**Dr. Babasaheb Ambedkar Technological University (Established as University of Technology in the State of Maharashtra)**
**(Under Maharashtra Act No. XXIX of 2014)**
**P.O. Lonere, Dist. Raigad, Pin 402 103,**
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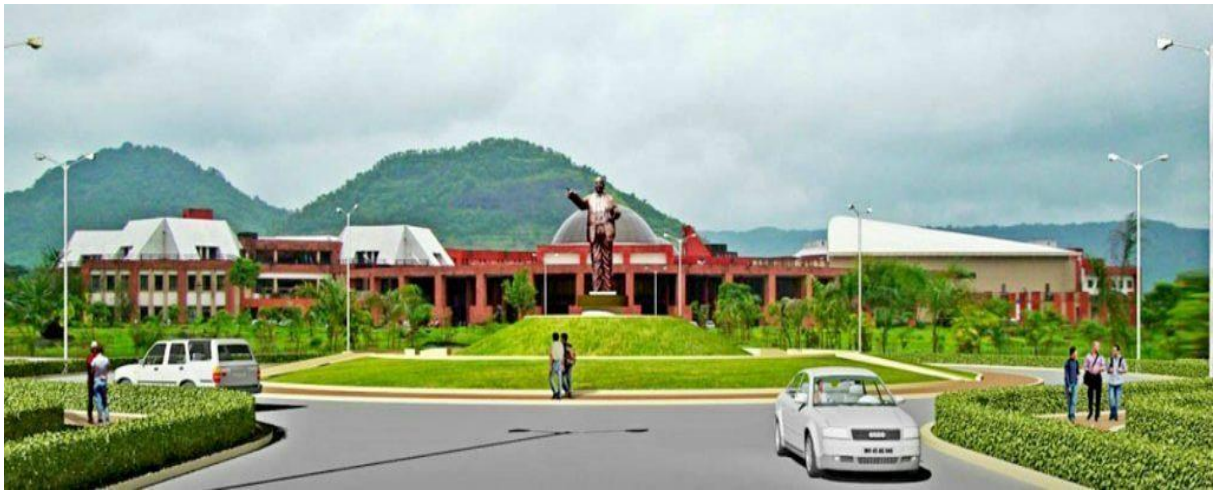
# CURRICULUM

# UNDER GRADUATE PROGRAMME

# B.TECH

## 3rd year PRODUCTION ENGINEERING

**ACADEMIC YEAR**
**2024-2025**



**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 V
## B.Tech in Production Engineering
## (2024-25)

| Semester V | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Course Category** | **Course Code** | **Course Title** | **Teaching Scheme** | | | **Evaluation Scheme** | | | | **Credit** |
| | | | **L** | **T** | **P** | **CA** | **MSE** | **ESE** | **Total** | |
| 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
## (2024-25)

| Semester VI | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Course Category | Course Code | Course Title | Teaching Scheme | | | Evaluation Scheme | | | | Credit |
| | | | 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<br>BTMPE603<br>BTAPE603 | Elective-III | 3 | - | - | 20 | 20 | 60 | 100 | 3 |
| PEC 4 | BTPPE604<br>BTMPE604<br>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 V

## Design of Machine Elements

| | | | | |
|---|---|---|---|---|
| BTPC501 | Design of Machine Elements | PCC 8 | 3L-1T-0P | 4 Credits |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3 hrs/week<br>Tutorial: 1 hr/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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:**

**MechanicalEngineeringDesignProcess**

Traditionaldesignmethods, generalindustrialdesignprocedure,designconsiderations, phasesindesign, creativity indesign,useofstandardization, preferredseries,introduction toISO9000,useofdesigndatabook,aestheticandergonomic considerationsindesign.

**Theories of Failure:**Maximumnormalstresstheory,Maximumshearstresstheory,Maximumdistortionenergytheory,comparisonofvarioustheoriesoffailure,

**Unit2:DesignofMachineElements**

**I. Against StaticLoading**

Directloadingandcombinedloading,Jointssubjectedtostaticloadinge.g. cotterandknucklejoint,turnbuckle,etc.introduction to fluctuatingloads.

**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: DesignofShafts, Keys, Couplings and Bearings**

Variousdesignconsiderationsintransmissionshafts, splined shafts, spindle and axlesstrength, lateral and torsional rigidity, ASME code for designingtransmissionshaft.

**TypesofKeys:**Classificationandfitmentinkeyways,Designofvarioustypesofkeys.

**Couplings:**Designconsideration,designofrigid,muffandflangetypecouplings, designofflexiblecouplings.

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

**Unit 4:DesignofThreaded Joints**

Stressesinscrewfasteners,boltedjointsundertension,torque requirementforbolttightening,preloadingofboltunderstaticloading,eccentricallyloaded boltedjoints.

**PowerScrews:**Formsofthreadsusedforpowerscrewandtheirapplications,torqueanalysisfor squareandtrapezoidalthreads,efficiencyofscrew,collarfriction,overallefficiency,self-lockinginpowerscrews,stressesinthepowerscrew,designofscrewandnut,differentialandcompound screw,re-circulatingballscrew.

**Welded Joints:**

Typeofweldedjoints,stressesinbuttandfilletwelds,strengthofweldedjointssubjectedtobendingmoments.

**Mechanical Springs**

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

ng

**Unit 5: Design of Gears and Drives**

Geardrives, Classification ofgears, Lawofgearing,Terminologyofspurgear, Standard system of geartoothforceanalysis,geartoothfailures,material selection,Numberofteeth,Facewidth,Beamstrengthequation,Effectiveloadongeartooth,Estimatio nofmodulebasedonbeamstrength.

Design formaximumpowercapacity, Lubricationofgears.

**HelicalGears:**

Terminology,Virtualnumberofteeth,Toothproportions,Forceanalysis,Beamstrengthequation,Effect iveloadongeartooth,Wearstrengthequation.

**BevelGears:**Typesofbevelgears,Terminologyofstraightbevel,forceanalysis,BeamandWearstrengt h,Effectiveloadongeartooth.

**WormGears:**Terminology,Proportions,Forceanalysis,Frictioninwormgears,Vectormethod, 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 |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3hrs/week<br>Tutorial: 1 hr/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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, "ManufacturingTechnology, Foundry,FormingandWelding" Vol.1, 3rd edition, TataMcGrawHillPublishingCo.Ltd,NewDelhi,2004

**References:**

1. ASMHandbook,Vol.15MetalForming,ASM International,MetalsPark, Ohio,1989.
2. DieDesignHandbook,ASTME,1989.
3. A.S.Deshpande, "SheetMetalEngineeringNotes", IITBombay,1999.

# Joining Technology

| | | | | |
|---|---|---|---|---|
| BTPC503 | PCC 10 | Joining Technology | 3-1-0 | Credits |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3hrs/week<br>Tutorial: 1 hr/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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. Houltcroft, “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 |

| | |
|---|---|
| **Teaching Scheme:** | **Examination Scheme:** |

| | |
|---|---|
| Lecture: 3hrs/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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, Zeotrops 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. Carriern 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.


## Engineering Tribology

| | | | | |
|---|---|---|---|---|
| BTMPE504C | PEC2 | Engineering Tribology | 3-0-0 | Credits |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3 hrs/week | Continuous Assessment: 20 Marks |

| | |
|---|---|
| | Mid Semester Exam: 20 Marks<br>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 | Evaluatethenatureofengineeringsurfaces,theirtopographyandsurface 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-bological 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 as peritycontact, 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",BailyBrothersandSwinfenLimited.
3. F. T. Barwell, "BearingSystems,PrinciplesandPractice",OxfordUniversityPress.

**References:**

1. B. C. Majumdar, "IntroductiontoTribologyofBearings",A. H.Wheeler&Co.PrivateLimited,Allahabad.
2. D. F. Dudley, "TheoryandPracticeofLubricationforEngineers",JohnWilleyandSons.
3. J. Halling, "PrinciplesofTribology",McMillanPressLimited.
4. CameronAlasTair, "BasicLubricationTheory",WileyEasternLimited.
5. M. J. Neale, "TribologyHandbook",Butterworth's.
6. D. D. Fuller, "Lubrication".

## Fundamental of Automobile Design (Product Design, PLM, CAE, Catia)

| | | | | |
|---|---|---|---|---|
| BTAPE504A | Automobile Design (Product Design, PLM, CAE, Catia) | PEC 2 | 3L-0T-0P | 3 Credits |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3hrs/week | Continuous Assessment: 20 Marks<br>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 | |

| Teaching Scheme | Examination Scheme |
|---|---|
| Lecture: 3 Hrs/week | Continuous Assessment: 20 Marks<br>Mid semester examination: 20 Marks<br>End Semester Exam: 60 Marks (3 hrs duration) |

**Pre-Requisites:** None

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

| | |
|---|---|
| CO1 | Identify the different parts of the automobile. |

| | |
|---|---|
| CO2 | Explain the working of various parts like engine, transmission, clutch, brakesetc., |
| 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**

| CourseOutcomesC | ProgramOutcomes | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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 |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3 hrs/week | Continuous Assessment: 20 MarksMid Semester Exam: 20 Marks<br>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 | Describe measurement of direct, diffuse and global solar radiations falling on horizontal and inclined surfaces. |
| 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 |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3 hrs/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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 | 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. ChetansinghSolanki, "RenewableEnergyTechnologies",PrenticeHallofIndia, 2008.

**References:**

1. S. P. Sukhatme, "SolarEnergy:PrinciplesofThermalCollectionandStorage", Tata McGrawHill Publications,NewDelhi,1992.
2. G. D.Rai, "SolarEnergyUtilization",KhannaPublisher,Delhi,1992.

# Human Resource Management

| | | | | |
|---|---|---|---|---|
| BTMOE505C | OEC1 | Human Resource Management | 3-0-0 | 3 Credits |

| Teaching Scheme: | Examination Scheme: |
|---|---|
| Lecture: 3 hrs/week | Continuous Assessment: 20 MarksMid Semester Exam: 20 Marks<br>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 | 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 ewemployee

**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, criterions 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 inhuman 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,StephenP. Robbins,
"Personnel/HumanResourcesManagement",PrenticeHallofIndiaPvt. Ltd,3rd edition,2002.
TrevorBolton, "AnIntroductiontoHuman Resource Management", InfinityBooks, 2001.

References:

EllenE.Kossek, "HumanResourceManagement–TransformingtheWorkplace",InfinityBooks,2001.
G.S.Batra, R.C.Dangwal, "HumanResourceManagementNewStrategies",
DeepandDeepPublicationsPvt.Ltd.,2001.
D.M.Silvera, "HRD: TheIndianExperience",NewIndiaPublications,2nd edition,1990.

## Product Design Engineering

| | | | | |
|---|---|---|---|---|
| BTMOE505D | OEC1 | Product Design Engineering – I | 3-0-0 | 3 Credits |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3hr/Week | Continuous Assessment: 20 MarksMid Semester Exam: 20 Marks<br>End Semester Exam: 60 Marks(Duration 03 hrs) |

- **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 designs,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 |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3 hrs/week<br>Tutorial: 1 hr/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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 |

**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 |

| **Practical Scheme:** | **Examination Scheme:** |
|---|---|
| Practical: 4hrs/batch | Continuous Assessment: 60 Marks<br>External Exam: 40 Marks |

**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 involvingassemblydrawingswithapartlistandoveralldimensionsandothersheetinvolvingdrawingsofindividualcomponents.Manufacturingtolerances,surfacefinishsymbolsandgeometrictolerancesshouldbespecified,wherevernecessary,soastomake it working drawing
2. A designreportgivingallnecessarycalculationsforthedesignofcomponentsandassemblyshould 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 |

## Semester-VI

## Machine Tools and Metal Cutting

| | | | | |
|---|---|---|---|---|
| BTPC601 | PCC 12 | Machine Tools and Metal Cutting | 3-1-0 | 4Credits |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3 hrs/week<br>Tutorial: 1 hr/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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, machininabilty 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:ClassificationofMetalRemovalProcessesandMachineTools**
Introduction to ManufacturingandMachining,Basicworking principle,configuration, specification and classification of machine tools, Construction, working principle and applicationsofshaping,planningandslottingmachines,Useof various attachmentsinMachine Tools,Estimationofmachiningtime

**Unit2:MechanicsofMachining(MetalCutting)**
Geometry ofsinglepointcuttingtools,Mechanismofchipformation,Orthogonalandobliquecutting,Useofchipbreakerinmachining,MachiningforcesandMerchant'sCircleDiagram(MCD), Analytical and Experimental determination of cutting forces, Dynamometers for measuringcuttingForces,Cuttingtemperature: causes,effects,assessmentandcontrol,Controlofcuttingtemperatureandcuttingfluidapplication

**Unit3:Machinability**
ConceptofMachinabilityandits improvement,Failureofcuttingtoolsandtoollife,CuttingToolMaterialsofcommonuse,AdvancedCuttingToolMaterials

**Unit4:AbrasiveProcesses(GrindingandSuperFinishing)**
Basicprinciple,purposeandapplicationofgrinding,Selectionofwheelsandtheirconditioning, Classificationofgrindingmachinesandtheiruses,Superfinishingprocesses,Honing,LappingandSuper finishing

**Unit5:Gear and thread manufacturing**
Production ofscrewthreadsbyMachining,Rolling and Grinding, Manufacturing ofGears, Broaching–PrinciplesandApplications

**Introduction to Jigs and Fixtures**
Role and importance of jigs and fixture, Principle of location and clamping, Locating, Supporting and clamping elements, Applicationoftypicaljigsandfixtures.

**Texts:**

1. P.N.Rao," ManufacturingTechnology-MetalCuttingandMachineTools",Vol.II,TataMcGrawHillPublishingCo.Ltd,NewDelhi,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.

# CAD/CAM/CIM

| | | | | |
|---|---|---|---|---|
| BTPC602 | PCC 13 | CAD/CAM/CIM | 3-1-0 | 4Credits |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3 hrs/week<br>Tutorial: 1 hr/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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 and describe the various input and output devices for a CAD work station |
| CO2 | Carry out/calculate the 2-D and 3-D transformation positions (Solve problems on 2-Dand 3-D transformations) |
| CO3 | Describe various CAD modeling techniques with their relative advantages and limitations |
| CO4 | Describe various CAD modeling techniques with their relative advantages and limitations |
| CO5 | Develop NC part program for the given component, and robotic tasks |
| CO6 | Describe the basic Finite Element procedure |
| CO7 | Explain various components of a typical FMS system, Robotics, and CIM |
| CO8 | Classify parts in part families for GT |
| CO9 | Describe and differentiate the CAPP systems |

**Mapping of course outcomes with program outcomes**

| Course Outcomes | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | | | | | | | | | | | 1 |
| CO2 | 3 | 2 | 1 | | 2 | | | | | | | 1 |
| CO3 | 1 | | 1 | | | | | | | | | 1 |
| 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-DtransformationssuchasTranslation,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,Latestdevelopmentin robotics

**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 |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3hrs/week<br>Tutorial: 1 hr/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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 word to joint and joint to word 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 |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3hrs/week<br>Tutorial: 1 hr/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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 |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3 hrs/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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 |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3 hrs/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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 |
| CO | 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 |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 2 hrs/week<br>Tutorial: 1 hr/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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.
4. Nicholas Lisitsyn, Alexis V Kudryashov, Oleg Trifonov, Alexander Gavryusin, N Acherkan, Nicholas Weinstein, "Machine Tool Design", Vol. I, University Press of the Pacific, 20 April 2000.

# Automobile Body Design

| | | | | |
|---|---|---|---|---|
| BTAPE603C | Automobile Body Design | PEC 3 | 3L-0T-0P | 3 Credits |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3hrs/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>End Semester Exam: 60 Marks (Duration 03 hrs) |

**Pre-Requisites:** (Pre-requisite: Automobile Design)

**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. 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 |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3hrs/week<br>Tutorial: 1 hr/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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 |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3hrs/week<br>Tutorial: 1 hr/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>End Semester Exam: 60 Marks(Duration 03 hrs) |

**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 Jercy, 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, Eaglewood Chiffs, New Jercy, 1991.

## Process Equipment Design

| | | | | |
|---|---|---|---|---|
| BTMPE604A | PEC4 | Process Equipment Design | 3-0-0 | Credits |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 2 hrs/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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 |

**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 rectors 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 frettage, 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 |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3 hrs/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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 |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3hrs/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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 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 Outcomes | Program 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 |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3 hrs/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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 equations 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-. 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 |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3 hrs/week<br>Tutorial: 1 hr/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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 |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3 hrs/week<br>Tutorial: 1 hr/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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 |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3 hrs/week<br>Tutorial: 1 hr/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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 |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Lecture: 3 hrs/week<br>Tutorial: 1 hr/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>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 |

| Teaching Scheme: | Examination Scheme: |
|---|---|
| Lecture: 3 hrs/week<br>Tutorial:1 hrs/week | Continuous Assessment: 20 Marks<br>Mid Semester Exam: 20 Marks<br>End Semester Exam: 60 Marks (Duration 03 hrs) |

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 tofind 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 discreteand 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 ($\beta_1$, $\gamma_1$); 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 Knowledgeware, 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,WileyInterscience 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

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|---|---|---|---|---|
| PCC14 | BTPCL606 | **Production Engineering Lab IV** | 0-0-4 | Credit |

| **Practical Scheme:** | **Examination Scheme:** |
|---|---|
| Practical: 4hrs/batch | Continuous Assessment: 60 Marks<br>External Exam: 40 Marks |

**ListofPractical'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. PartmodelingofmachineelementsusinganyoneoftheCADsoftwareoutofProE,CATIA,UnigraphicsorAutodeskInventorProfessional.
2. Assemblymodelingofassemblyorsub-assemblyofengineeringproductsusinganyoneoftheCADsoftwareoutofProE,CATIA,UnigraphicsorAutodeskInventorProfessional.
3. DraftingofPartsandAssemblyofengineeringassemblyusinganyoneoftheCADsoftwareoutofProE, CATIA, Unigraphics, orAutodeskInventorProfessional.
4. Minimum4structuralanalysisproblemstobesolvedusingacaesoftwarelike Ansys,Hyperworksetc.
5. Minimum2Jobs(Programs)onCNCTurningoperations
6. Minimum2Jobs(programs)onCNCMillingoperation
7. CaseStudyofanIndustrialRobot

**Group-B (CNC Machines and Programming Lab):**

**ListofPractical'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):

**ListofPractical'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, venture 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

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|---|---|---|---|---|
| BTPS607 | B Tech Seminar | PROJ-3 | 0L-0T-2P | 1 Credits |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Practical: 2 hrs/week | Continuous Assessment: 60 Marks<br>Mid Semester Exam: --<br>End Semester Exam: 40 Marks |

| | |
|---|---|

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

| | | | | |
|---|---|---|---|---|
| BTPP608 | Mini Project | PROJ-4 | 0L-0T-2P | 1 Credits |

| **Teaching Scheme:** | **Examination Scheme:** |
|---|---|
| Practical: 2 hrs/week | Continuous Assessment: 60 Marks<br>Mid Semester Exam: --<br>End Semester Exam: 40 Marks(Duration 03 hrs) |

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.