment, Stresses in shell at saddle.

Texts:

1. V. V. Mahajani, S. B. Umarji, "Process Equipment Design", Macmillan Publisher India Ltd.
2. L. E. Brownell, E. H. Young, "Process equipment design", John Wiley and Sons.
3. C. Bhattacharya, "Introduction to process Equipment Design".

Reference Book:

1. Dennis Moss, "Pressure Vessel Design Manual", Elsevier.
2. John F. Harvey, "Theory and Design of Pressure Vessels", CBS Publication.

Product Life Cycle Management

BTMPE604B	PEC4	Product Life Cycle Management	3-0-0	3Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Objectives: Establishing industry partnerships that guide, support, and validate PLM research and education activities assisting with the integration of PLM into College curricula and facilitating the PLM career opportunities.

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Outline the concept of PLM.
CO2	Illustrate the PDM system and its importance.
CO3	Illustrate the product design process.
CO4	Build the procedure for new product development.
CO5	Classify and compare various technology forecasting methods.
CO6	Outline the stages involved in PLM for a given product.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1				1						1	

CO2	1				1		1				1	
CO3	1		1		1							
CO4	1		1		1						1	
CO5	1				1		1					
CO6	1				1				1			1

Course Contents:

Unit 1: Introduction and strategies to PLM

Need for PLM, opportunities and benefits of PLM, different views of PLM, components of PLM, phases of PLM, PLM feasibility study, PLM visioning, Industrial strategies, strategy elements, its identification, selection and implementation, change management for PLM.

Unit 2: Product Data Management (PDM)

Human resources in product lifecycle, Information, Standards, Vendors of PLM Systems and Components, PDM systems and importance, reason for implementing a PDM system, financial Justification of PDM, barriers to PDM implementation

Unit 3: Product Design

Engineering design, organization and decomposition in product design, product design process, methodical evolution in product design, concurrent engineering, design for 'X' and design central development model. Strategies for recovery at end of life, recycling, human factors in product design. Modeling and simulation in product design.

Unit 4: New Product Development

Structuring new product development, building decision support system, Estimating market opportunities for new product, new product financial control, implementing new product development, market entry decision, launching and tracking new product program, Concept of redesign of product

Unit 5: Technology Forecasting and PLM Software and Tools

Future mapping, invocating rates of technological change, methods of technology forecasting such as relevance trees, morphological methods and mission flow diagram, combining forecast of different technologies, uses in manufacture alternative.

PLM Software and Tools

Product data security. Product structure, workflow, Terminologies in workflow, The Link between Product Data and Product Workflow, PLM applications, PDM applications.

Texts/References:

1. Grieves, Michael, "Product Lifecycle Management", Tata McGraw-Hill, 2006, ISBN 007145230330.
2. Antti Saaksvuori, AnselmiImmonen, "Product Life Cycle Management", Springer, 1st edition, 2003.
3. Stark, John, "Product Lifecycle Management: Paradigm for 21stCentury Product Realization", Springer-Verlag, 2004.
4. Fabio Giudice, Guido La Rosa, "Product Design for the environment-A life cycle approach", Taylor & Francis, 2006.

5. Robert J. Thomas, “NPD: Managing and forecasting for strategic processes”.

Finite Element Method

BTMPE604C	PEC4	Finite Element Method	3-0-0	3Credits
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Teaching Scheme: Lecture: 3hrs/week	Examination Scheme: Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)
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Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the basic principle of Finite element methods and its applications
CO2	Use matrix algebra and mathematical techniques in FEA
CO3	Identify mathematical model for solution of common engineering problem
CO4	Solve structural , thermal problems using FEA
CO5	Derive the element stiffness matrix using different methods by applying basic mechanics laws
CO6	Understand formulation for two and three dimensional problems

Mapping of course outcomes with program outcomes

Course	Program Outcomes
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Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1		1				1		1	1
CO2	2	3	2	1	2	1		1			2	1
CO3	3	2	2	1	1				1		2	1
CO4	3	3	2	1	2		1		1		2	1
CO5	3	1	1		1		1				2	1
CO6	1	1	1						1		1	1

Course Contents:

Unit 1: Introduction

Finite element analysis and its need, Advantages and limitations of finite element analysis (FEA), FEA procedure.

Unit 2: Elements of Elasticity

Stress at a point, Stress equation of equilibrium, 2-D state of stress, Strains and displacements, Stress-strain relationship for 2-D state of stress, Plane stress and plane strain approach.

Unit 3: Relevant Matrix Algebra

Addition, subtraction and multiplication of matrices, Differentiation and integration of matrices, Inverse of a matrix, Eigen values and eigen vectors, Positive definite matrix, Gauss elimination.

Unit 4: One-Dimensional Problems

Introduction, FE modeling, Bar element, Shape functions, Potential energy approach, Global stiffness matrix, Boundary conditions and their treatments, Examples.

Unit 5: Trusses and Frames and Two-dimensional Problems

Introduction, Plane trusses, Element stiffness matrix, Stress calculations, Plane frames, examples.

Two-dimensional Problems

Introduction and scope of 2-D FEA, FE modeling of 2-D problem, Constant strain triangle, other finite elements (no mathematical treatment included), Boundary conditions.

Texts:

T. R. Chandrupatla, A.D. Belegundu, "Introduction to Finite Elements in Engineering", Prentice Hall of India Pvt. Ltd., 3rd edition, New Delhi, 2004.

P. Seshu, "A Textbook of Finite Element Analysis", Prentice Hall of India Pvt. Ltd., New Delhi, 2003.

R. D. Cook, D. S. Malkus, M. E. Plesha, R. J. Witt, "Concepts and Applications of Finite Element Analysis", John Wiley & Sons, Inc.

References:

K. J. Bathe, "Finite Element Procedures", Prentice Hall of India Pvt. Ltd., 2006.

Computational Fluid Dynamics

BTAPE604B	Computational Fluid Dynamics	PEC 4	3L-0T-0P	3 Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks(Duration 03 hrs)

Pre-Requisites: None

Course Outcomes:At the end of the course, students will be able to

CO1	Identify applications of finite volume and finite element methods to solve Navier-Stokes equations.
CO2	Evaluate solution of aerodynamic flows. Appraise & compare current CFD software. Simplify flow problems and solve them exactly.
CO3	Design and setup flow problem properly within CFD context, performing solid modeling using CAD package and producing grids via meshing tool
CO4	Interpret both flow physics and mathematical properties of governing Navier-Stokes equation and define proper boundary conditions for solution.
CO5	Use CFD software to model relevant engineering flow problems. Analyse the CFD results Compare with available data, and discuss the findings

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

Course Contents:

Unit-I: Introduction to CFD

CFD – a research and design tool, CFD as third dimension of engineering supplementing theory and experiment, Steps in CFD solution procedure, strengths and weakness of CFD, Flow modelling using control volume - finite and infinitesimal control volumes, Concept of substantial derivative, divergence of velocity, Basic governing equations in integral and differential forms – conservation of mass, momentum and energy (No derivations), Physical interpretation of governing equations, Navier-Stoke’s model and Euler’s model of equations.

Unit- II: Basic Discretization Techniques

Introduction to grid generation (Types of grids such as structured, unstructured, hybrid, multiblock, Cartesian, body fitted and polyhedral etc.), Need to discretize the domain and governing equations, Finite difference approximation using Taylor series, for first order (Forward Difference Approximation, Backward Difference Approximation, Central difference Approximation) and second order (based on 3 node, 4 node and 5 node points), explicit and Implicit approaches applied to 1D transient conduction equation, Couetteflow equation () using FTCS and Crank Nicholson’s Method, Stability Criteria concept and physical interpretation, Thomas Tri-diagonal matrix solver.

Unit-III: Two Dimensional Steady and unsteady heat conduction

Solution of two dimensional steady and unsteady heat conduction equation with Dirichlet, Neumann, Robbins and mixed boundary condition – solution by Explicit and Alternating Direction Implicit method (ADI Method), Approach for irregular boundary for 2D heat conduction problems.

Unit-IV: Application of Numerical Methods to Convection – Diffusion system

Convection: first order wave equation solution with upwind, Lax–Wendroff, Mac Cormack scheme, Stability Criteria concept and physical interpretation **Convection –Diffusion:** 1D and 2D steady Convection Diffusion system – Central difference approach, Peclet Number, stability criteria, upwind difference approach, 1 D transient convection-diffusion system

Unit-V: Incompressible fluid flow

Solution of Navier-Stoke’s equation for incompressible flow using SIMPLE algorithms and its variation (SIMPLER), Application to flow through pipe, Introduction to finite volume method.

CFD as Practical approach

Introduction to any CFD tool, steps in pre-processing, geometry creation, mesh generation, selection of physics and material properties, specifying boundary condition, Physical Boundary condition types such as no slip, free slip, rotating wall, symmetry and periodic, wall roughness, initialising and solution control for the solver, Residuals, analysing the plots of various parameters (Scalar and Vector contours such as streamlines, velocity vector plots and animation). Introduction to turbulence models. Reynolds Averaged Navier-Stokes equations (RANS), $k-\epsilon$, $k-\omega$. Simple problems like flow inside a 2-D square lid driven cavity flow through the nozzle

Texts/References:

1. "Computational Fluid Dynamics", John D Anderson: The Basics with Applications, McGraw-Hill
2. "Computational Fluid Dynamics", J. Tu, G.-H. Yeoh and C. Liu: A practical approach, Elsevier.
3. "Introduction to Computational Fluid Dynamics", A. W. Date: Cambridge University Press
4. "Computer Simulation of Fluid flow and heat transfer", P.S.Ghoshdastidar: Tata McGraw-Hill.
5. "Numerical Simulation of internal and external flows", Vol. 1, C. Hirsch, Wiley
6. Computational Fluid Mechanics and Heat transfer, Tannehill, Anderson, and Pletcher,

Open Elective-II

Quantitative Techniques in Project Management

BTMOE605A	OEC 2	Quantitative Techniques in Project Management	3-1-0	4Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: Engineering Mathematics-I/II/III

Course Outcomes: At the end of the course, students will be able to:

CO1	Define and formulate research models to solve real life problems for allocating limited resources by linear programming.
CO2	Apply transportation and assignment models to real life situations.
CO3	Apply queuing theory for performance evaluation of engineering and management systems.
CO4	Apply the mathematical tool for decision making regarding replacement of items in real life.
CO5	Determine the EOQ, ROP and safety stock for different inventory models.
CO6	Construct a project network and apply CPM and PERT method.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	3	2				3	1	3	1
CO2	3	1	1	3	2				3	2	3	1
CO3	3	1	1	3	2				3	2	3	1
CO4	3	1	1	3	2	1			3	2	3	1
CO5	3	1	1	3	2	1			3	2	3	1
CO6	3	1	1	3	2	2			3	2	3	1

Course Contents:

Unit 1: Introduction

Introduction to Operations Research, Stages of Development of Operations Research, Applications of Operations Research, Limitations of Operations Research Linear programming problem, Formulation, graphical method, Simplex method, artificial variable techniques.

Unit 2: Assignment and Transportation Models

Transportation Problem, North west corner method, Least cost method, VAM, Optimality check methods, Stepping stone, MODI method, Assignment Problem, Unbalanced assignment problems, Travelling salesman problem.

Unit 3: Waiting Line Models and Replacement Analysis

Queuing Theory: Classification of queuing models, Model I (Birth and Death model) M/M/I (∞ , FCFS), Model II - M/M/I (N/FCFS).

Replacement Theory, Economic Life of an Asset, Replacement of item that deteriorate with time, Replacement of items that failed suddenly.

Unit 4: Inventory Models

Inventory Control, Introduction to Inventory Management, Basic Deterministic Models, Purchase Models and Manufacturing Models without Shortages and with Shortages, Reorder level and optimum buffer stock, EOQ problems with price breaks.

Unit 5: Project Management Techniques and Time and Cost Analysis

Difference between project and other manufacturing systems. Defining scope of a project, Necessity of different planning techniques for project managements, Use of Networks for planning of a project, CPM and PERT.

Time and Cost Analysis

Time and Cost Estimates: Crashing the project duration and its relationship with cost of project, probabilistic treatment of project completion, Resource allocation and Resource leveling.

Texts:

1. P. K. Gupta, D. S. Hira, "Operations Research", S. Chand and Company Ltd., New Delhi, 1996.

2. L. C. Jhamb, “Quantitative Techniques for managerial Decisions”, Vol. I and II, Everest Publishing House, Pune, 1994.
3. N. D. Vohra, “Operations Research”, Tata McGraw Hill Co., New Delhi.

References:

1. H. Taha, “Operations Research–An Introduction”, Maxwell Macmillan, New York.
2. J. K. Sharma, “Operations Research–An Introduction”, Maxwell Macmillan, New Delhi.
3. Harvey M. Wagner, “Principles of Operations Research with Applications to Managerial Decisions”, Prentice Hall of India Pvt. Ltd., New Delhi, 2nd edition, 2005.
4. Rubin and Lewin, “Quantitative Techniques for Managers”, Prentice Hall of India Pvt. Ltd., New Delhi.

Nanotechnology

BTMOE605B	OEC2	Nanotechnology	3-1-0	4 Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Demonstrate the understanding of length scales concepts, nanostructures and nanotechnology.
CO2	To impart basic knowledge on various synthesis and characterization techniques involved in Nanotechnology
CO3	To educate students about the interactions at molecular scale
CO4	Evaluate and analyze the mechanical properties of bulk nanostructured metals and alloys, Nano-composites and carbon nanotubes.
CO5	To make the students understand about the effects of using nanoparticles over conventional methods

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1		3	3	2	1		3		1	3
CO2	3	2			3	3	2				1	3

CO3	1	1	1	3	2				2	1		1
CO4	1	1		3	3	2	1		3		1	3
CO5	1	1	1	3	2				2	1		1

Course Contents:

Unit 1: Scientific Revolutions

Types of Nanotechnology and Nano machines: the Hybrid nanomaterial. Multiscale hierarchical structures built out of Nano sized building blocks (nano to macro). Nanomaterial's in Nature: Nacre, Gecko, Teeth. Periodic table, Atomic Structure, Molecules and phases, Energy, Molecular and atomic size, Surfaces and dimensional space: top down and bottom up.

Unit 2: Forces between Atoms and Molecules

Particles and grain boundaries, strong Intermolecular forces, Electrostatic and Vander Waals forces between surfaces, similarities and differences between intermolecular and inter particle forces covalent and coulomb interactions, interaction polar molecules. Thermodynamics of self-assembly.

Unit 3: Opportunity at the Nano Scale

Length and time scale in structures, energy landscapes, Inter dynamic aspects of inter molecular forces, Evolution of band structure and Fermi surface.

Unit 4: Nano Shapes

Quantum dots, Nano wires, Nano tubes, 2D and 3D films, Nano and mesopores, micelles, bilayer, vesicles, bionano machines, biological membranes.

Unit 5: Influence of Nano Structuring and Nano Behaviour

Influence of Nano structuring on mechanical, optical, electronic, magnetic and chemical properties-gram size effects on strength of metals- optical properties of quantum dots.

Nano Behaviour

Quantum wires, electronic transport in quantum wires and carbon nano-tubes, magnetic behavior of single domain particles and nanostructures, surface chemistry of Tailored monolayer, self-assembling.

Texts:

1. C. Koch, "Nanostructured materials: Processing, Properties and Potential Applications", Noyes Publications, 2002.
2. C. Koch, I. A. Ovidko, S. Seal and S. Veprek, "Structural Nano crystalline Materials: Fundamentals & Applications", Cambridge University Press, 2011.

References:

1. Bharat Bhushan, "Springer Handbook of Nanotechnology", Springer, 2nd edition, 2006.

2. Laurier L. Schramm, “Nano and Microtechnology from A-Z: From Nano-systems to Colloids and Interfaces”, Wiley, 2014.

Energy Conservation and Management

BTMOE605C	OEC2	Energy Conservation and Management	3-1-0	4 Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand energy problem and need of energy management
CO2	Carry out energy audit of simple units
CO3	Study various financial appraisal methods
CO4	Analyse cogeneration and waste heat recovery systems
CO5	Do simple calculations regarding thermal insulation and electrical energy conservation

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12

CO1	1	2	3		2	3			2	2		2
CO2	1	1	3	1	2	3			2	2		2
CO3	2	1	1							1		2
CO4	3	3			2	3						1
CO5			3			2						1

Course Contents:

Unit1: Introduction

General energy problem, Energy use patterns and scope of conservation. Energy Management Principles: Need, Organizing, Initiating and managing an energy management program.

Unit2: Energy Auditing

Elements and concepts, Types of energy audits, Instruments used in energy auditing.

Economic Analysis: Cash flows, Time value of money, Formulae relating present and future cash flows-single amount, uniform series.

Unit3: Financial Appraisal Methods

Paybackperiod, Netpresentvalue, Benefit-costratio, Internal-rate of return, Life cycle costs/benefits. Thermodynamics of energy conservation, Energy conservation in Boilers and furnaces, Energy conservation in Steam and condensate system.

Unit4: Cogeneration and Insulation and Heating

Concept, Types of cogeneration systems, performance evaluation of a cogeneration system.

Waste Heat Recovery: Potential, benefits, waste heat recovery equipment's.

Space Heating, Ventilation Air Conditioning (HVAC) and water heating of building, Transfer of heat, Space heating methods, Ventilation and air conditioning, Heat pumps, Insulation, Cooling load, Electric water heating systems, Electric energy conservation methods.

Insulation and Heating

Industrial Insulation: Insulation materials, Insulation selection, Economical thickness of insulation. Industrial Heating: Heating by indirect resistance, direct resistance heating (salt bath furnace), and Heat treatment by induction heating in the electric arc furnace industry.

Unit5: Energy Conservation in Electric Utility and Industry

Energy costs and two part tariff, Energy conservation in utility by improving load factor, Load curve analysis, Energy efficient motors, Energy conservation in illumination systems, Importance of Power factor in energy conservation, Power factor improvement methods, Energy conservation in industries

Texts:

1. Callaghan, "EnergyConservation".
2. D.L.Reeg, "IndustrialEnergyConservation", PergamonPress.

References:

1. T.L.Boyen, "ThermalEnergyRecovery", WileyEastern.
2. L.J.Nagrath, "SystemModelingandAnalysis", TataMcGrawHill Publications.
3. S.P.Sukhatme, "SolarEnergy", TataMcGrawHill Publications.

Wind Energy

BTMOE605D	OEC2	Wind Energy	3-1-0	4 Credits
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Teaching Scheme:	Examination Scheme:
Lecture: 3 hrs/week Tutorial: 1 hr/week	Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand historical applications of wind energy
CO2	Understand and explain wind measurements and wind data
CO3	Determine Wind Turbine Power, Energy and Torque
CO4	Understand and explain Wind Turbine Connected to the Electrical Network AC and DC
CO5	Understand economics of wind energy

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1							2	2	2	1		1

CO2		3	2	1	3	2	2	2	2			1
CO3	3	3	1	1	2	2	1					1
CO4	3	3		1								1
CO5	3	2	1									1

Course Contents:

Unit 1: Introduction and Wind Measurements

Historical uses of wind, History of wind electric generations

Wind Characteristics: Metrology of wind, World distribution of wind, Atmospheric stability, Wind speed variation with height, Wind speed statistics, Weibull statistics, Weibull parameters, Rayleigh and normal distribution

Wind Measurements

Biological indicators, Rotational anemometers, other anemometers, Wind direction

Unit 2: Wind Turbine Power, Energy and Torque

Power output from an ideal turbine, Aerodynamics, Power output from practical turbines, Transmission and generation efficiency, Energy production and capacity factor, Torque at constant speeds, Drive train oscillations, Turbine shaft power and torque at variable speeds.

Unit 3: Wind Turbine Connected to the Electrical Network

Methods of generating synchronous power, AC circuits, the synchronous generator, per unit calculations, the induction machine, motor starting, Capacity credit features of electrical network

Unit 4: Wind Turbines with Asynchronous Electric Generators

Asynchronous systems, DC shunt generator with battery load, Per unit calculation, Self-excitation of the induction generators, Single phase operation the induction generator, Field modulated generators, Roesel generator.

Asynchronous Load: Piston water pumps, Centrifugal pumps, Paddle wheel heaters, Batteries, Hydrogen economy, and Electrolysis cells.

Unit 5: Economics of Wind Systems

Capital costs, Economic concepts, Revenues requirements, Value of wind generated electricity

Texts:

1. S. Ahmad, "Wind Energy: Theory and Practice", Prentice Hall of India Pvt. Ltd.

References:

1. Garg L. Johnson, "Wind Energy Systems" Prentice Hall Inc., New Jersey, 1985.
2. Desire Le Gouriers, "Wind Power Plants: Theory and Design" Pergamon Press, 1982.

Introduction to Probability Theory and Statistics

BTMOE605D	Introduction to Probability Theory and Statistics	OEC 2	3L-1T-0P	4 Credits
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Teaching Scheme: Lecture: 3 hrs/week Tutorial: 1 hrs/week	Examination Scheme: Continuous Assessment: 20 Marks Mid Semester Exam: 20 Marks End Semester Exam: 60 Marks (Duration 03 hrs)
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Pre-Requisites: None

Course Objective

The objective of this course is

- (i) To Acquire the knowledge of mean, median, mode, dispersion, etc.
- (ii) To develop the basics of Probability theory
- (iii) To get the knowledge of random variables and their expectations
- (iv) To establish acquaintance with various probability distributions
- (v) To Acquire the knowledge of correlation and regression.

Course Outcome

At the end of the course, the student will be able to

- (i) Apply the concepts to find the measure of the central tendency, dispersion and moments for grouped data

- (ii) Make use of the correlation, and regression analyses to find the correlation and regression coefficients
- (iii) Observe and analyze the behavior of various discrete and continuous probability distributions
- (iv) Investigate the properties such as mathematical expectation and variance of the random variables.

Course Contents:

Unit I: Probability

Probability Theory: Definition of probability, Addition theorem of probability, Multiplication theorem of probability, Conditional probability, Bayes' theorem of inverse probability, Properties of probabilities with proofs. **[08 Hours]**

Unit II: Theoretical Probability Distributions

Theoretical Probability Distributions: Binomial distribution, Poisson distribution, Normal distribution, Fitting of binomial distributions, Properties of Binomial, Poisson and normal distributions, Relation between binomial and normal distributions, Relation between Poisson and normal distributions, Importance of normal distribution, Examples. **[08 Hours]**

Unit III: Moments, Skewness and Kurtosis

Moments about mean and an arbitrary point; Skewness: positive skewness, negative skewness, symmetric frequency distribution, Bowley's coefficient of skewness, Karl Pearson's coefficient of skewness, Measures of skewness based on moments (β_1, γ_1); Concepts of kurtosis, leptokurtic, mesokurtic and platykurtic frequency distributions. **[08 Hours]**

Unit IV: Correlation and Regression

Correlation: Types of correlation, Karl Pearson's correlation coefficient (Covariance Method), Spearman's rank correlation method, Regression: lines of regression, fitting of lines of regression by the least squares method, interpretation of slope and intercept, properties of regression coefficients. **[08 Hours]**

Unit V: Sampling Theory and Testing of Hypothesis

Introduction to sampling distributions, Population and sample, Null hypothesis and Alternative hypothesis, Single and two tailed test, Testing of hypothesis, Level of significance, Critical region, Procedure for testing of hypothesis. **[08 Hours]**

Text Books:

1. Fundamentals of Statistics by S. C. Gupta, Himalaya Publishing House Pvt. Ltd., New Delhi.
2. Probability and Statistics by Dr. B. B. Singh, Synergy Knowledge, Mumbai.
3. Mathematical Statistics by P. Mukhopadhyay, New Central Book Agency, Kolkata.
4. Fundamentals of Mathematical Statistics by S. C. Gupta and V. K. Kapoor, S. Chand and Sons, New Delhi.

5. An Introduction to Probability and Statistics by V. K. Rohatgi and A. K. Md. EhsanesSaleh, Wiley Interscience Publication, New York.
6. Introduction to Probability and Statistical Applications by P. L. Meyer, Addison Wesley Publishing Co., Massachusetts.

Reference Books:

1. Probability, Statistics with Reliability, Queuing and Computer Science Applications by Kishor S. Trivedi, Wiley India Pvt. Ltd., Mumbai.
2. Probability, Queuing Theory and Reliability Engineering by G. Haribaskaran, Laxmi Publications, New Delhi.
3. Probability and Statistics by R. S. Murray, J. S. John, R. Alu Srinivasan and D. Goswami, Schaum's Outlines series, McGraw Hill Publications, New Delhi.
4. Introduction to Theory of Statistics by A. M. Mood, F. A. Graybill and D. C. Boes, Tata McGraw – Hill Publications, Pune.

Production Engineering Lab-IV

PCC14	BTPCL606	Production Engineering Lab IV	0-0-4	Credit
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Practical Scheme:	Examination Scheme:
Practical: 4hrs/batch	Continuous Assessment: 60 Marks External Exam: 40 Marks

List of Practical's/Experiments/Assignments (Any 4 from Group-A, Any 4 from Group-B and Any 3 from Group-C):

Group-A (CAD/CAM/CIM):

1. Part modeling of machine elements using any one of the CAD software out of ProE, CATIA, Unigraphics or Autodesk Inventor Professional.

2. Assembly modeling of assembly or sub-assembly of engineering products using any one of the CAD software out of ProE, CATIA, Unigraphics or Autodesk Inventor Professional.
3. Drafting of Parts and Assembly of engineering assembly using any one of the CAD software out of ProE, CATIA, Unigraphics, or Autodesk Inventor Professional.
4. Minimum 4 structural analysis problems to be solved using a CAE software like Ansys, Hyperworks etc.
5. Minimum 2 Jobs (Programs) on CNC Turning operations
6. Minimum 2 Jobs (programs) on CNC Milling operation
7. Case Study of an Industrial Robot

Group-B (CNC Machines and Programming Lab):

List of Practical's/Experiments/Assignments

Each student shall be required to complete and submit the manual for the list of experiments. Each experiment will last for 2 turns.

1. To develop a manual part program of a given component on CNC Lathe using G and M codes.
2. To develop a manual part program of a given component on CNC Lathe using stock removal cycle.
3. To develop a manual part program of a given component on CNC Lathe using canned cycle.
4. To develop a manual part program of a given component on CNC Milling machine using G and M code.
5. To develop a manual part program of a given component on CNC Milling machine using pocket milling cycles.
6. To develop a manual part program of a given component on CNC Milling machine using canned drilling cycle.

Group-C (Metrology and Quality Control):

List of Practical's/Experiments/Assignments

1. Calibration of pressure gauge using dead weight gauge calibrator
2. Measurement of displacement using LVDT
3. Calibration of strain gauge
4. Measurement of flow rate using orifice, venturi and Rota meters and their error analysis
5. Measurement of flow rate using microprocessor based magnetic flow meter, vortex, Ultrasonic, turbine flow meters
6. Determination of characteristics of thermocouples, RTD, thermistors
7. To calibrate the given micrometer using slip gauge as standard
8. Measurement of taper by sine bar
9. To calibrate a dial gauge indicator

10. Study and use of optical flat
11. Surface roughness measurement
12. Tool makers' microscope.

B. Tech Seminar

BTPS607	B Tech Seminar	PROJ-3	0L-0T-2P	1 Credits
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Teaching Scheme: Practical: 2 hrs/week	Examination Scheme: Continuous Assessment: 60 Marks Mid Semester Exam: -- End Semester Exam: 40 Marks
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Objective:

- To expose and make students aware with latest research and research publications
- To understand the research and research publication, references, citation
- To enhance the presentation skill
- To enhance the report writing
- To make the student aware about research publication sites

Students are expected to prepare a seminar report on the chosen topic/area selected with the discussion of chosen guide based on the available literature on the chosen topic.

Mini Project

BTTP608	Mini Project	PROJ-4	0L-0T-2P	1 Credits
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Teaching Scheme: Practical: 2 hrs/week	Examination Scheme: Continuous Assessment: 60 Marks
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Dr. Babasaheb Ambedkar Technological University, Lonere

	Mid Semester Exam: -- End Semester Exam: 40 Marks(Duration 03 hrs)
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Students are expected to carry out a mini project under a project guide based on the chosen area. The project may be prototype/software based which may demonstrate Engineering application or community service. After completion the project work it is necessary that student should prepare a project report under the supervision of the assign guide and present before the committee.