UNIVERSITY OF MUMBAI

Bachelor of Engineering

Mechanical Engineering

Final Year (Sem. VII)

Revised Syllabus (REV- 2012)
w. e. f. Academic Year 2015-2016

Under

FACULTY OF TECHNOLOGY

(As per Semester Based Credit and Grading System)

B. E. Mechanical-(Semester VII)

Subject Code	Subject Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract.	Theory	Pract.	Total
MEC701	Machine Design -II	4	2	4	1	5
MEC702	CAD/CAM/CAE [&]	4	2	4	1	5
MEC703	Mechanical Utility Systems	4	2	4	1	5
MEC704	Production Planning and Control	4	2	4	1	5
MEE701X	Elective- I	3	2	3	1	4
MEP701	Project- I	--	6[#]	--	3	3
Total		**19**	**16**	**19**	**8**	**27**

Subject Code	Subject Name	Examination Scheme							
		Theory					Term Work	Pract. /oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test1	Test 2	Avg.					
MEC701	Machine Design- II	20	20	20	80	03	25	25	150
MEC702	CAD/CAM/CAE[&]	20	20	20	80	03	25	25	150
MEC703	Mechanical Utility Systems	20	20	20	80	03	25	--	125
MEC704	Production Planning and Control	20	20	20	80	03	25	25*	150
MEE701X	Elective -I	20	20	20	80	03	25	--	125
MEP701	Project- I	--	--	--	--	--	50	--	50
Total		**--**	**--**	**100**	**400**	**--**	**175**	**75**	**750**

[&] Common with Automobile Engineering *** Only ORAL examination based on term work and syllabus**

# indicates work load of Learner (Not faculty) in VII semester for Project

Project –I and II: Students groups and load of faculty per week
Project Groups: Students can form groups with minimum 2 (Two) and not more than 4 (Four)
Faculty Load : In semester VII 1/2 hour per week per project group
In semester VIII 1 hour per week per project group
Each faculty is permitted to take (guide) maximum 4 (Four) project groups.

Course codes	**Elective I**
MEE7011	Product Life Cycle Management (PLM)
MEE7012	Power Plant Engineering [&]
MEE7013	Energy Management
MEE7014	Supply Chain Management [&]
MEE7015	Computational Fluid Dynamics [&]
MEE7016	Advanced Turbo Machinery
MEE7017	Piping Engineering
MEE7018	Emission and Pollution Control
MEE7019	Operations Research
MEE70110	Total Productive Maintenance (TPM)
MEE70111	Robotics
MEE70112	Digital Prototyping for Product Design –I

[&] Common with Automobile Engineering

NOTE

Use of standard design data books like PSG Data Book, Design Data by Mahadevan is permitted at the examination and shall be supplied by the institute.

Internal Assessment

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Practical/Oral Examination

Each student will be given a small task of design based on syllabus, which will be assessed by examiners during the oral examination.

The distribution of marks for oral-practical examination shall be as follows:

Design Task	……	15 marks
Oral	……	10 marks

1. Evaluation of practical/oral examination to be done based on the performance of design task.
2. Students work along with evaluation report to be preserved till the next examination.

Theory Examination

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

References

1. Machine Design Exercises - S.N. Trikha, Khanna Publications, Delhi
2. Design of machine elements - V. B. Bhandari Tata McGraw Hill Pub.
3. Machine Design - An Integrated Approach - Robert L. Norton - Pearson Education Asia.
4. Mechanical Engineering Design - J. E. Shigley - McGraw Hill
5. Machine Design Exercises - S.N. Trikha, Khanna Publications, Delhi
6. Recommended Data Books – PSG and K. Mahadevan
7. Gear Design Handbook - GitinMaitra
8. Material handling equipments - N. Rudenko , Peace Publication
9. Material handling equipments - Alexandrov, MIR Publication
10. Machine Design - Reshetov - Mir Publication
11. Machine Design - Patel, Pandya, Sikh Vol – I & II, C. Jamnadas& Co. Educational & Law Publishers
12. Design of Machine Elements - V.M. Faires.
13. Design of Machine Elements - Spotts.
14. Pumps – Sahu

Course Code	Course/Subject Name	Credits
MEC702	**CAD/CAM/CAE[&]**	**4+1**

[&] Common with Automobile Engineering

Objectives

1. To introduce new and exciting field of Intelligent CAD/CAM/CAE with particular focus on engineering product design and manufacturing.
2. To develop a holistic view of initial competency in engineering design by modern computational methods.

Outcome: A learner will be able to….

1. Identify proper computer graphics techniques for geometric modelling.
2. Transform, manipulate objects and store and manage data.
3. Prepare part programming applicable to CNC machines.
4. Use rapid prototyping and tooling concepts in any real life applications.
5. Identify the tools for Analysis of a complex engineering component.

Modules	Details	Hrs.
01	**Computer Graphics and Techniques for Geometric Modeling** Computer Graphics: Two dimensional computer graphics, vector generation, the windowing transformation, Three dimensional Computer graphics, viewing transformation, Homogeneous coordinates, Perspective projection, Hidden line removal & hidden surface removal algorithm, light & shade ray tracing. The parametric representation of geometry, Bezier curves, Cubic Spline curve, B-Spline curve, parametric representation of line, circle, ellipse & parabola. Constructive solid geometry (CSG), Boundary Representation (B-Rep), Wire Frame Modeling, Solid Modeling, Surface Modeling, Parametric Modeling, feature based modeling, Feature recognition, Design by feature.	08
02	**Transformation, Manipulation & Data Storage** 2D & 3D Transformations (Translation, Rotation, & Scaling & Magnification), Concatenations, Matrix representation, Problems & object oriented programming on Transformations. Object transformation, mirror transformation, Artificial Intelligence in Design & Manufacturing, Representation of Knowledge, and Knowledge base Engineering.	08
03	**NC & CNC Technology** Tape coding & format, Manual Part Programming, Computer Aided Part Programming, CNC functions & advantages, DNC, adaptive Control, CNC programming concepts, Trends & new developments in NC, Part programmers job, functions of a post processor, NC part programming languages, Elements of a APT language, The Macro Statement in APT, NC programming with interactive graphics. Constructional details of CNC machines, Feedback devices- Velocity & displacement, Machining Centers and its types, Automated Material Handling & storage Systems like Robots, AGVs and AS/RS etc.	08
04	**Computer Aided Engineering (CAE)** Fundamentals of computer aided engineering, CAE includes mass property calculations, kinematic analysis and animation (movement, visualization, simulation and FEA). Case study based on modeling and analysis of structural, thermal/fluid, and dynamic (vibration analysis) system. Parameter optimization.	08

05	**Computer Integrated Manufacturing & Technology Driven Practices** Introduction, Evolution, Objectives, CIM Hardware and Software, CIM Benefits, Nature and role of the elements of CIM, Identifying CIM needs, Data base requirements of CIM, Role of CAD/CAM in CIM, Obstacles to Computer Integrated Manufacturing, Concept of the future CIM systems, Socio -techno- economic aspects of CIM.	08
06	**Rapid Prototyping and Tooling** Introduction to RP, Technology Description, Overview of RP, Benefits and Application. RP Processes: Process overviews, STL file Generation, Classes of RP systems: Stereo-lithography Approach (SLA), SLA with photo-polymerization (mathematical modelling of the process), SLA with liquid thermal polymerization, Selective Laser Sintering (SLS), Fused deposition modelling, Laminated object manufacturing, Laser powder forming. Prototype properties: Material properties, colour, dimensional accuracy, stability, surface finish, machinability, environmental resistance, operational properties. RP Applications: Design, Concept Models, Form & fit checking, Functional testing, CAD data verification, Rapid Tooling, Rapid manufacturing, Science & Medicine, RP processes for MEMS, Photolithography, Direct Laser Writer, Bulk Lithography for 3D micro fabrication (Modelling of beam propagation and curing in resin system).	08

List of Exercises

1. Programming for transformations,
2. Solid modeling using any 3D modeling software
3. Part programming and part fabrication on CNC trainer (Turning / Milling)
4. Geometrical optimization of any mechanical component using computer aided engineering concepts.
5. Development of physical 3D mechanical structure using any one of the rapid prototyping processes.
6. Rapid tooling for any one of the engineering or medical applications.

Term Work

Term work shall consist of any three exercises from the above list and a course project in a group of not more than three (3) students on either computer aided engineering or rapid prototyping and tooling

The distribution of marks for term work shall be as follows:

- Exercises : 15 Marks
- Course Project : 05 Marks
- Attendance (Theory & Practical) : 05 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Internal Assessment

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems.

Practical / Oral Examination

Practical examination of 2 hours duration based on any one of the following.

1) Programming for Algorithms, transformations.
2) Part Programming and machining of components.
3) 3D Modeling on software.
4) Analysis of component for optimization

The distribution of marks for oral-practical examination shall be as follows:

Practical Examination	……	15 marks
Oral	……	10 marks

1. Evaluation of practical/oral examination to be done based on the performance of design task.
2. Students work along with evaluation report to be preserved till the next examination.

Theory Examination

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

References

1. "CAD/CAM Computer Aided and Manufacturing" by Mikell P. Groover and Emory W. Zimmers, Jr., *Eastern Economy Edition*
2. "CAD/ CAM , Theory & Practice" by Ibrahim Zeid, R. Sivasubramanian, *Tata McGraw Hill Publications*
3. "Computer Graphics" by Donald Hearn and M. Pauline Baker, *Eastern Economy Edition*
4. "CAD/CAM Principles, Practice and Manufacturing Management" by Chris McMahon, Jimmie Browne, *Pearson Education*
5. "CAD/CAM/CIM" by P. Radhakrishan, S. Subramanyan, V. Raju, *New Age International Publishers*
6. "CAD/CAM Principles and Applications" by P.N. Rao, *Tata McGraw Hill Publications*
7. "Principle of Computer Graphics" by William .M. Neumann and Robert .F. Sproul, *McGraw Hill Book Co. Singapore.*
8. David L. Goetsch, Fundamental of CIM technology ,Delmar publication
9. David Bedworth, Computer Integrated Design and Manufacturing, *McGraw Hill.*
10. "CNC Machines" by B.S. Pabla and M. Adithan, *New Age International Publishers.*
11. "Numerical Control and Computer Aided Manufacturing" , T.K. Kundra, P.N. Rao, N.K. Tiwari, *Tata McGraw Hill*
12. "CNC Technology and Programming", Krar, S., and Gill, A., *McGraw Hill publishers*
13. "Computer Integrated Manufacturing- An Introduction with Case Studies" by Paul G. Ranky, *Prentice Hall International*
14. "Flexible Manufacturing Systems" by H.K. Shivanand, M.M. Benal, V.Koti, *New Age International Publishers*
15. "Automation, Production Systems and Computer Integrated Manufacturing ", Groover M.P., *Prentice-Hall of India Pvt. Ltd*
16. "Mathematical Elements for Computer Graphics", Rogers D F I and Adams J A, McGraw-Hill.

17. “Computer Integrated Manufacturing Hand Book” by Eric Teicholz, Joel N. Orr, McGraw Hill International Editions
18. “Rapid Prototyping” Chee Kai ChuaWorld Scientific Publishing
19. “Rapid Prototyping:Principles and Applications” RafiqNoorani, Wiley
20. “Rapid Prototyping:Principles and Applications” C.K. Chua,K.F.Leong, C.S. Lim World Scientific Publishing
21. “Rapid Prototyping and Manufacturing” P. F. Jacobs, Society of Manufacturing Engineers.

Course Code	Course/Subject Name	Credits
MEC703	**Mechanical Utility Systems**	**4+1**

Objectives

1. To study compressors, pumps and their utilities
2. To acquaint with various energy conservation techniques in pumping and compressed air systems

Outcomes: The learner will be able to**:**

1. Describe operating principles of compressors and pumps
2. Evaluate performance of reciprocating/rotary compressors
3. Illustrate and analyze characteristic curves of pumps
4. Interpret possibilities of energy conservation in pumping and compressed air systems

Module	Detailed Contents	Hrs.
01	**Reciprocating Compressors** Single stage reciprocating compressor-neglecting clearance. Multistage of compressors. Two stage air compressors. Perfect inter-cooling. Ideal inter cooler pressure. Minimum work, Free air delivered, volumetric efficiency, isothermal and adiabatic efficiency. Effect of clearance volume on F.A.D and volumetric efficiency. Work, power and efficiency calculations.	10
02	**Rotary Compressors** **Centrifugal compressor:** Velocity diagrams, work input, Efficiency, Effect of blade shape, Slip factor, Types of casings, Impeller and diffuser system and design aspects **Axial flow compressors:** Velocity triangles and calculation of work input and efficiency **Losses in Compressors:** Choking, Surging and Stalling	08
03	**Pumps** Classification of pumps - positive displacement and non - positive displacement. Positive Displacement pumps: Types and applications, general features of rotary pumps like gear pumps, vane pumps etc., general feature of reciprocating pumps, definition of head, discharge, work done and efficiency, types of reciprocating pumps, indicator diagram, use of air vessel.	08
04	**Centrifugal Pumps** Types - radial flow, mixed flow and axial flow, Priming of pumps, components of the pump, Euler's equation and velocity triangles, correction factors for the head, design constant e.g., head constant, flow constant etc., Types of blade profiles, aerofoil theory of axial flow pumps, Pressure recuperating devices, Radial thrust and axial thrust and methods used to balance them. Trouble shooting in centrifugal pumps, self priming pumps. Concept of system and system characteristics, Series and parallel operation of pumps. System curve for branch network. Determination of operating point. Cavitation in pumps, Determination of available and required NPSH	12

05	**Energy Conservation in Pumping System** Estimating operating parameters, Calculation of percentage loading, Part load efficiency and methods of improving efficiency, Improving loading, Changing impeller, trimming impeller, Variable speed drive, etc.	05
06	**Energy Conservation in Compressed air system** Applications of compressed air in industry, Compressed air network, Leak detection in compressed air network, Load unload test, pump-up test, Methods to improve performance	05

List of Experiments

1. Study of rotary compressors
2. Demonstration of different components of centrifugal pump by dismantling the pump system
3. Trial on reciprocating compressor
4. Trial on positive displacement pump
5. Trial on single stage centrifugal pump
6. Trial on multistage centrifugal pump
7. Presentation on various energy conservation techniques in pumping and compressed air system

Term work

Term work shall consist of minimum **03** assignments covering numerical on compressors and pumps and at least **o6** experiments from the above list. The distribution of marks for term work shall be as follows:

- Laboratory work (experiments/assignments): 15 marks
- Assignments: 05 marks
- Attendance (Theory and Practical): 05 marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Internal Assessment

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems.

Theory Examination

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

References

1. Thermal Engineering – R. K. Rajput
2. Steam and gas turbine – R. Yadav
3. Turbines, Compressors & Fans by S M Yahya, Tata Mc graw Hill
4. Hydraulic. Machinery - JagdishLal
5. Industrial Energy Management and Utilisation, L.C.Witte, P.S.Schmidt, D.R.Brown , Hemisphere Publ, Washington,1988.
6. Energy Management Handbook, W.C.Turner, Wiley, New York, 1982.
7. Technology Menu for Efficient energy use- Motor drive systems, Prepared by National Productivity Council and Center for & Environmental Studies- Princeton Univ, 1993.
8. Study material for Energy Auditor and Energy Manager Examination, Bureau of Energy Efficiency (www.beeindia.in)

Course Code	Course/Subject Name	Credits
MEC704	**Production Planning and Control**	**4+1**

Objectives

1. To provide a comprehensive exposure to Production Planning & Control (PPC) and its significance in Industries.
2. To acquaint students with various activities of PPC.
3. To give insight into the ongoing & futuristic trends in the control of inventory.
4. To appraise about need and benefits of planning functions related to products and processes.
5. To give exposure to production scheduling and sequencing

Outcomes: The learner will be able to**..**

1. Illustrate production planning functions and manage manufacturing functions in a better way.
2. Develop competency in scheduling and sequencing in manufacturing operations and effect affordable manufacturing lead time.
3. Manage and control inventory with cost effectiveness.
4. Get conversant with various documents procedural aspects and preparation of orders for various manufacturing methods.

Module	Details	Hours
01	**Concepts of PPC:** 1.1 Manufacturing systems- components and types, need for PPC, functions of PPC, relationship of PPC with other departments. 1.2 Factors influencing PPC in the organization, manufacturing methods- projects & jobbing products, batch, mass / flow production, continuous / process production. 1.3 Management policies- planning for meeting demands, work distribution, centralization, 1.4 Organization of PPC- status of PPC department, internal structure, degree of centralization, PPC as an integrated approach.	**06**
02	**Activities of PPC:** 2.1 Prerequisites of PPC- data pertaining to design, equipment, raw materials, tooling, performance standards, labour& operating systems. 2.2 Order preparation- works order preparation for various manufacturing methods, subsidiary orders, shop or production orders, inspection orders and stores issue orders.	**04**
03	**Inventory Control:** 3.1 Basic concepts of inventory, purpose of holding stock and influence of demand on inventory 3.2 Ordering procedures, Two Bin system, ordering cycle, economical order quantity and economical lot size, ABC analysis and reorder procedures. 3.3 Recent trends- computer integrated PP systems, JIT system and MRP-I, MRP-II and ERP (only theory).	**08**

04	**Product Planning and Process Planning** 4.1 Product planning: product information and its relevance. Problems in lack of product planning. 4.2 Process planning: Prerequisite information requirement, steps in process planning, process planning in different situations, documents in process planning, machine / process selection & Computer Aided Process Planning. 4.3 Forecasting: Various Qualitative and Quantitative models, their advantages and disadvantages.	**10**
05	**Linear Programming Concepts** Introduction to Linear Programming, Problem Formulation, Simplex method. Assignment, Transportation and Transshipment Models.	**08**
06	**Production Scheduling and Sequencing** 6.1 Inputs for scheduling, loading and scheduling devices, factors influencing scheduling, scheduling techniques, use of Gantt Charts and basic scheduling problems. 6.2 Product sequencing, dispatching: progress report & expectation of manufacturing lead time technique for aligning completion time &due dates. 6.3 Project management: concepts of project planning, monitoring and control, elements of network analysis –PERT & CPM, cost analysis & crashing.	**12**

Term Work

The Term work shall comprise of the following:-

1. At least six exercises/assignments comprising problems covering different topics from the syllabus.
2. One seminar presentation based on a selected topic from the syllabus.
3. One seminar presentation pertaining to a case study related to PPC

The distribution of marks for term work shall be as follows:

- Lab work (Exercises /Assignments): **10** marks
- Presentation: **10** marks
- Attendance (Theory and Practical's) : **05** marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Internal Assessment

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Oral examination

1. Oral examination shall be conducted based on term work and syllabus content
2. Examiners are expected to give small task or ask questions either to evaluate understanding of basic fundamentals or to evaluate their capability of applying basic theory to practical applications.

Theory Examination

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

References

1. Production Planning and Control, L. C. Jhamb –Everest Publishing House.
2. Production Planning and Control, W. Boltan-Longman Scientific & Technical.
3. Production Systems- Planning, Analysis& Control, James. L. Riggs-John Wiley & Sons.
4. Manufacturing Planning and Control Systems, Thomas E. Vollman, Willam L. Berry& Others-Galgotia Publishers.
5. Manufacturing Process Planning and Systems Engineering, Anand Bewoor-Dreamtech Press.
6. Production and Operations Management, S.N.Chary- TMH publishing company.
7. Modernization & Manufacturing Management, L.C. Jhamb - Everest Publishing House.

Course Code	Course/Subject Name	Credits
MEE7011	**Product Lifecycle Management**	**3+1**

Objectives

1. To familiarize the students with the need, benefits and components of PLM.
2. To acquaint students with Product Data Management & PLM strategies.
3. To give insights into new product development program and guidelines for designing and developing a product.
4. To appraise about technology forecasting & its implications.

Outcome: The learner will be able to…..

1. Gain knowledge about phases of PLM, PLM strategies and methodology for PLM feasibility study and PDM implementation.
2. Illustrate various approaches and techniques for designing and developing products.
3. Apply product engineering guidelines / thumb rules in designing products for moulding, machining, sheet metal working etc.
4. Identify and use appropriate technology forecasting, methods for different areas of technology.

Modules	Detailed contents	Hrs.
1.	**Introduction to Product Lifecycle Management (PLM)** Product Lifecycle Management (PLM), Need for PLM, Product Lifecycle Phases, Opportunities of Globalization, Pre-PLM Environment, PLM Paradigm, Importance & Benefits of PLM, Widespread Impact of PLM, Focus and Application, A PLM Project, Starting the PLM Initiative, PLM Applications **PLM Strategies** Industrial strategies, Strategy elements, its identification, selection and implementation, Developing PLM Vision and PLM Strategy , Change management for PLM	05
2.	**Product and Product Data** Product Importance, Range, Parts, Ingredients, Components, Assemblies, Identifier, Requirements From Customer, Requirement to Product Specification, Identification Standards, Unique Identifier, Unique Key, Traceability. Communication of Identifier, Product Classification, Versions, Variants, Options, Product Ownership, Product Structure and Architecture, Product Data types and importance, Product Data Models **Product Data Management (PDM)** PDM systems and importance, Components of PDM, Reason for implementing a PDM system, Financial justification of PDM, Barriers to PDM implementation	07
3.	**Product Design** Basic principles of Design, Evolution of Design, The generic product development process, Identifying Customer Needs, Product Specifications, Concept Generation, Concept Selection, Concept Testing, Product Architecture, Product Aesthetics- Size, Form, Colour etc, Ergonomics or Human Factors in Product Design, Modelling and Simulation in Product Design, New Product Development Process	07
4.	**Integration of Environmental Aspects in Product Design** Sustainable Development, , Design for X System and tools, Design for Disassembly, Design for Environment, Need for Life Cycle Environmental Strategies, Useful Life Extension Strategies, End-of-Life Strategies, Introduction of Environmental Strategies into the Design Process, Life Cycle Environmental Strategies and Considerations for Product Design	06

5.	**Life Cycle Assessment and Life Cycle Cost Analysis** Properties, and Framework of Life Cycle Assessment, Phases of LCA in ISO Standards, Fields of Application and Limitations of Life Cycle Assessment, Cost Analysis and the Life Cycle Approach, General Framework for LCCA, Evolution of Models for Product Life Cycle Cost Analysis, Case Studies in LCA and LCCA	06
6.	**Technology Forecasting** Evolution for technology forecasting and its importance, Future mapping, Methods of technology forecasting, Numerical Data Based, Judgement Based such as Relevance Trees, Morphological Method, Network Analysis, Delphi Method, Cross Impact Method	05

Term Work

Term work shall comprise of the following:-

1. One assignment on understanding basic PLM curve, perspective from manufacturer and user point of view, drawing and analysing the PLM curve for specific products.
2. One assignment on product data, PDM and its suitable applications/examples.
3. One case study on understanding complete product design procedure, documenting and interpreting data related to design process.
4. One case study on Design for Disassembly (DfD), disassembly of an actual product/system and understanding for DfD, Design for Environment (DfE).
5. One case study on Useful life extension and End of life strategies of actual products.
6. One presentation pertaining to one of the topic from the syllabus.

The distribution of marks for term work shall be as follows:

- Assignments: 05 Marks
- Case Studies: 10 Marks
- Presentations: 05 Marks
- Attendance(Theory and Practical's): 05 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Internal Assessment

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

References

1. John Stark, “Product Lifecycle Management: Paradigm for 21st Century Product Realisation”, Springer-Verlag, 2004. ISBN: 1852338105
2. Fabio Giudice, Guido La Rosa, AntoninoRisitano, “Product Design for the environment-A life cycle approach”, Taylor & Francis 2006, ISBN: 0849327229
3. SaaksvuoriAntti, ImmonenAnselmie, “Product Life Cycle Management”, Springer, Dreamtech, ISBN: 3540257314
4. Michael Grieve, “Product Lifecycle Management: Driving the next generation of lean thinking”, Tata McGraw Hill, 2006, ISBN: 0070636265
5. Karl Ulrich, Steven Eppinger, “Product Design and Development”,McGraw Hill Education, 2008, ISBN- 9780070146792
6. Jack R. Meredith and Samuel J. Mantel, “Technology Forecasting”, 1995, John Wiley and Sons

Course Code	Course/Subject Name	Credits
MEE7012	**Power Plant Engineering[&]**	**3+1**

[&] Common with Automobile Engineering

Objectives

1. Study basic working principles of different power plants
2. Study power plant economics

Outcomes: Learner will be able to…

1. Comprehend various equipments/systems utilized in power plants
2. Discuss types of reactors, waste disposal issues in nuclear power plants
3. Illustrate power plant economics

Module	Detailed Contents	Hrs.
01	Introduction: Energy resources and their availability, types of power plants, selection of the plants, review of basic thermodynamic cycles used in power plants.	04
02	Hydro Electric Power Plants : Rainfall and run-off measurements and plotting of various curves for estimating stream flow and size of reservoir, power plants design, construction and operation of different components of hydro-electric power plants, site selection, comparison with other types of power plants.	06
03	Steam Power Plants: Flow sheet and working of modern-thermal power plants, super critical pressure steam stations, site selection, coal storage, preparation, coal handling systems, feeding and burning of pulverized fuel, ash handling systems, dust collection-mechanical dust collector and electrostatic precipitator.	08
04	Combined Cycles: Constant pressure gas turbine power plants, Arrangements of combined plants (steam & gas turbine power plants), re-powering systems with gas production from coal, using PFBC systems, with organic fluids, parameters affecting thermodynamic efficiency of combined cycles. Problems.	06
05	Nuclear Power Plants: Principles of nuclear energy, basic nuclear reactions, nuclear reactors-PWR, BWR, CANDU, Sodium graphite, fast breeder, homogeneous; gas cooled. Advantages and limitations, nuclear power station, waste disposal.	06
06	Power Plant Economics: Load curve, different terms and definitions, cost of electrical energy, tariffs methods of electrical energy, performance & operating characteristics of power plants- incremental rate theory, input-out put curves, efficiency, heat rate, economic load sharing, Problems.	06

List of Experiments

1. Case study report on at least two types of power plants
2. Group presentation (Group shall not be more than 3 students) on topics relevant to syllabus
3. Industrial visit to any power plant

Term Work

Term work shall consist of one case study report and 5 assignments covering maximum syllabus

The distribution of marks for term work shall be as follows:

- Case study**:** **05 marks**
- Industrial visit report: **05 marks**
- Presentation: **05 marks**
- Assignments : **05 marks**
- Attendance (Theory and Practical) **:** **05 marks**

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Internal Assessment

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

References

1. Power Plant Engineering, A K Raja, Amit Praksh Shrivastava, Manish Dwivedi, New Age International Publishers
2. Power Plant Familiarization, Manual of Central Training Resources Unit of NTPC India, 1991
3. Power Plant Engineering, 2nd ed, P.K. Nag , Tata McGraw-Hill Pub. Com., New Delhi.
4. Hydro-Electric and Pumped Storage Plants, M G Jog, New Age International Publishers
5. A Text Book of Power Plant Engineering, R.K. Rajput, Laxmi Publications
6. A Course in Power Plant Engineering, Arora, Domkundwar, DhanpatRai & Co.
7. Power Plant Engineering, P.C. Sharma, S.K. Kataria& Sons.
8. Power Plant Engineering, G.R. Nagpal, Khanna Publishers
9. Power station Engineering and Economy by Bernhardt G.A. Skrotzki and William A. Vopat, Tata Mc Graw Hill Publishing Campany Ltd., New Delhi
10. Nuclear Energy An Introduction to the Concepts, Systems and Applications of Nuclear Processes, 6th Edition, Raymond L Murray, , ELSEVIER
11. Power Plant Engineering, Manoj Kumar Gupta, PHI Learning
12. Nuclear Power Plant Engineering, James Rust, Haralson Publishing Company
13. Nuclear Power Plants, Edited by Soon Heung Chang, InTech Publishers, 2012
14. Nuclear Power Plants, Geotge Petridis and DimitriosNicolau, NOVA Publishers

Course Code	Course/Subject Name	Credits
MEE 7013	**Energy Management**	**3+1**

Objectives

1. Study principles of energy management
2. Study energy economics and auditing
3. Study electrical energy management, cogeneration and waste heat recovery

Outcomes: Learner will be able to…

1. Summarize and explain need for energy management, economics and auditing
2. Describe importance of and analyze efficiency in thermal and electrical utilities
3. Assess need of waste heat recovery and cogeneration

Module	Detailed Contents	Hrs.
01	General Aspects of Energy Management: Current energy scenario: India and World, Current energy consumption pattern in global and Indian industry, Principles of Energy management, Energy policy, Energy action planning, Energy security and reliability, Energy and environment, Need of Renewable and energy efficiency.	04
02	Energy Auditing : Need of Energy Audit, Types of energy audit, Components of energy audit, Energy audit methodology, Instruments, equipment used in energy audit, Analysis and recommendations of energy audit - examples for different applications, Energy audit reporting, Energy audit software.	06
03	Energy Economics : Costing of Utilities - Determination of cost of steam, natural gas, compressed air and electricity. Financial Analysis Techniques - Simple payback, Time value of money, Net Present Value (NPV), Return on Investment (ROI), Internal Rate of Return (IRR), Risk and Sensitivity analysis.	08
04	Energy Efficiency in Thermal Utilities: Energy performance assessment and efficiency improvement of Boilers, Furnaces, Heat exchangers, Fans and blowers, pumps, Compressors and HVAC systems. Assessment of steam distribution losses, Steam leakages, Steam trapping, Condensate and flash steam recovery system	06
05	Electrical Energy Management and Lighting: Distribution and transformer losses. Electrical motors - types, efficiency and selection. Speed control, Energy efficient motors. Electricity Act 2003. Lighting - Lamp types and their features, recommended illumination levels, lighting system energy efficiency.	06
06	Cogeneration and Waste Heat Recovery, Cogeneration- Need, applications, advantages, classification, the cogeneration design process. Waste heat recovery- Classification and application, Potential for waste-heat recovery in Industry, Commercial WHR devices, saving potential. CDM projects and carbon credit calculations.	06

List of Experiments

1. Energy audit of a small scale industry/institute and submit report with recommendation.
2. Energy audit of HVAC or Compressed air or Boiler and steam system and submit report with recommendations.
3. Carry out the Energy audit of Electrical system.
4. Electrical tariff calculations
5. Visit to cogeneration or waste heat recovery plant and submit a report

Term Work

Term work shall consist of experiments from the list including energy audit reports, 3 assignments covering maximum portion of the syllabus and a report on factory visit

The distribution of marks for term work shall be as follows:

- Laboratory work (Experiments) **:** **10 marks**
- Assignments : **05 marks**
- Visit report: **05 marks**
- Attendance (Theory and Practical) **:** **05 marks**

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Internal Assessment

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

References

1. Energy engineering and management, AmlanChakrabarti, PHI Learning, New Delhi 2012
2. Handbook of Energy Audit, Albert Thumann P.E. CEM, William J. Younger CEM, The Fairmont Press Inc., 7th Edition.
3. Energy management Handbook, 5th Edition, Wayne C. Turner, The Fairmont Press Inc., Georgia.
4. Handbook on Energy Audit and Environment management, Abbi Y. A., Jain Shashank, TERI, New Delhi, 2006
5. Energy Performance assessment for equipment and Utility Systems Vol. 1 to 4, Bureau of Energy Efficiency, Govt. of India
6. General Aspects of Energy Management and Energy Audit, Bureau of Energy Efficiency, Govt of India
7. Boiler Operators Guide Fourth Edition, Anthony L Kohan, McGraw Hill
8. Energy Hand book, Second edition, Von Nostrand Reinhold Company - Robert L. Loftness.
9. Sustainable Energy Management, MirjanaGolusin, SinisaDodic, Stevan Popov, Academic Press
10. Trivedi P R, Jolka K R, Energy Management, Commonwelth Publications, New Delhi
11. www.enrgymanagertraining.com
12. www.bee-india.nic.in

Course Code	Course/Subject Name	Credits
MEE7014	**Supply Chain Management[&]**	**3+1**

[&] Common with Automobile Engineering

Objectives

1. To acquaint with key drivers of supply chain performance and their inter-relationships with strategy.
2. To impart analytical and problem solving skills necessary to develop solutions for a variety of supply chain management & design problems.
3. To study the complexity of inter-firm and intra-firm coordination in implementing programs such as e-collaboration, quick response, jointly managed inventories and strategic alliances.

Outcomes: Learner will be able to…..

1. Illustrate the role & functions of supply chain management and its processes.
2. Analyze the flows of material, information and funds in an integrated manner.
3. Evaluate various performance measures of supply chain management.

Module	Details	Hrs.
01	**Building a Strategic Frame Work to Analyse Supply Chains** Supply chain stages and decision phases, Process view of supply chain: Supply chain flows, Examples of supply chains, Competitive and supply chain strategies, Achieving strategic fit: Expanding strategic scope, Drivers of supply chain performance. Framework for structuring drivers: inventory, transportation facilities, information obstacles to achieving fit.	04
02	**Designing the Supply Chain Network** Distribution Networking: Role, Design, Supply Chain Network(SCN):Role, Factors, Framework for design decisions.	05
03	**Materials Management** Scope, Importance, Classification of materials, Procurement, Purchasing policies, Vendor development and evaluation. Inventory control systems of stock replenishment, Cost elements, EOQ and its derivative modules.	06
04	**Dimensions of Logistics** Introduction: A Macro and Micro Dimensions, Logistics interfaces with other areas, Approach to analyzing logistics system, Logistics and systems analyzing: Techniques of logistics system analysis, factors affecting the cost and Importance of logistics.	06
05	**Warehouse and Transport Management** Concept of strategic storage, Warehouse functionality, Warehouse operating principles, Developing warehouse resources, Material handling and packaging in warehouses, Transportation Management, Transport functionality and principles, Transport infrastructure, transport economics and Pricing. Transport decision making.	07
06	**IT in Supply Chain** 6.1 IT framework, Customer Relationship Management (CRM),internal Supply chain management, Supplier Relationship Management (SRM) and Transaction Management. Coordination in a Supply Chain 6.2 Lack of supply chain coordination and the Bullwhip effect, Obstacle to Coordination, Managerial levers, Building partnerships and trust. Emerging Trends and Issues 6.3 Vendor managed inventory-3PL-4PL, Reverse logistics: Reasons, Role, Activities; RFID systems: Components, Applications, Implementation; Lean supply chain, Implementation of Six Sigma in supply chain, Green supply chain.	08

Term Work

Term work shall consist of,

1. Assignments: On topics drawn from syllabus [At least 1 assignment per module].
2. Seminar / case study on the modules / trending scenario (current) in industry.

The distribution of marks for term work shall be as follows;

- Seminar / Case study Presentation & report: **10** marks
- Assignments: **10** marks
- Attendance (Theory and Practical): **05** marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Internal Assessment

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

References

1. *Supply Chain Management Strategy, Planning, and operations*, Sunil Chopra and Peter Meindl
2. *Materials Management & Purchasing*, Ammer D.S. Taraporawala
3. *Designing & Managing Supply chain*, David Simchi Levi, Philip Kaminsky& Edith Smichi Levi
4. *Supply Chain Redesign: Transforming Supply Chains into Integrated Value Systems*, Robert B Handfield, Ernest L Nicholas
5. *The Management of Business Logistics: A Supply Chain Perspective*, Coyle, Bardi, Langley

Course Code	Course/Subject Name	Credits
MEE 7015	**Computational Fluid Dynamics[&]**	**3+1**

[&] Common with Automobile Engineering

Objectives

1. Study basic principles of modeling a system using software
2. Study grid generation and discretization methods

Outcomes: Learner will be able to…

1. Demonstrate & explain geometrical model of a fluid flow
2. Describe specific boundary conditions and solution parameters
3. Analyze the results and draw the appropriate inferences

Module	Detailed Contents	Hrs.
01	**Introduction:** What is CFD, Scope and Application of CFD, Methods of Predictions like Experimental and theoretical, Working of Commercial CFD Softwares, Solution methodology-Preprocessing, Solver, Post processing.	04
02	**Mathematical description of Physical Phenomenon:** Governing Differential Equations, Meaning of Differential equation, The Continuity Equation, A Momentum equation, The Energy Equation, The General Differential Equation, Boundary Conditions, Initial and Boundary Conditions, Initial and Boundary Conditions, Initial and Boundary Value problems	06
03	**Grid Generation and Discretization Methods:** Structured and unstructured Grids: O-type, H-type, C-type of Structured Grid Generation, Mesh Adaptation. The Nature of Numerical Methods: The Discritization Concept, The Structure of the Discritization Equation. Methods of Deriving the Discretization Equations, Taylor-Series Formulation, Variational Formulation, Method of Weighted Residuals, Control Volume Formulation	08
04	**Heat Conduction, Convection and Diffusion:** Steady One-dimensional Conduction, Unsteady One-dimensional Conduction, Two and Three-dimensional Situations, Over relaxation and Under relaxation, Steady One-dimensional and Two Dimensional Convection-Diffusion, Unsteady One-dimensional Convection	06
05	**Incompressible Fluid Flow:** Governing Equations, Stream Function-Vorticity Method, Determination of Pressure for Viscous Flow, The SIMPLE, SIMPLER Algorithm, Introduction to Turbulence Modeling, Basic Theories of Turbulence, The Time-Averaged Equations for Turbulent Flow.	06
06	**Finite Volume Methods**: FVM solutions to steady one, two and three dimensional diffusion problems and unsteady one and two dimensional diffusionproblems, FVM solutions to convection-diffusion problems - one and twodimensional, steady and unsteady; Advection schemes; Pressure velocity coupling	06

List of Experiments

1. Simulate and solve, two problems, each 2-d and 3-d steady and unsteady flows using any commercial CFD package like Ansys-FLUENT, STAR CCM, FLUIDYNE, Ansys-CFX, etc.
2. Write codes for, at least one each, 1-d and 2-d steady conduction with and without source and do the post processing to verify with analytical results
3. Write codes, at least one, for steady, 2-d conduction-advection problems and do the post processing to verify with analytical results

Term Work

Term work shall consist of experiments from the list, 3 assignments covering maximum portion of the syllabus.

The distribution of marks for term work shall be as follows:

- Laboratory work (Experiments) **:** **15 marks**
- Assignments : **05 marks**
- Attendance (Theory and Practical) **:** **05 marks**

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Internal Assessment

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

References

1. An introduction to computational fluid dynamics-The finite volume method, Versteeg.H.K. , Malalasekera.W., Prentice Hall
2. Computational Fluid Mechanics and Heat Transfer, Anderson, D.A., Tannehill, I.I., and Pletcher, R.H., Hemishphere Publishing Corporation, New York, USA, 1984.
3. Introduction to Computational Fluid Dynamics, Niyogi P. ,Laha M.K., Chakrabarty S.K., Pearson Education, India.
4. Computational Fluid Flow and Heat Transfer, Muralidhar, K.,andSundararajan,T., Narosa Publishing House ,New Delhi1995.
5. Computer Simulation of flow and heat transfer, Ghoshdasdidar, P. S., Tata McGraw-Hill Publishing Company Ltd., 1998.
6. Finite Element Programming of the Navier Stock Equation, Taylor, C and Hughes J.B., Pineridge Press Ltd.U.K.1981.
7. Computational Techniques for Fluid Dynamics: Fundamental and General Techniques, Fletcher, C.A.J., Springer-Verlag, 1987.
8. Numerical Fluid Dynamics, Bose, T. K., Narosa Publishing House, 1997.

Course Code	Course/Subject Name	Credits
MEE 7016	**Advanced Turbo Machinery**	**3+1**

Objectives

1. To study principles of turbo machinery
2. To develop knowledge and ability to design/suggest turbo machine for particular application
3. To study testing and control of fans/blowers

Outcomes: Learner will be able to:

1. Recognize typical designs of turbo machines
2. Determine the velocity triangles in turbo machinery stages operating at design and off-design conditions
3. Analyse performance of various turbo machines

Module	Details	Hrs.
01	**Principles of Turbo machinery:** Introduction, Overview and Machinery Classification, Review of Conservation Laws, Scaling Laws, Work and Efficiencies in Compressor Stages, Selection of centrifugal, axial, mixed flow, Axial flow machines based on specific Speed.	**06**
02	**Flow Through Cascades:** Two-dimensional Flow, Cascade of Blades, Cascade Tunnel, Axial Turbine Cascades, Axial Compressor Cascades.	**06**
03	**Analysis of Axial Turbine Stage:** Single Impulse Stage, Multi-stage velocity and Pressure Compounded Impulse, Reaction Stages, Losses and Efficiencies, Performance Charts.	**06**
04	**Analysis of Centrifugal Blower:** Theoretical Characteristic Curves, Euler Characteristics and Euler Velocity Triangles, Losses and Efficiencies, Flow through impeller Casing, , Multi-vane Impellers of Impulse Type, Cross flow Fans.	**06**
05	**Testing and Control of Fans:** Fan Testing, Noise Control, Materials and Components Blower, Regulation, Speed Control, Throttling Control at Discharge and Inlet.	**06**
06	**Design and Application of Blowers:** Special Design and Applications of Blower, Induced and Forced Draft Fans for Cooling Towers, Ventilation Systems, Booster Systems.	**06**

Term Work

Term work shall consist of minimum 6 assignments and a presentation on syllabus related topic (prepared and presented by a group of not more than 3 students).

The distribution of marks for term work shall be as follows.

- Assignments: **10** marks
- Presentation: 1**0 Marks**
- Attendance (Theory and Practical): **05** marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Internal Assessment

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

References

1. Stepanoff A.J. Turbo blowers, John Wiley & Sons, 1970.
2. Brunoeck, Fans, Pergamon Press, 1973.
3. Austin H. Chruch, Centrifugal pumps and blowers, John Wiley and Sons, 1980.
4. S.L. Dixon, Fluid Mechanics, Thermodynamics of Turbomachinery , Elsevier
5. S.L. Dixon. Worked examples in Turbomachinery, Pergamon Press, 1984.
6. S M Yahya, Turbines, Compressors and Fans, Tata McGraw Hill Publishing Company Ltd.

Course Code	Course/Subject Name	Credits
MEE 7017	**Piping Engineering**	**3+1**

Objectives

1. Study fundamental, codes and standards of piping systems
2. Study piping layout and drawings
3. Study basic loading conditions and failure nodes

Outcomes: Learner will be able to…

1. Discuss different piping standards and codes
2. Read piping symbols, drawings and layouts
3. Analysis of piping supports and systems in terms of stress

Module	Detailed Contents	Hrs.
01	**Introduction to Piping:** Introduction to phases of plant design**,** Role of Piping within project plan. Design Philosophy, Process data sheets, Process flow diagram, Piping & Instrumentation diagrams, and Equipment layout. Interdisciplinary inputs/coordination.	04
02	**Piping fundamentals:** Piping elements (pipes, fittings, flanges, gasket, bolting, Valves), Pipe schedule, Pipe thickness calculations, pipe fittings (bends, elbow, Tees, Reducers, Stub ends, cross), Special pipe fittings, expansion joints, types of flanges, pressure temperature rating for flanges.	06
03	**Piping Codes & Standards** American Standards, Indian standards, British Standards for Piping Engineering. Selection of Design code. Unified numbering system (UNS). **Piping materials** : ASME, ASTM , IS materials for piping components such as pipe, fittings, flanges, bolting, supports, expansion joints, valves etc. Selection of materials.	08
04	**Piping Drawing** Piping symbols, orthographic (Plan & Elevation) drawings. **Plot Plan**, **Equipment Layout & Piping GA Drawings:** Plot Plan Development & Requirements (General guidelines) Equipment Layout Terminology, Control Point & Battery Limits. Preparation of Equipment Layout. Piping GA Drawing Requirements and Layout Procedure. Pump GA Drawing and Layout Consideration.	06
05	**Piping supports** Fixed supports like Rest , Line guide, Line stop, Hold down, Rigid strut etc., Flexible supports like variable spring support, constant spring support, Snubber etc.	06
06	**Piping Stress Analysis :** Need of Stress Analysis, Procedure to carry out stress analysis, Loads on the piping system(such as sustained , thermal, hydro-test loads, water hammer, relief valve outlet)**,** Allowable stress**,** Flexibility analysis, thermal load calculations, critical line list preparation , Steps involve in stress analysis of piping system, Pipe support.	06

List of Experiments

1. Draw Piping Symbols.
2. Draw General Arrangement for Plant Layout.
3. Draw Orthographic drawing of any 5 piping systems

Term Work

Term work shall consist of experiments from the list including assignments on

1. Introduction to Piping
2. Piping fundamentals
3. Piping Codes & Standards
4. Piping materials
5. Piping supports
6. Piping Stress Analysis

The distribution of marks for term work shall be as follows:

- Laboratory work (Experiments) **:** **10 marks**
- Assignments : **10 marks**
- Attendance (Theory and Practical) **:** **05 marks**

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Internal Assessment

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

References

1. Piping Handbook, Mohinder L. Nayyar, McGraw-Hill Publication
2. Piping Design Handbook, Macetta John, M. Dekker , 1992
3. ASME code for Process Piping ,ASME B31.1
4. ASME code for Process Piping , ASME B31.3
5. ASME B16.5 , Pipe ,Flanges & Flange Fittings
6. An International Code 2007 ASME Boiler & Pressure Vessel Code, Rules For Construction of Pressure Vessels, Section II A, B, C & D

Course Code	Course/Subject Name	Credits
MEE 7018	**Emission and Pollution Control**	**3+1**

Objectives

1. Study impacts of pollution on environment
2. Study emission measurement and control techniques

Outcomes: Learner will be able to…

1. Illustrate sources of emission, measure and quantify air pollution level and harmful effects of pollution
2. Summarize and explain pollution norms, clean air act etc.
3. Describe importance of emission measurement and control
4. Assess need of eco-friendly fuel and vehicle

Module	Detailed Contents	Hrs.
01	Air Pollution due to Automobile Exhaust: Exhaust gas constituents & analysis, Ingredients responsible for air pollution, Harmful effects of various ingredients on plant ecology & human life. Pollution Norms: European pollution norms, Indian pollution norms as per Central Motor Vehicle Rules (C.M.V.R.).	04
02	Sources of Emission: Air Pollution due to engine exhaust, Emission from petrol tank & carburetor, crankcase blow-by. Effect of valve timing, ignition timing, Combustion chamber design, Fuel injection, fuel composition, air fuel ratio, mechanical condition of engine components and driving mode.	06
03	Smoke: Smoke problems, types of smoke, factors affecting diesel smoke, odor, Smog formation. Exhaust Emission Control: Basic method of emission control, catalytic converter, After burners, reactor manifold, air injection, crank case emission control, evaporative loss control, Exhaust gas recirculation, Fuel additives.	08
04	Control Techniques for SI and CI: Design changes, optimization of operating factors, exhaust gas re-circulation, fumigation and air injector PCV system-Exhaust treatment in SI engines - Thermal reactors, Catalysts, Uses of unleaded petrol.	06
05	Alternative Fuels: CNG, LPG, Bio-Diesel, Hydrogen, fuel cells, Eco-friendly vehicles, Electric & Solar operated vehicle.	06
06	Instrumentation for Exhaust Emission Measurement: Measurement procedure, Sampling Methods, Orsat Apparatus, Infrared Gas analyzer, Flame Ionization Detector (FID), Gas chromatograph, Smoke meters.	06

List of Experiments

1. Study of Emission Norms
2. Measurement of emission by portable exhaust gas analyzer.
3. Measurement of emission by Infra Red Gas Analyzer (IRGA)
4. Measurement of smoke by Bosch smoke meter
5. Measurement of smoke by Hartridge smoke meter
6. Study of Exhaust Gas Recirculation (EGR)
7. Study of Evaporative Loss Control Device (ELCD)
8. Study of catalytic converter
9. Analysis of exhaust gas using Orsat Apparatus
10. Study of LPG / CNG Kit

Term Work

Term work shall consist of minimum 6 experiments from the list, 3 assignments covering maximum portion of the syllabus and a report on factory visit

The distribution of marks for term work shall be as follows:

- Laboratory work (Experiments) **:** **15 marks**
- Assignments : **05 marks**
- Attendance (Theory and Practical) **:** **05 marks**

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Internal Assessment

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

References

1. Internal Combustion Engine and Air Pollution, E.F. Oberts, Row Publisher, NY
2. Vehicle Operation & Testing: Automotive Vehicle Technology Vol. 7, J.G. Giles
3. Carburetion, Vol. 4, C.H. Fisher
4. Carburetion and Fuel Injection System: Motor Manual, Vol. 2, A.W. Judge, TheCaton Pub. Co. Ltd., London
5. Environmental engineering, C J Rao, New Age Publishers
6. Environmental studies, D L Manjunath, Pearson
7. Instrumental Method of Analysis, H.H. Willard and Others, CBS Publishers & Distributors, Delhi.
8. Automobile Engineering, G.B.S. Narang, CBS Publishers & Distributors, Delhi
9. Electronics & Instrumentation Handbook, Gupta B. R., Wheeler Publishing
10. Light & Heavy Vehical technology, M. J. Nunney, Elsevier

Course Code	Course/Subject Name	Credits
MEE7019	**Operations Research**	**3+1**

Objectives

1. To familiarize the students with the use of practice oriented mathematical applications for optimization functions in an organization.
2. To familiarize the students with various tools of optimization, probability, statistics and simulation, as applicable in particular scenarios in industry for better management of various resources.

Outcomes: Learner will be able to…..

1. Illustrate the need to optimally utilize the resources in various types of industries.
3. Apply and analyze mathematical optimization functions to various applications.
2. Demonstrate cost effective strategies in various applications in industry.

Module	Details	Hrs.
01	**Linear Programming**: Linear Programming Problem Formulation, Graphical solution, Simplex method, Twophase method, Big-M method, Principle of Duality, Dual Simplex, Sensitivity Analysis.	**11**
02	**Transportation problem**: Formulation - Optimal solution, Degeneracy. **Assignment problem:** Formulation - Optimal solution, Traveling Salesman problem. **Sequencing:** Introduction - Flow Shop sequencing - n jobs through two machines - n jobs through three machines - Job shop sequencing - two jobs through 'm' machines.	**05**
03	**Replacement**: Introduction - Replacement of items that deteriorate with time - when money value is not counted and counted - Replacement of items that fail completely, group replacement. **Queuing Models**: Introduction -Single Channel - Poisson arrivals - Exponential service times - with infinite population and finite population models, Multichannel - Poisson arrivals - Exponential service times with infinite population single channel Poisson arrivals.	**05**
04	**Game Theory**: Introduction - Minimax (Maximin) -Criterion and optimal strategy - Solution of games with saddle points – Rectangular games without saddle points - 2 X 2 games - dominance principle - m X2 & 2 X n games, graphical method.	**05**
05	**Inventory Models**: Introduction - Single item - Deterministic models - Purchase inventory models with one price break and multiple price breaks - shortages are not allowed - Stochastic models - demand may be discrete variable or continuous variable -Instantaneous production - Instantaneous demand and continuous demand and no set up cost.	**05**
06.	**Dynamic programming**: Introduction - Bellman's Principle of optimality - Applications of dynamic programming- capital budgeting problem - shortest path problem – Minimum Spanning Tree. **Simulation**: Definition - Types of simulation models - phases of simulation - applications of simulation - Inventory and Queuing problems - Advantages and Disadvantages - Simulation Languages.	**05**

Term Work

Term work shall consist of;

1. Assignments: On topics drawn from syllabus [At least 1 assignment per module].
2. Based on topics from syllabus, minimum 06 problems are to be solved and presented with inferences.
3. Exposure to problem solving using MS Office Excel and software packages such as TORA, WinQSB and LINDO is recommended.

The distribution of marks for term work shall be as follows;

- Laboratory work (problem solving: manual/programs and journal): **10** marks
- Assignments: **10** marks
- Attendance (Theory and Practical): **05** marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Internal Assessment

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

References

1. *Operations Research: Principle and Practices*, A. Ravindran, D. Phillips, Wiley India.
2. *Operations Research*, S. D. Sharma, KedarNath Ram Nath-Meerut.
3. *Operations Research*, R. Panneerselvam, PHI Publications.
4. *Operations Research*, A. M. Natarajan, P. Balasubramani, A. Tamilarasi, Pearson Education
5. *Operations Research* - An introduction, Hamdy A Taha, Pearson Education.
6. *Operations Research*, KantiSwarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons.
7. *Operations Research: Methods and Problems*, Maurice Saseini, ArhurYaspan and Lawrence Friedman.
8. *Introduction to O.R*, Hiller & Libermann (TMH)

Course Code	Course/Subject Name	Credits
MEE70110	**Total Productive Maintenance**	**3+1**

Objectives

1. To apprise the students of modern approaches in the field of maintenance.
2. To provide sufficient knowledge base pertaining to maintenance planning and management in industries.
3. To provide better insight into the ongoing global trends, pertaining to maintenance management.
4. To illustrate some of the simple instruments used for condition monitoring in maintenance in the industry.

Outcomes: Learner will be able to..

1. Get the exposure to the concept of overall equipment efficiency and its relevance in enhancing the productivity in industries.
2. Acquire skills in online condition monitoring techniques and maintenance logistics.
3. Develop competency in initiating and managing TPM tools in a manufacturing organization.

Module	Details	Hrs.
01	**Maintenance Concepts** Objectives and functions, Tero technology, Reliability Centered Maintenance, (RCM), maintainability prediction, availability and system effectiveness, organization for maintenance.	**06**
02	**Maintenance Models** Minimal repair, maintenance types, balancing preventive maintenance and breakdown maintenance, preventive maintenance schedules: deviations on target values, preventive maintenance schedules: functional characteristics, replacement models.	**06**
03	**TPM Concepts** Importance of TPM, Zero breakdown concepts, Zero Defects and TPM, maximizing equipment effectiveness, autonomous maintenance program, five pillars of TPM, TPM Small group activities.	**07**
04	**TPM Planning and Implementation** Organization for TPM, management decision, awareness and training for TPM, establishment of basic policies and goals, formation of master plan, TPM implementation, Ongoing global trends in TPM.	**07**
05	**Maintenance Logistics** Human factors in maintenance, maintenance manuals, maintenance staffing methods, queuing applications, simulation, spare parts management, maintenance planning and scheduling.	**05**
06	**Online Monitoring** Condition Monitoring Techniques, Vibration Monitoring and Signature Analysis. Wear Debris Monitoring, Maintenance Management Information System, Expert systems, Corrosion Monitoring and Control.	**05**

Term Work

Term work shall consist of at least two assignments from each module and presentation of a case study on TPM and analysis based on the topics mentioned above.

The distribution of marks for term work shall be as follows;

- Assignments: **10** marks
- Case study presentation: **10** marks
- Attendance (Theory and Practical): **05** marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Internal Assessment

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

References

1. *Introduction to TPM* , Seiichi Nakajima, Productivity Press, Chennai.
2. *Maintenance and Spare Parts Management,*Gopalakrishnan, P, Banerji, A.K., Prentice – Hall of India Pvt. Ltd.
3. *Equipment planning for TPM Maintenance Prevention Design*, Goto F, Productivity Press.
4. *Total Productive Maintenance for Workshop Leaders*, Shirose K., Productivity Press.
5. *TPM for Operators,*Shirose, K., Productivity Press.
6. *New Directions for TPM*, Suzuki, T., Productivity Press.
7. *Maintenance Planning and Control,* Kelly, A, Butterworth, London.

Course Code	Course/Subject Name	Credits
MEE70111	**Robotics**	**3+1**

Objectives

1. To familiarize the students with the significance of robotic system in agile and automated manufacturing processes.
2. To prepare the students to be conversant with robotic elements/ peripherals, their selection and interface with manufacturing equipments.
3. To familiarize the students with the basics of robot kinematics.

Outcomes: Learner will be able to..

1. Acquire the skills in understanding robot language and programming.
2. Acquire the skill in robot task planning for problem solving.
3. Develop skills in understanding various sensors, robot peripherals and their use.
4. Develop skills in identifying areas in manufacturing, where robotics can be deployed for enhancing productivity.

Module	Details	Hrs.
01	**Introduction** Automation, robotics, Robotic system & Anatomy, Classification, Future Prospects.	**03**
02	**Drives** Control Loops, Basic Control System Concepts & Models, Control System Analysis, Robot Activation & Feedback Components, Position & Velocity Sensors, Actuators, Power Transmission system. **Robot & its Peripherals** **End Effecters:** Type mechanical and other grippers, Tool as end effecter. **Sensors:** Sensors in Robotics, Tactile Sensors, Proximity & Range Sensors, Sensor Based Systems, Vision systems Equipment.	**07**
03	**3.1 Machine vision** Introduction, Low level & High level Vision, Sensing & Digitizing, Image Processing & analysis, Segmentation , Edge detection, Object Description & recognition, interpretation, Applications. **3.2 Programming for Robots** Method, Robot Programme as a path in space, Motion interpolation, motion & task level Languages, Robot languages, Programming in suitable languages, characteristics of robot.	**08**
04	**Robot Kinematics** Forward, reverse & Homogeneous Transformations, Manipulator Path control, Robot Dynamics.	**06**
05	**Root Intelligence & Task Planning** Introduction, State space search, Problem reduction, use of predictive logic Means. Ends Analysis, Problem solving, Robot learning, Robot task planning.	**06**
06	**Robot application in manufacturing** Material transfer, machine loading & un loading, processing operation, Assembly & inspectors, robotic Cell design & control, Social issues & Economics of Robotics.	**06**

Term Work

Term work shall consist of,

1. Assignments: On topics drawn from syllabus [At least 1 assignment per module].
2. Practical's: Minimum SIX exercises based on above topics including programming of robots.

The distribution of marks for term work shall be as follows:

- Laboratory work (Experiment/ programs and journal): **10 marks**
- Assignments: **10 marks**
- Attendance (Theory and Practical): **05 marks**

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Internal Assessment

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

References

1. Industrial Robotics : Technology, Programming & Applications : Grover, Weiss, Nagel, Ordey, Mc Graw Hill.
2. Robotics: Control, Sensing, Vision & Intelligence: Fu, Gonzalex, Lee,McGraw Hill.
3. Robotic technology & Flexible Automation: S R Deb, TMH.
4. Robotics for Engineers: YoramKoren, Mc GrawHill .
5. Fundamentals of Robotics : Larry Health
6. Robot Analysis & Control : H Asada, JJE Slotine
7. Robot Technology: Ed. A Pugh, Peter Peregrinus Ltd. IEE, UK
8. Handbook of Industrial Robotics: Ed. Shimon Y. Nof, John Wiley. ISBN: 9780471177838.

Course Code	Course/Subject Name	Credits
MEE70112	**Digital Prototyping for Product Design –I**	**3+1**

Objectives

1. To acquaint learner to product development process, industrial design and mechanical design workflows
2. To acquaint learner to product design ideas using 2D digital sketches

Outcomes: Learner will be able to…

1. Describe the product development process
2. Combine Industrial design & Mechanical Design workflows
3. Express product design ideas using 2D digital sketches
4. Model an assembly of components with kinematic linkages

Modules	Detailed Content	Hrs.
01	**Introduction:** Importance, considerations of a good design; design morphology; designing to codes and standards; Technological innovation and design process; identification of customer needs; quality function deployment and product design specification. Cloud Services in product Design	**02**
02	**Concept Generation and Evaluation:** Creativity and problem solving; inventive problem solving; generating design concepts; axiomatic design evaluation methods; decision making; conceptual design; embodiment design and detail design; product architecture; configuration design. Use of surface modelling tools to create shapes, volumes, surfaces; Use of parametric modelling tools. Combining Industrial design and mechanical design.	**08**
03	**Collaboration and Concurrent Engineering:** Importance of collaboration and concurrent engineering in the design process. Logically organizing and maintains valid links to files in your individual or team-based design projects. Work-in-progress data management integrated with the design applications. Accessing design information anywhere using cloud technology	**08**
04	**Graphic Design Principles:** Elements of Design, Geometric Dimensioning and Tolerancing; Dimensions and Annotations: Bidirectional Associativity; creating sketches for 3D model; constrain sketches; Principles of 2D Design; Visual Elements; Relational Elements; Types of Models; Surface Modelings. Solid Modeling; Solid Modeling Techniques; Design Intent.	**08**
05	**Designing Part:** Industrial Design workflow T- spline Technology. Design for Manufacture and Assembly (DFMA) Part creation workflow. Create complex shapes by sweeping or lofting profiles; Using IGES surfaces in the design process.	**04**
06	**Managing Assemblies:** Industrial Assemblies; Application of Assemblies (Automotive, Home Appliances, consumer electronic assemblies; Assembly Modeling techniques (Top-down, Bottom-up); Interference and Collision Detection; Bill of Materials; Kinematics & dynamics of a mechanism; Creating Adaptive part; Using Design Accelerator for creating functional design ; Motion Analysis	**06**

List of Digital Prototyping Projects

1. Designing computer mouse using cloud services (Fusion 360)
2. Design new car seat component with conceptual sketches and renderings
3. Design new seat basic component
4. Design new automotive seat complex component (Exploring Component design projects)
5. Assembly of sub assembly within automotive seat and Pick and place robot
6. Manufacturing drawing creation for automotive seat components /optional Projects

Term Work

Term work shall consist of above projects in group of not more than 2 students and seminar on latest trends/developments in Product Design

The distribution of marks for term work shall be as follows:

- Course Project : **15** Marks
- Seminar : **05** Marks
- Attendance (Theory & Practical's) : **05** Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Internal Assessment

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

References

1. K.Otto and K. Wood, Product Design, Pearson Education, 2001.
2. D.G. Ullman, The Mechanical Design Process, McGraw- Hill, 1997
3. Joseph E. Shigley& Larry D. Mitchell, "Mechanical Engineering Design", Fourth Edition, McGraw-Hill International Book Company
4. Design of machine elements -- V. B. Bhandari. Tara Mcgraw Hill Pub.
5. Mastering Autodesk Inventor by Sybex
6. Autodesk Inventor 2012 for Designers by CADCIM Technologies
7. Autodesk Fusion 360 Learning and resources