AC29/4/2013 Item no 4.80

UNIVERSITY OF MUMBAI

Revised Syllabus

Program- Bachelor of Engineering

Course -Mechanical Engineering

(Second Year – Sem. III & IV)

Under

FACULTY OF TECHNOLOGY

(As per Credit Based Semester and Grading System from 2013-14)

Deans Preamble:

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education.The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty of Technology, University of Mumbai, in one of its meeting unanimously resolved that, each Board of Studies shall prepare some Program Educational Objectives (PEO's) and give freedom to affiliated Institutes to add few (PEO's) and course objectives and course outcomes to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. It was also resolved that, maximum senior faculty from colleges and experts from industry to be involved while revising the curriculum. I am happy to state that, each Board of studies has adhered to the resolutions passed by Faculty of Technology, and developed curriculum accordingly. In addition to outcome based education, semester based credit and grading system is also introduced to ensure quality of engineering education.

Semester based Credit and Grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes and Faculty of Technology has devised a transparent credit assignment policy and adopted ten points scale to grade learner's performance. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 12-13 weeks and remaining 3-2 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

Credit and grading based system was implemented for First Year of Engineering from the academic year 2012-2013. Subsequently this system will be carried forward for Second Year Engineering in the academic year 2013-2014, for Third Year and Final Year Engineering in the academic years 2014-2015 and 2015-2016 respectively.

Dr. S. K. Ukarande
Dean,
Faculty of Technology,
Member - Management Council, Senate, Academic Council
University of Mumbai, Mumbai

Chairman Preamble:

Engineering education in India is expanding and is set to increase manifold. Themajorchallenge in the current scenario is to ensure quality to the stakeholders along with expansion. To meet this challenge, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education and reflects the fact that in achieving recognition, the institution or program of study is committed and open to external review to meet certain minimum specified standards.The major emphasis of this accreditation process is to measure the outcomes of the program that is being accredited. Program outcomes are essentially a range of skills and knowledge that a student will have at the time of graduation from the program. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating the philosophy of outcome based education in the process of curriculum development.

As the Chairman, Board of Studies in Mechanical Engineering of University of the Mumbai, I am happy to state here that, the Program Educational Objectives were finalized in a brain storming session, which was attended by more than 20 members from different affiliated Institutes of the University. They are either Heads of Departments or their senior representatives from the Department of Mechanical Engineering. The Program Educational Objectives finalized for the undergraduate program in Mechanical Engineering are listed below;

1. To prepare the Learnerwith a sound foundation in the mathematical, scientific and engineering fundamentals.
2. To prepare the Learner to use modern tools effectively in order to solve real life problems.
3. To prepare the Learner for a successful career in Indian and Multinational Organisations and to excel in their Postgraduate studies.
4. To encourage and motivate the Learnerin the art of self-learning.
5. To inculcate a professional and ethical attitude, good leadership qualities and commitment to social responsibilities in the Learner’s thought process.

In addition to the above, 2 to3 more program educational objectives of their own may be added by affiliated Institutes.

In addition to Program Educational Objectives, for each course of undergraduate program, objectives and expected outcomes from the point of view of a learnerare also included in the curriculum to support the philosophy of outcome based education. I strongly believe that even a small step taken in the right direction will definitely help in providing quality education to the major stake holders.

Dr. S. M. Khot
Chairman, Board of Studies in Mechanical Engineering, University of Mumbai

Program Structure for B E Mechanical Engineering

S. E. (Mechanical/Automobile) Sem.- III

Course Code	CourseName	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract.	Theory	Pract.	Total
MEC301	Applied Mathematics III[@]	4	--	4	--	4
MEC302	Thermodynamics[$]	4	--	4	--	4
MEC303	Strength of Materials[$]	4	2	4	1	5
MEC304	Production Process- I[$]	4	--	4	--	4
MEL305	Computer Aided M/c Drawing[+]	--	2*+4	-	3	3
MEL306	Data Base &Information Retrieval System[#]	--	2*+2	-	2	2
MEL307	Machine Shop Practice- I[$]	--	4	--	2	2
Total		**16**	**16**	**16**	**8**	**24**

Course Code	CourseName	Examination Scheme							
		Theory					Term Work	Pract. /oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test1	Test 2	Avg.					
MEC301	Applied Mathematics III[@]	20	20	20	80	03	--	--	100
MEC302	Thermodynamics[$]	20	20	20	80	03	--	--	100
MEC303	Strength of Materials[$]	20	20	20	80	03	25	--	125
MEC304	Production Process- I[$]	20	20	20	80	03	--	--	100
MEL305	Computer Aided M/c Drawing[+]	--	--	--	--	--	50	50	100
MEL306	Data Base &Information Retrieval System[#]	--	--	--	--	--	50	50	100
MEL307	Machine Shop Practice- I[$]	--	--	--	--	--	50	--	50
Total		**--**	**--**	**80**	**320**	**--**	**175**	**100**	**675**

* Theory for entire class to be conducted, [@] Course common to Mech/Auto/Prod/Civil, [+]Course common to Mech/Auto/Prod, [#] Course common to Mech/Auto/Prod/Civil, [$] Courses common to Mech/Auto

S. E. (Mechanical/Automobile) Sem.- IV

Course Code	CourseName	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract.	Theory	Pract.	Total
MEC401	Applied Mathematics IV[@]	4	--	4	--	4
MEC402	Fluid Mechanics[$]	4	2	4	1	5
MEC403	Theory of Machines- I[$]	4	2	4	1	5
MEC404	Production Process- II[$]	4	--	4	--	4
MEC405	Material Technology[$]	3	2	3	1	4
MEC406	Industrial Electronics[$]	3	2	3	1	4
MEL407	Machine Shop Practice- II[$]	--	4	--	2	2
Total		**22**	**12**	**22**	**6**	**28**

Course Code	CourseName	Examination Scheme							
		Theory					Term Work	Pract. /oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test1	Test 2	Avg.					
MEC401	Applied Mathematics IV[@]	20	20	20	80	03	--	--	100
MEC402	Fluid Mechanics[$]	20	20	20	80	03	25	25	150
MEC403	Theory of Machines- I[$]	20	20	20	80	03	25	--	125
MEC404	Production Process- II[$]	20	20	20	80	03	--	--	100
MEC405	Material Technology[$]	20	20	20	80	03	25	--	125
MEC406	Industrial Electronics[$]	20	20	20	80	03	25	25	150
MEL407	Machine Shop Practice- II[$]	--	--	--	--	--	50	25	75
Total		**--**	**--**	**120**	**480**	**--**	**150**	**75**	**825**

[@] Course common to Mech/Auto/Prod/Civil, [$] Courses common to Mech/Auto

Course Code	Course/Subject Name	Credits

MEC301	Applied Mathematics –III[@]	4

Objectives:

1. To provide sound foundation in the mathematical fundamentals necessary to formulate, solve and analyze engineering problems.
2. To study the basic principles of Laplace Transform, Fourier Series, Complex Variables.

Outcomes: Learner should be able to ….

1. Demonstrate the ability of using Laplace Transform and Fourier Series in solving the Ordinary Differential Equations and Partial Differential Equations.
2. Identify the analytic function, harmonic function, orthogonal trajectories and to apply bilinear transformations and conformal mappings.
3. Identify the applicability of theorems and evaluate the contour integrals.

Module	Details	Hrs
1	**Laplace Transform** 1.1 Function of bounded variation, Laplace Transform of standard functions such as 1, t^n, e^{at}, $\sin at$, $\cos at$, $\sinh at$, $\cosh at$ 1.2 Linearity property of Laplace Transform, First Shifting property, Second Shifting property, Change of Scale property of L.T. (without proof) $L\{t^n f(t)\}, L\left\{\frac{f(t)}{t}\right\}, L\left\{\int_0^t f(u)du\right\}, L\left\{\frac{d^n f(t)}{dt^n}\right\}$ Heaviside Unit step function, Direc Delta function, Periodic functions and their Laplace Transform.	6
2	**Inverse Laplace Transform** 2.1 Linearity property, use of theorems to find inverse Laplace Transform, Partial fractions method and convolution theorem. 2.2 Applications to solve initial and boundary value problems involving ordinary differential equations with one dependent variable.	5
3	**Complex variables:** 3.1 Functions of complex variable, Analytic function, necessary and sufficient conditions for $f(z)$ to be analytic (without proof), Cauchy-Riemann equations in polar coordinates. 3.2 Milne- Thomson method to determine analytic function $f(z)$ when it's real or imaginary or its combination is given. Harmonic function, orthogonal trajectories. 3.3 Mapping: Conformal mapping, linear, bilinear mapping, cross ratio, fixed points and standard transformations such as Rotation and magnification, invertion and reflection, translation.	10
4	**Complex Integral** 4.1 Line integral of a function of a complex variable, Cauchy's theorem for analytic function, Cauchy's Goursat theorem (without proof), properties of line integral,Cauchy's integral formula and deductions. 4.2 Singularities and poles: 4.3 Taylor's and Laurent's series development (without proof) 4.4 Residue at isolated singularity and its evaluation. 4.5 Residue theorem, application to evaluate real integral of type $\int_0^{2\pi} f(\cos\theta, \sin\theta)\, d\theta$, & $\int_{-\infty}^{\infty} f(x)\, dx$	10
5	**Fourier Series** 5.1 Orthogonal and orthonormal functions, Expressions of a function in a	10

	series of orthogonal functions. Dirichlet's conditions. Fourier series of periodic function with period 2π & $2l$. 5.2 Dirichlet's theorem(only statement), even and odd functions, Half range sine and cosine series, Parsvel's identities (without proof) 5.3 Complex form of Fourier series.	
6	**Partial Differential Equations** 4.1 Numerical Solution of Partial differential equations using Bender-Schmidt Explicit Method, Implicit method(Crank- Nicolson method) Successive over relaxation method. 4.2 Partial differential equations governing transverse vibrations of an elastic string its solution using Fourier series. 4.3 Heat equation, steady-state configuration for heat flow. 4.4 Two and Three dimensional Laplace equations.	**10**

[@] Course common to Mech/Auto/Prod/Civil

Theory Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

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

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.

Reference Books:

1. Elements of Applied mathematics, P N & J N Wartikar, Pune VidyarthiGruhaPrakashan
2. Higher Engineering Mathematics, Dr B. S. Grewal, Khanna Publication
3. Advanced Engineering Mathematics, E Kreyszing, Wiley Eastern Limited
4. Integral Transforms and their Engineering Applications, Dr B. B. Singh, Synergy Knowledgeware, Mumbai
5. Complex Variables: Churchill, Mc-Graw Hill
6. Numerical Methods, Kandasamy, S. Chand & CO.

Course Code	Course/Subject Name	Credits
MEC302	**Thermodynamics[$]**	**4**

Objectives:

1. To understand the concepts of Energy in general and Heat and Work in particular.
2. To understand the fundamentals of quantification and grade of energy.
3. To apply the concepts of thermodynamics to basic energy systems.

Outcomes: Learner should be able to ….

1. Demonstrate understanding of basic concepts of thermodynamics.
2. Differentiate between quality and quantity of energy, heat and work, enthalpy and entropy, etc.
3. Analyze basic power cycles.
4. Apply the laws of thermodynamics to various real life systems.

Module	Details	Hrs
1	**Introduction and Basic Concepts:** Application areas of thermodynamics, Systems and Control volumes, Properties of system, Continuum, State and equilibrium, Processes and cycles, Temperature and Zeroth law of thermodynamics, Heat and thermodynamic concept of work. **First Law of Thermodynamics:** Statement, Heat and work calculations, Application of first law to non-flow and flow systems, steady flow energy equation as applied to boiler, condenser, nozzle and turbine.	**8**
2	**Second Law of Thermodynamics:** Statements and their equivalence, thermal energy reservoirs, concept of heat engine, refrigerator, heat pump and perpetual motion machines, Carnot cycle and principles. **Entropy:** Concept of entropy, Temperature- entropy plot, Clausius inequality theorem, Principle of Increase of entropy, entropy balance, entropy generation in daily life, first and second law combined,entropy changes of an ideal gas during reversible processes.	**8**
3	**Availability:** Available and unavailable energy, Available energy (AE) referred to cycle and energy source, Availability in steady flow process, availability in non-flow process, Irreversibility, Definition of second law efficiency. **Property Relations:** Introduction to Maxwell relations, Clausius-Clapeyron equation, volume expansivity and isothermal compressibility, Mayer relation, Joule-Thomson coefficient.	**8**
4	**Properties of Steam:** Dryness fraction, enthalpy, internal energy and entropy, steam table, polynomial form of steam equations and Mollier chart, First law applied to steam processes. **Vapour Power Cycles:** Carnot vapour cycle, Rankine cycle, Ideal reheatRankine cycle, Introduction to cogeneration.	**8**
5	**Gas Power Cycles:** Air standard assumptions, Otto cycle, Diesel cycle, dual cycle, Stirling cycle, Ericsson cycle, Atkinson cycle, Brayton cycle.	**8**
6	**Reactive Systems:**	**8**

	Combustion, theoretical and actual combustion processes, enthalpy of formation and enthalpy of combustion, Adiabatic flame temperature, first law analysis of reactive system.	

[$] Course common to Mech/Auto

Theory Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

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

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.

Reference Books:

1. Thermodynamics: An Engineering Approach by Yunus A. Cengel and Michael A Boles,7e, TMH.
2. Engineering Thermodynamics- A Generalized Approach by P L Dhar, ELSEVIER
3. Thermodynamics by P K Nag, TMH, 5TH Edition
4. Modern Engineering Thermodynamics by Robert T Balmer, ELSEVIER
5. Thermodynamics and Heat Engines by R Yadav, Central Publishing house.
6. Thermodynamics by Onkar Singh, New Age International
7. Thermal Engineering by Mahesh Rathod, McGrawHill Publications
8. Thermodynamics by C P Arora, TMH
9. Thermodynamics by R K Rajput, Laxmi Publications.
10. Schaum's Outlines: Thermodynamics for Engineers by Merle C. Potter
11. Engineering Thermodynamics through Examples by Y V C Rao, Universities Press (India) Pvt Lt.
12. Fundamentals of Thermodynamics by Moran & Shapiro.
13. Basic Engineering Thermodynamics by Rayner Joel, Longman Publishers
14. Fundamentals of Classical Thermodynamics by Van Wylen G.H. & Sonntag R.E., John Wiley & Sons.
15. Thermodynamics by W.C. Reynolds, , McGraw-Hill & Co.
16. Holman, J.P. Thermodynamics. McGraw- Hill
17. Basic Engineering \thermodynamics by Zemanski and Van ness, TMH

Course Code	Course/Subject Name	Credits
MEC303	**Strength of Materials$**	**4+1**

Objectives:

1. To gain knowledge of different types of stresses, strain and deformation induced in the mechanical components due to external loads.
2. To study the distribution of various stresses in the mechanical elements such as beams, shafts etc.
3. To study Effect of component dimensions and shape on stresses and deformations.

Outcomes: Learner should be able to ….

1. Demonstrate fundamental knowledge about various types of loading and stressesinduced.
2. Draw SFD and BMD for different types of loads and support conditions.
3. Compute and analyze stresses induced in basic mechanical components.
4. Analyze buckling and bending phenomenon in columns and beams respectively.

Module	Details	Hrs
1	**Moment of Inertia:** Mass Moment of Inertia , Area Moment Of Inertia, Parallel Axis theorem, Polar Moment of Inertia, Principal axes, Principal moment of inertia **Stress and Strain:** Definition**,** Stress- strain,uni-axial, bi-axial and tri-axial stresses, tensile & compressive stresses, shear stress-Elastic limit, Hooke's Law. **Elastic Constants:** Poission's Ratio, Modulus of elasticity, Modulus of rigidity, Bulk modulus, Yield stress, Ultimate stress. Factor of safety, state of simple shear, relation between elastic constants, Volumetric Strain, Volumetric strain for tri-axial loading, Deformation of tapering members, Deformation due to self-weight, bars of varying sections, composite sections, **Thermal Stress**	12
2	**Shear Force and Bending Moment in Beams:** Axial force, shear force and bending moment diagrams for statically determinate beams includingbeams with internal hinges for different types of loading, relationship between rates of loading, shearforce& bending moment.	8
3	**Stresses in Beams:** Theory of pure Bending, Assumptions, Flexural formula for straight beams, moment of resistance,bending stress distribution, Section moduli for different sections, beams for uniform strength, Flitchedbeams. **Direct & Bending Stresses**: Core of Section, Chimneys subjected to wind pressure **Shear Stress in Beams:** Distribution of shear stress, across plane sections used commonlyfor structural purposes, shear connectors.	8
4	**Torsion:** Torsion of circular shafts-solid and hollow, stresses in shafts when transmitting power, shafts in series and parallel. **Strain Energy:** Resilience, proof Resilience, strain energy stored in the member due to gradually applies load, suddenly applied load, impact load. Strain energy	8

	stored due to Shear, Bending and Torsion.	
5	**Deflection Of Beams:** Deflection of Cantilever, simply supported and over hanging beamsusing double integration and Macaulay's Method for different type of loadings. **Thin Cylindrical and Spherical Shells:** Cylinders and Spheres due to internal pressure. Cylindrical Shell with hemi spherical End.	8
6	**Columns and Struts:** Buckling load, Types of end conditions for column, Euler's column theory and its limitations, Rankine- Gordon Formula	4

[$] Course common to Mech/Auto

Term Work:

List of Experiment:

1. Tension test on mild steel bar (stress - strain behavior, modulus determination)
2. Test on-tor-steel bar
3. Torsion test on mild steel bar/cast iron bar
4. Brinell hardness test
5. Rockwell hardness test
6. Izod impact test / Charpy test
7. Flexural test on beam (central point load)
8. Flexural test on beam (two point load)

Distribution of marks for Term work shall be as follows:

Laboratory work (experiments/assignments): 20 marks
Attendance (Theory and practical's): 05 marks

Theory Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

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

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.

ReferenceBooks:

1. Strength of Materials, Subramanyam, Oxford University Press, Edition 2005
2. Mechanics of Materials, B.C Punmia Ashok Jain, Arun Jain, Lakshmi Publications, NewDelhi.
3. Strength of Materials, Basavarajaiah and MahadevappaKhanna Publishers, New Delhi.
4. Strength of Materials, Singer Harper and Row Publications
5. Elements of Strength of Materials, Timoshenko and Young Affliated East-West Press.
6. Mechanics of Materials, James M. Gere (5th Edition), Thomson Learning
7. Strength of Materials—S. Ramamrutham, DhanpatRai Pvt. Ltd.
8. Mechanics of Materials—S. S. Rattan, TMH Pvt. Ltd.
9. Mechanics of Structures—S. B. Junnarkar, Charotar Publication.
10. Strength of Materials—W. Nash, Schaum's Outline Series, McGraw Hill Publication.

Course Code	Course/Subject Name	Credits

MEC304	Production Process – I[$]	4

Objectives:

1. To study basic production processes.
2. To study how to select appropriate production processes for a specific application.
3. To know the fundamentals of non-destructive testing.

Outcomes: Learner should be able to ……

1. Demonstrate understanding of non-chip forming processes such as casting, forging, metal joining, etc.
2. Understand basics of powder metallurgy.
3. Identify the role of Non Destructive Techniques in production processes.

Module	Details	Hrs
1	Classification of Production Processes: Examples and field of applications **Metal Casting Process:** Fundamentals of metal casting, Pattern materials and types of Patterns for casting, Types of Casting (like sand, shell-mold, CO_2 mold casting, Cold box, Hot box, Investment, vacuum, pressure, die, centrifugal, etc.), Design considerations, Inspection of castings, Casting defects.	**10**
2	**Forming Processes:**Principles and process characteristics, Rolling types and capacities, Rolling parameters: Draught, spread, elongation ,roll pressure, torque, work and power in rolling., Effect of front and back tension on rolling load, Principles of roll pass. Miscellaneous processes like thread rollingroll forging, production of seamless tube by rolling, defects in rolled products. Forging (basic principles, machines, types etc), extrusion and wire drawing	**08**
3	**Welding and Joining Processes:**Mechanical fastening (Riveting), adhesive bonding, soldering and brazing. Welding Introduction, Fusion welding, gas and arc welding, submerged arc welding, inert gas welding, Electric slag welding, Carbon-dioxideshielded welding, thermit welding, Pressure welding, solid phase welding, resistance welding, and friction welding. Welding Equipment, process capability of welding its and applications. Weld joints- types, edge preparations. Weldability – designs, process and metallurgical considerations – testing and improvement of weldability – microstructure of weld – welding defects, advancements in welding.	**16**
4	**Powder Metallurgy:** like sintering and metal injection molding: Principle, process, applications, advantages and disadvantages of powder metallurgy, Processes of powder making and mechanisms of sintering.	**06**
5	**Moulding with polymers:**Basic concepts related to Injection Molding, Compression moulding, Transfer moulding, Blow Molding, Rotational Molding, Thermoforming and Extrusion.Applications of plastics in Engineering field. **Moulding with ceramics**: Blow moulding and extrusion of glass.	**06**
6	**Non Destructive Techniques:** Dye Penetrant, Magnetic, Electrical, Ultrasonic and Radiographic non-destructive testing methods.	**04**

[$] Coursecommon to Mech/Auto

Theory Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.

2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

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

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.

ReferenceBooks:

1. Workshop Technology By W. A. J. Chapman part I, II & III
2. A Textbook of Foundry Technology by M. Lal
3. Production Technology by R. C. Patel and C. G. Gupta Vol I, II.
4. Production Technology by Jain & Gupta.
5. Manufacturing, Engineering and Technology SI by SeropeKalpakjian, Steven R. Schmid, published by Prentice Hall
6. Introduction to manufacturing processes by John A. Schey, published by McGraw-Hill
7. Manufacturing Processes & Materials for Engineers by Doyle.
8. Production Technology by HMT.
9. Production Technology by Raghuvanshi
10. Elements of Workshop Technology HazraChaudharyVol I, II.
11. Foundry technology by P.L. Jain .
12. Manufacturing processes by P. N. Rao, Vol. 1 and 2.
13. ASME Handbook Vol. 15 and 16.
14. Welding Technology by Little

Course Code	Course/Subject Name	Credits
MEL305	**Computer Aided Machine Drawing**$^{+}$	**3**

Objectives:

1. To visualize an object and convert it into a drawing.
2. To gain knowledge of conventional representation of various machining and mechanical details as per IS.
3. To become conversant with 2-D and 3-D drafting.

Outcomes: Learner should be able to….

1. Visualize and prepare detail drawing of a given object.
2. Draw details and assembly of mechanical systems.
3. Read and interpret a given drawing.
4. Create 2-D and 3-D models using any standard CAD software with manufacturing considerations.

Module	**Details**	**Hrs.**	
		Theory	**Practical**
1	**1.1 Solid Geometry:**Intersection of surfaces and interpenetration of solids- Intersection of prism or cylinder with prism; cylinder or cone, both solids in simple position only. Primary auxiliary views and auxiliary projections of simple machine parts.	08	--
	1.2 Machine Elements: Preparation of 2-D drawings of standard machine elements (nuts, bolts, keys, cotter, screws, spring etc.)	--	04
	1.3 Conventional representation of assembly of threaded parts in external and sectional views, Types of threads; thread designation, Conventional representation of machine components and materials, Designation of standard components.	01	--
2	2.1 Limits fits and tolerances: Dimensioning with tolerances indicating various types of fits in details and assembly drawings, Types of assembly drawings, part drawings, drawings for catalogues and instruction manuals, patent drawings, drawing standards.	04	--
	2.2 Details and assembly drawing: Introduction to the unit assembly drawing, steps involved in preparing assembly drawing from details and vice-versa, Sequence in assembly.	02	--
	2.3 Preparation of details and assembly drawings of *any two*from: Clapper block, Single tool post, Lathe and Milling tail stock.	--	05
	2.4 Cotter, Knuckle joint, Keys and Couplings: keys-sunk, parallel woodruff, saddle, feather etc. Coupling: simple, muff, flanged.	03	--
	2.5 Protected flange coupling, Oldham's coupling, Universal coupling.	--	06
3	**3.1 Preparation of details and assembly drawings of Bearings:** Simple, solid, Bushed bearing. I.S. conventional representation of ball and roller bearing.	01	--
	3.2 Pedestal bearing, footstep bearing	--	04
4	**4.1 Preparation of details and assembly drawings of pulleys, Pipe joints:**ClassificationofPulleys, pipe joints	02	--
	4.2 Pulleys: Flat belt, V-belt, rope belt, Fast and loose pulleys.	--	05
	4.3 Pipe joints *(any two)*: Flanged joints, Socket and spigot joint, Gland and stuffing box, expansion joint.	--	06
5	**5.1 Preparation of details and assembly drawings of Valves, I.C.**	02	--

	Engine parts: Types of Valves, introduction to I.C. Engine 5.2 Preparation of details and assembly drawings of*(any three):*Air cock;Blow off cock, Steam stop valve, Gate valve, Globe valve, Non return Valve, I.C. Engine parts: Piston, Connecting rod, Cross head, Crankshaft, Carburetor, Fuel pump, injector, and Spark plug.	--	08
6	**6.1 Preparation of details and assembly drawings of Jigs and Fixtures:** Introduction to Jigs and fixtures, 6.2 Jigs and Fixtures (*any two from each*) 6.3 Reverse Engineering of a physical model: disassembling of any physicalmodel having not less than five parts, sketch the minimum views required for each component, measure all the required dimensions of each component, convert these sketches into 3-D model and create an assembly drawing with actual dimensions	01 -- --	-- 06 04

[+]Course common to Mech/Auto/Prod

Term work:

A. Minimum two questions from theory part of each module should be solved as a home work in A-3 size sketch book.

B. A-3 size Printouts/plots of the problems solved in practical class from the practical part of each module

Problems from practical parts of each module should be solved using any standard CAD packages like IDEAS, PRO-E, CATIA, Solid Works,Inventor etc.

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

Home work sketch book	…….	20 marks
Printouts/Plots	…….	20 marks
Attendance (Theory and practical's)	…….	10 marks

Practical/Oral examination:

1. Practical examination duration is **three hours**, based on Part-B of the Term work, and should contain two sessions as follows:
   Session-I: Preparation of 3-D models of parts, assembling parts and preparing views of assembly from given 2-D detailed drawing.
   Session-II: Preparation of minimum five detailed 3-D part drawings from given 2-D assembly drawing.
   Oral examination should also be conducted to check the knowledge of conventional and CAD drawing.
2. Questions provided for practical examination should contain minimum five and not more than ten parts.
3. The distribution of marks for practical examination shall be as follows:

Session-I	……	20 marks
Session-II	……	20 marks
Oral	……	10 marks

4. Evaluation of practical examination to be done based on the printout of students work
5. Students work along with evaluation report to be preserved till the next examination

ReferenceBooks:

1. Machine Drawingby N.D. Bhatt.
2. A text book of Machine Drawing byLaxminarayan&M.L.Mathur.(Jain brothers Delhi).
3. Machine DrawingbyKamat&Rao.
4. Machine DrawingbyM.B.Shah
5. A text book of Machine Drawing by R.B.Gupta(Satyaprakashan, Tech. Publication)
6. Machine Drawing by K.I.Narayana, P.Kannaiah, K.Venkata Reddy.
7. Machine Drawing by Sidheshwar and Kanheya
8. Autodesk Inventor 2011 for Engineers and Designers by ShamTickoo,SurinderRaina (dreamtech Press).
9. Engineering Drawing by P J Shah
10. Engineering Drawing by N D Bhatt

Subject Code	Subject Name	Credits
MEL306	**Database & Information Retrieval system#**	**02**

Objective:

1. Learn and practice data modeling using the entity-relationship and developing database designs.
2. Understand the use of Structured Query Language (SQL)and learn SQL syntax.
3. Apply Graphical User Interface techniques for retrieve the information from database.
4. Understand the needs of database processing and learn techniques for controlling the consequences of concurrent data access.

Outcome: The student should be able to …

1. To describe data models and schemas in DBMS.
2. To understand the features of database management systems and Relational database.
3. To use SQL- the standard language of relational databases.
4. To understand the functional dependencies and design of the database.
5. To understand the graphical user Interface design.

Module	Detailed content	Hours
1	**Introduction Database Concepts:** What is a database? , Characteristics of databases, Example of database, File system V/s Database system, What is DBMS?, Users of Database system, Advantage of using an enterprise database, Concerns when using an enterprise database, Data Independence, DBMS system architecture, Database Administrator,	02
2	**Entity–Relationship Data Model :** Introduction,Benefits of Data Modeling, Types of Models,Phases of Database Modeling, The Entity-Relationship (ER) Model,Generalization, Specialization and Aggregation,Extended Entity-Relationship (EER) Model.	04
3	**Relational Model and Algebra :** Introduction , Mapping the ER and EER Model to the Relational Model , Data Manipulation , Data Integrity ,Advantages of the Relational Model, Relational Algebra , Relational Algebra Queries, Relational Calculus.	04
4	**Structured Query Language (SQL) :** Overview of SQL , Data Definition Commands,Set operations , aggregate function , null values, , Data Manipulation commands, Data Control commands , Views-Using Virtual Tables in SQL, Nested and complex queries .	04
5	**Introduction to Transactions Management and Concurrency:** Transaction concept, Transaction states, ACID properties, Implementation of atomicity and durability, Concurrent Executions, Serializability, Recoverability, Concurrency Control: Lock-based , Timestamp-based , Validation-based protocols, Deadlock handling, Recovery System: Failure Classification, Storage structure, Recovery & atomicity, Log based recovery, Shadow paging.	04

6	**Graphical User Interface** : Murphy 's Law of G U I Design, Features of G U I, Icons and graphics, Identifying visual cues, clear communication, color selection, GUI standard, planning GUI Design Work. **Visual programming :** ***Sharing Data and Code*:** Working with Projects, Introduction to Basic language, Using inbuilt controls and ActiveX controls, creating and using classes, Introduction to Collections, Using and creating ActiveX Components, dynamic data exchange, object linking and embedding ***Creating visual software entities:*** Working with text, graphics, working with files, file management, serial communication, multimedia control interfaces.	06

* 2hours theory can be taught to entire class followed by 2hours practical in batches
[#] Course common to Mech/Auto/Prod/Civil

Term Work:

Assign minimum two case studies for each student to perform on their case studies following experiments-

1) Problem Definition and draw ER /EER diagram
2) Design Relational Model
3) Perform DDL operation
4) Perform DML and DCL operations
5) Design Forms using Visual programming
6) Retrieve the information through GUI.

Distribution of marks for Term work shall be as follows:

Laboratory work (programs/printouts): 40 marks
Attendance (Theory and practicals): 10 marks

Practical/Oral Examination:

1. Practical examination duration is 2hours and questions to be based on the list of experiments mentioned in Term Work.
2. Evaluation of practical examination to be done by examiner based on the printout of students work
3. Practical examination: 40 marks, oral examination based on practical examination: 10 marks
4. Students work along with evaluation report to be preserved till the next examination

ReferenceBooks:

1. G. K. Gupta :"Database Management Systems", McGraw – Hill.
2. Korth, Slberchatz,Sudarshan, :"Database System Concepts", 6th Edition, McGraw – Hill
3. GUI Design for dummies,IDG books.
4. Visual Basic 2005, How to program (3RD Edition) Deitel&Deitel, Pearson Education.
5. Dr. P.S. Deshpande, SQL and PL/SQL for Oracle 10g,Black Book, Dreamtech Press
6. Mark L. Gillenson, PaulrajPonniah, " Introduction to Database Management",Weley
7. SharamanShah ,"Oracle for Professional", SPD.
8. Raghu Ramkrishnan and Johannes Gehrke, " Database Management Systems",TMH
9. Mark L Gillenson, "Fundamentals of Database Management System", Wiley India

Course Code	Course/Subject Name	Credits
MEL307	**Machine Shop Practice – I[$]**	**2**

Objectives:

1. To understand basic machining processes.
2. To understand various machining operations and machine protocols.

Outcomes: Learner should be able to …

1. Operate various machines like lathe, shaper etc.
2. Perform plain turning, taper turning, and screw cutting etc. on lathe machine.
3. Perform machining operations on shaper.
4. Demonstrate metal joining process like compressive welding.

Module	Details	Hrs
1	Introduction to Lathe Machine, demonstration of various machining processes performed on lathe machine. One Job on Plain and Taper Turning One job on Precision Turning, Taper Turning and Screw Cutting	**18**
2	Introduction to Shaping Machine and various machining processes performed on Shaping Machine One job on shaping machine to make horizontal and inclined surface	**12**
3	Introduction to various forging tools. Two jobs on Forging of Cutting Tools used on Lathe Machine	**12**
4	One simple exercise on Welding, Preparation of a component using Compressive Welding Joint	**6**

[$] Course common to Mech/Auto

Term Work:

1. All the jobs mentioned above
2. Complete Work-Shop Book which give details of drawing of the job and time sheet

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

Job Work with complete workshop book ……. 40 marks
Attendance (Practicals) ……. 10 marks

Course Code	Course/Subject Name	Credits
MEC401	**Applied Mathematics –IV@**	**4**

Objectives:

1. To inculcate an ability to relate engineering problems to mathematical context.
2. To provide a solid foundation in mathematical fundamentals required to solve engineering problem.
3. To study the basic principles of Vector analyses, statistics and probability and complex integration.
4. To prepare students for competitive exams.

Outcomes: Learner should be able to ….

1. Use matrix algebra with its specific rules to solve the system of linear equations.
2. Understand and apply the concept of probability distribution and sampling theory to engineering problems.
3. Apply principles of vector differential and integral calculus to the analysis of engineering problems.
4. Identify, formulate and solve engineering problems.

Module	Details	Hrs
1	**Matrices** 1.1 Brief revision of vectors over a real field, inner product, norm, Linear Dependance and Independence and orthogonality of vectors. 1.2 Characteristic polynomial, characteristic equation, characteristic roots and characteristic vectors of a square matrix, properties of characteristic roots and vectors of different types of matrices such as orthogonal matrix, Hermitian matrix, Skew-Hermitian matrix, Cayley Hamilton theorem (without proof) Functions of a square matrix, Minimal polynomial and Derogatory matrix.	**09**
2	**Vector calculus** 2.1 Brief revision of Scalar and vector point functions, Gradient, Divergence and curl. 2.2 Line integrals, Surface integrals, Volume integrals. Green's theorem(without proof) for plane regions and properties of line integrals, Stokes theorem(without proof), Gauss divergence theorem (without proof) related identities and deductions.(No verification problems on Stoke's Theorem and Gauss Divergence Theorem)	**11**
3	**Non Linear Programming** 3.1 Unconstrained optimization, problems with equality constraints Lagranges Multiplier method. 3.2 Problem with inequality constraints Kuhn-Tucker conditions.	**06**
4	**Probability Distributions** 4.1 Discrete and Continuous random variables, Probability mass and density function, Probability distribution for random variables, Expected value, Variance. 4.2 Probability Distributions:Binomial, Poisson and Normal Distributions. For detailed study.	**10**
5	**Sampling Theory** 5.1 Sampling distribution. Test of Hypothesis. Level of significance, critical region. One tailed and two tailed tests. Interval Estimation of population parameters. Large and small samples. 5.2 Test of significance for Large samples: Test for significance of the difference between sample mean and population means, Test for	**10**

	significance of the difference between the means of two samples. 5.3 Student's t-distribution and its properties. Test of significance of small samples: Test for significance of the difference between sample mean and population means, Test for significance of the difference between the means of two Samples, paired t-test. 5.4 Analysis of Variance(F-Test): One way classification, Two-way classification(short-cut method) 5.5 Chi-square distribution and its properties, Test of the Goodness of fit and Yate's correction.	
6	**Correlation and Regression** 6.1 Correlation,Co-variance, Karl Pearson Coefficient of Correlation & Spearman's Rank Correlation Coefficient (non-repeated & repeated ranks) 6.2 Regression Coefficients & lines of regression	**06**

[@] Course common to Mech/Auto/Prod/Civil

Theory Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

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

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.

ReferenceBooks:

1. Fundamentals of Mathematicals Statistics, S C Gupta & V K Kapoor, S. Chand & Co
2. Higher Engineering Mathematics, Dr B. S. Grewal, Khanna Publication
3. Elements of Applied mathematics, P N & J N Wartikar, Pune VidyarthiGruhaPrakashan
4. Advanced Engineering Mathematics, E Kreyszing, Wiley Eastern Limited
5. Operations Research, S.D. Sharma, S. Chand & CO.
6. Vector Analysis by Murray R. Spiegel, Shaum Series
7. Operations Research, Kantiswarup, Manmohan, P K Gupta, S. Chand & CO.

Course Code	Course/Subject Name	Credits
MEC402	**Fluid Mechanics[$]**	**4+1**

Objectives:

1. To understand fluid statics and fluid dynamics.
2. To understand application of mass, momentum and energy equation in fluid flow.
3. To learn various flow measurement techniques.

Outcomes: Learner should be able to ….

1. Understand properties of fluids and classification of flows
2. Formulate and solve equations of the control volume for fluid flow systems
3. Calculate resistance to flow of incompressible fluids through closed conduits and over surfaces
4. Apply fundamentals of compressible fluid flows to relevant systems

Module	Details	Hrs
1	1.1 Fluid Definition and properties, Newton's law of viscosity concept of continuum, Classification of fluids 1.2 Fluid Statics: Definition of body and surface forces, Pascal's law, Basic hydrostatic equation, Forces on surfaces due to hydrostatic pressure, Buoyancy and Archimedes' principle	**6**
2	**2 Fluid Kinematics:** 2.1 Eulerian and Lagrangian approach to solutions; Velocity andacceleration in an Eulerian flow field; Definition of streamlines, path lines and streak lines; Definition of steady/unsteady, uniform/non-uniform, one-two and three dimensional flows; Definition of control volume and control surface, Understanding of differential and integral methods of analysis 2.2 Definition and equations for stream function, velocity potential function in rectangular and cylindrical co-ordinates, rotational and irrotational flows; Definition and equations for source, sink, irrotational vortex, circulation	**6**
3	**3 Fluid Dynamics:** 3.1 Integral equations for the control volume: Reynold's Transport theorem(with proof), equations for conservation of mass, energy and momentum, Bernoulli's equation and its application in flow measurement, pitot tube, venture, orifice and nozzle meters. 3.2 Differential equations for the control volume: Mass conservation in 2 and 3 dimension in rectangular and cylindrical co-ordinates, Euler's equations in 2,3 dimensions and subsequent derivation of Bernoulli's equation; Navier-Stokes equations(without proof) in rectangular cartesian co-ordinates; Exact solutions of Navier-Stokes Equations to viscous laminar flow between two parallel planes (Couette flow and plane Poiseuille flow)	**12**
4	**4 Real fluid flows:** 4.1 Definition of Reynold's number, Laminar flow through a pipe (Hagen-Poiseuille flow), velocity profile and head loss; Turbulent flows and theories of turbulence-Statistical theory, Eddy viscosity theory and Prandtl mixing length theory; velocity profiles for turbulent flows- universal velocity profile, $1/7^{th}$ power law; Velocity profiles for smooth and rough pipes 4.2 Darcy's equation for head loss in pipe(no derivation),Moody's diagram, pipes in series and parallel, major and minor losses in pipes	**8**
5	**5 Boundary Layer Flows:** 5.1 Concept of boundary layer and definition of boundary layer thickness, displacement, momentum and energy thickness; Growth of boundary layer,	**8**

	laminar and turbulent boundary layers, laminar sub-layer; Von Karman Momentum Integral equation for boundary layers, analysis of laminar and turbulent boundary layers, drag, boundary layer separation and methods to control it, streamlined and bluff bodies 5.2 Aerofoil theory: Definition of aerofoil, lift and drag, stalling of aerofoils, induced drag	
6	**6 Compressible Fluid flow:** 6.1 Propagation of sound waves through compressible fluids, Sonic velocity and Mach number; Application of continuity , momentum and energy equations for steady state conditions; steady flow through nozzle, isentropic flow through ducts of varying cross-sectional area, Effect of varying back pressure on nozzle performance, Critical pressure ratio 6.2 Normal shocks, basic equations of normal shock, change of properties across normal shock	**8**

[$] Course common to Mech/Auto

Term Work: Any 8 experiments to be performed of which at least 6 experiments will be in Fluid Dynamics, Experiment no: 14 is desirable

List of Experiments:

1. Calibration of pressure gauge
2. Determination of pressure surge in pipes
3. Measurement of hydrostatic force on bodies/surfaces
4. Verification of Archimedes' Principle
5. Verification of Pascal's law
6. Calibration of venture meter / orificemeter / nozzlemeter / pitot tube
7. Determination of friction factor for pipes
8. Determination of major and minor losses in piping systems
9. Verification of energy equation
10. Verification of momentum principle
11. Verification of Bernoulli's equation
12. Calculation of lift and drag in aerofoils
13. Determination of pressure profile over an aerofoil
14. Mini Project along with brief report in which a group of students (Max 4) will design/fabricate/assemble a unit to demonstrate any principle of fluid mechanics.

Note: Error analysis is recommended

Distribution of marks for Term work shall be as follows:

Laboratory work (experiments/assignments): 20 marks
Attendance (Theory and practical's): 05 marks

Theory Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

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

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:

1. The distribution of marks for oral-practical examination shall be as follows:
    i. Practical performance …… 15 marks
    ii. Oral …… 10 marks
2. Evaluation of practical examination to be done based on the experiment performed and the output of the experiment during practical examination
3. Students work along with evaluation reportto be preserved till the next examination

Reference Books:

1. Fluid Mechanics : Streeter and Wylie, McGraw Hill
2. Fluid Mechanics : F.M.White, McGraw Hill
3. Fluid Mechanics: K.L.Kumar
4. Introduction to Fluid Mechanics: Fox and McDonald
5. Introduction to Fluid Mechanics: James.A.Fay
6. Prandtl Essentials of Fluid Mechanics :Herbert Oertel(Ed)
7. Fluid Mechanics: B.M.Massey
8. Fluid Mechanics: Cengel and Cimbala
9. Mechanics of Fluids: Irving Shames
10. Advanced Fluid Dynamics: Muralidhar and Biswas
11. Fluid Mechanics and Hydraulics, S. K. Ukarande, Ane Books Pvt.Ltd.

Course Code	Course/Subject Name	Credits
MEC403	**Theory of Machines – I[$]**	**4+1**

Objectives:

1. To provide basic concept of kinematics and kinetics of machine elements.
2. To study basics of power transmission.

Outcomes: Learner should be able to ….

1. Define various components of mechanisms.
2. Construct/Compose mechanisms to provide specific motion.
3. Draw velocity and acceleration diagrams of various mechanisms.
4. ConstructCAM profile for the specific follower motion.
5. Select appropriate power transmission mechanism.

Module	Details	Hrs
1	**1.1 Kinetics of rigid bodies** Mass M.I. about centroidal axis and about any other axis. Radius of Gyration. D'Alemberts Principle of Bodies under rotational motion about a fixed axis and plane motion. Application of motion of bars, Cylinders and spheres only. Kinetics of Rigid Bodies: Work and Energy. Kinetic energy in translating motion, Rotation about fixed axis and in general plane motion, Work Energy Principle and Conservation of Energy. **1.2 Basic Kinematics:** Kinematic link, Types of links, Kinematic pair, Types of constrained motions, Types of Kinematic pairs, Kinematic chain, Types of joints, Mechanism, Machine, Degree of freedom (Mobility), Kutzbachcrieterion, Grubler's criterion. Four bar chain and its inversions, Grashoff's law, Slider crank chain and its inversions, Double slider crank chain and its inversions.	**08**
2	**2.1 Special Mechanisms:** **Straight line generating Mechanisms:** Exact Straight Line Generating Mechanisms – Peaucellier's and Hart's Approximate Straight Line Generating Mechanisms – Watt's, Grasshopper and Tchebicheff's. **Offset slider crank mechanisms,** Pantograph. Hook joint- single and double **Steering gear mechanisms –** Ackerman, Davis	**05**
3	**3.1 Velocity Analysis of mechanisms (mechanisms up to 6 links).** Velocity analysis by instantaneous center of rotation method (Graphical approach) Velocity analysis by relative velocity method (Graphical approach)Analysis is extended to find rubbing velocities at joints, mechanical advantage (Graphical approach). Velocity analysis of low degree complexity mechanisms (Graphical approach). Auxiliary point method **3.2 Velocity and Acceleration analysis of mechanism.** Velocity and Acceleration – analysis by relative method (mechanismsup to 6 link) including pairs involving Coriolis acceleration (Graphical Approach).	**13**

4	**4. Cam Mechanisms:** 4.1 Cam and its Classifications. 4.2 Followers and its Classification. 4.3Motion analysis and plotting of displacement-time, velocity-time,acceleration- time, jerk-time graphs for uniform velocity. UARM, SHM and Cycloid motions (combined motions during one stroke excluded). 4.4 Motion analysis of simple cams – R-R cam, D-R-R and D-R-D-R camoperating radial translating follower. 4.5 Pressure angle and method to control pressure angle 4.6 Layout of cam profiles.	**08**
5	**5. Flexible Connectors:** 5.1 Belt – Types of belts, velocity ratio, slip & creep, length of belt for open & cross system. Law of belting, Dynamic analysis- driving tensions, centrifugal tension, initial tension, condition of maximum power transmission. 5.2 Chains – types of chains, chordal action, variation in velocity ratio, Length of chain	**07**
6	**6. Gears** 6.1 Law of gearing, Involute and Cycloid gear tooth profile, Construction of Involute profile. 6.2 Path of contact, arc of contact, contact ratio for involutes and cycloidal tooth profile, Interference in involutes gears. Critical Numbers of teeth for interference free motion.Methods to control interference in involutes gears. 6.3 Static force analysis in gears- spur, helical, worm & worm wheel.	**07**

[$] Course common to Mech/Auto

Term Work:

1. Velocity analysis by Instantaneous Center of Rotation- 3 to 5 Problems
2. Velocity analysis by relative method - 3 to 5 Problems
3. Velocity – Acceleration analysis by relative method - 3 to 5 Problems
4. Motion analysis and plotting of displacement-time, velocity-time, acceleration- time, jerk- time and Layout of cam profiles- 3 to 5 Problems
5. Construction of conjugate / involved profiles - 1 to 2 Problems
6. Mini Project on design and fabrication of any one mechanism for a group of maximum 4 students

Distribution of marks for Term work shall be as follows:

Laboratory work (experiments/assignments): 20 marks
Attendance (Theory and practical's): 05 marks

Theory Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3) .

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

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.

ReferenceBooks:

1. Theory or Mechanisms and Machines by Amitabh Ghosh and A. Kumar Mallik.
2. Theory of Machines and Mechanism by John Uiker, Garden Pennock& Late. J. F. shigley
3. Theory of Machines – P. L. Ballaney
4. Theory of Machines by S. S. Rattan
5. Kinematics of Machines by R T Hinckle (Prentice Hall Inc.)
6. Kinematics By V.M. Fairs (McGraw Hill)
7. Mechanism Design: Analysis and Synthesis Vol. I by A. Erdman and G.N. Sander (Prentice Hall)
8. Kinematics and Dynamics of Planer Mechanisms by Jeremy Hirsihham (McGraw Hill).

Course Code	Course/Subject Name	Credits
MEC404	**Production Process – II[$]**	**4**

Objectives:

1. To study machine tools and basic machining processes.
2. To know the fundamentals of metal cutting and tool engineering.
3. To familiarize with modern machine tools.

Outcomes: Learner should be able to ….

1. Understand chip forming processes such as turning, milling, drilling, etc.
2. Understand the design aspects of cutting Tools and Economics of machining.
3. Distinguish between the conventional and modern machine tools.

Module	Details	Hrs
1	**Classification, Selection and application of Machine Tools:** 1.1 Lathe Machines, Milling Machines, Drilling Machines, Grinding Machines, Broaching machines, Lapping/Honing machines and shaping/ slotting/planning Machines. 1.2 Gear Manufacturing -Gear milling, standard cutters and limitations, gear hobbing, gear shaping, gear shaving and gear grinding processes.	**12**
2	**CNC machines:** Introduction, principles of operation, Types – Vertical machining centers and horizontal machining centers, major elements, functions, applications, controllers, open loop and closed loop systems, coordinate measuring machines, maintenance of CNC machines, G, M Codes, Basic CNC programming	**06**
3	**Metal Cutting & Tool Engineering:** Features of machining processes, concept of speed and cutting, mechanism of chip formation, concept of shear plane, chip reduction coefficient force analysis. Merchants circle of cutting forces, expression for shear plane angle and coefficient of friction in terms of cutting forces and tool angles. Merchants theory-original and modified cutting force and power calculation in machining processes, gross power , efficiency of machine tools, effect of various parameters on cutting forces, methods of estimating of cutting forces.	**08**
4	**Measurement of Tool Forces and Economics of metal cutting:** Different types of dynamometers and their operations. Tool life definition, mechanism of tool wear and measurement, preliminary and ultimate feature, factors Influencing tool life such as speed, feed, depth of cut, tool material, cutting fluids etc. Machinability, Economics of metal cutting:-parameters affecting machining cost. Tool life for minimum cost and for maximum productivity.	**08**
5	**Surface Finish, Cutting Tool Materials, Coolants:** Surface finish-influence of various parameters cutting tool materials-composition, field of application and manufacture.(carbon tool steel, high speed steel, non-ferrous alloys, carbides and ceramics), Selection of grinding wheel and dressing & truing of grinding wheels, coolants –function of coolants, effects on cutting force, tool life and surface finish, Types of coolants, Choice of coolants.	**06**
6	**Design of Cutting Tools or Tool design:** Tool geometry and definition of principles tool angles of single point cutting tools, Design of single point cutting tools, Form tools, Drills, Milling cutters, Inserted type cutters, Broach tools, Standard inserts and Holders for Turning.	**12**

[$] Coursecommon to Mech/Auto

Theory Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

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

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.

ReferenceBooks:

1. Tool Design by Donaldson.
2. Machining Process by H.L. Juneja
3. Production Technology - HMT
4. Manufacturing, Engineering and Technology SI by SeropeKalpakjian, Steven R. Schmid, published by Prentice Hall
5. Fundamentals of Tool Design by ASTME
6. Metal cutting Theory & Cutting Tool Designing by V. Arshinov, G Alekseev
7. Principle of Metal cutting by Sen& Bhattacharya
8. Fundamentals of Metal Machining by GeofferyBoothroyd
9. Manufacturing science by Ghosh and Mallick.

Course Code	Course/Subject Name	Credits
MEC405	**Material Technology$**	**3+1**

Objectives:

1. To study basic engineering materials, their properties, applications & selection.
2. To study types and causes of failure of components in service.

Outcomes: Learner should be able to ….

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

Module	Details	Hrs
1	**Classification of Materials:** Metallic materials, Polymeric Materials,Ceramics and Composites: Definition, general properties, applications with examples. **Lattice Imperfections:** Definition, classification and significance of Imperfections Point defects: vacancy, interstitial and impurity atom defects. Their formation and effects. Dislocation: Edge and screw dislocations Burger's vector. Motion of dislocations and their significance. Surface defects: Grain boundary, sub- angle grain boundary and stacking faults. Their significance. Generation of dislocation. Frank Reed source, conditions of multiplication and significance. **Deformation:** Definition, elastic and plastic deformation, Mechanism of deformation and its significance in design and shaping, Critical Resolved shear stress. Deformation in single crystal and polycrystalline materials Slip systems and deformability of FCC, BCC and HCP lattice systems. **Strain Hardening:** Definition importance of strain hardening. Dislocation theory of strain hardening, Effect of strain hardening on engineering behaviour of materials. Recrystallization Annealing: stages of recrystallization annealing and factors affecting it	**8**
2	**Failure mechanisms:** **Fracture:** Definition and types of facture, Brittle fracture: Griffith's theory of facture. Orowan's modification. Dislocation theory of facture. Critical stress and crack propagation velocity for brittle fracture. Ductile fracture: Notch effect on fracture. Fracture toughness. Ductility transition. Definition and signification. Conditions of ductility transition factors affecting it. **Fatigue Failure:** Definition of fatigue and significance of cyclic stress. Mechanism of fatigue and theories of fatigue failure, Fatigue testing. Test data presentation and statistical evolution. S-N Curve and its interpretation. Influence of important factors on fatigue. Notch effect,surface effect,Effect of pre-stressing, corrosion fatigue, Thermal fatigue. **Creep:** Definition and significance of creep. Effect of temperature and creep on mechanical behaviors of materials. Creep testing and data presentation &analysis.Mechanism and types of creep. Analysis of classical creep curve	**8**

	and use of creep rate in designing of products for load bearing applications. Creep Resistant materials.	
3	**Theory of Alloys& Alloys Diagrams :** Significance of alloying, Definition, Classification and properties of different types of alloys. Different types of phase diagrams (Isomorphous, Eutectic, Peritectic, Eutectoid, Peritectoid) and their analysis. Importance of Iron as engineering material, Allotropic forms of Iron, Influence of carbon in Iron-Carbon alloying Iron-Iron carbide diagram and its analysis,TTT diagram,Hardenability concepts and tests, Graphitization of Iron- Grey iron, white iron, Nodular and malleable irons. Their microstructures, properties and applications	**8**
4	**Heat treatment Process:** Technology of heat treatment. Classification of heat treatment process. Annealing- Principle process, properties and applications of full annealing, Diffusion annealing, process annealing and Cyclic annealing, Normalizing, Hardening heat treatment. Tempering, Subzero treatment, Austempering, Martempering, Maraging and Ausforming process. Surface hardening: Hardening and surface Hardening methods. Their significance and applications. Carburizing, Nitriding, Cyaniding, Carbonitriding, induction hardening and flame hardening processes	**6**
5	**Effect of Alloying Elements in Steels**: Limitation of plain carbon steels. Significance of alloying elements. Effects of major and minor constituents, Effect of alloying elements on ferrite, carbide, austenite, Effect of alloying elements on phase transformation Classification of tool steels and metallurgy of tool steels and special steels	**4**
6	**Introduction to New materials:** Composites: Basic concepts of composites, Processing of composites, advantages over metallic materials,various types of composites and their applications. Nano Materials: Introduction, Concepts, synthesis of nanomaterials, examples, applications and nano composites. Polymers: Basic concepts, Processing methods, advantages and disadvantages over metallic materials, examples and applications.	**4**

[$] Course common to Mech/Auto

Term Work:

List of Experiment: Minimum eight experiments

1. Study of metallurgical microscope.
2. Metallographic sample preparation and etching.
3. Microstructures of plain carbon steels.
4. Microstructures of cast irons.
5. Fatigue test – To determine number of cycles to failure of a given material at a given stress.
6. Annealing, Normalising and Hardening of medium carbon steel and observation of microstructures.
7. Study of tempering characteristics of hardened steel.
8. Determination of hardenability of steel using Jominy end Quench Test.
9. Corrosion rate test

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

Laboratory work (assignments/Experiments/seminarreport):	20 Marks.
Attendance (Theory and practical's):	05 marks

Theory Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

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

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.

ReferenceBooks:

1. Materials Science and Engineering by William D. Callister, Jr. – Adapted by R. Balasubramaniam. Wiley India (P) Ltd.
2. The Structure and Properties of Materials Vol I: M. G. Moffet, G. T. W. Pearsall & J. Wulff.
3. Material Science and Metallurgy, By V.D. Kodgire.
4. Metallurgy for Engineer- E.C. Rollason - ELBS SOC. And Edward Arnold, London.
5. Mechanical Behaviour of Materials- Courtney- McGraw Hill International New Delhi.
6. Introduction of Engineering Materials, By B.K. Agrawal, McGraw Hill Pub. Co. ltd
7. Mechanical Metallurgy: G.E. Dieter , McGraw Hill International New Delhi.
8. Metallurgy Engineering Part I&II-R. A. Higgins &HodderStoughlon, London.
9. A text book of Metallurgy- A.R.Bailey – Macmillan & Co. Ltd., London.
10. Introduction to solids- L.V.Azaroff- McGraw Hill International New Delhi.
11. The Structure and Properties of Engineering Alloys- W.F. Smith- McGraw hill Int.
12. Strengthening of Metals Packner - ReinhildPuplishing Corporation, New Delhi.
13. Engineering Physical Metallurgy, By Y. Lakhtin , Mir Publishers, Moscow.
14. Physical Metallurgy for Engineers, By Donald S. Clarke and Wibur R. Varney, D. Van Nostrand Co.INC.
15. Engineering Metallurgy Part I & II, By Raymond A. Higgins, English Language Book Society &Hodder&Stragton.
16. A text book of Metallurgy, By A.R.BaileyMcMillan&ltd ,London.
17. Structure and Properties of Alloys, By Robert M, Brick, Robert B, Gordon , McGraw Hill International Book Co.
18. Metallurgy for Engineers, By E.C. Rollason, English Language Book Society &Edward Arnold Publisher Ltd.
19. The Science and Engineering of Materials, By Donald R. Askeland- PWS Publishing Co. Physical Metallurgy by Avner
20. M.G. Fontana, Corrosion Engineering, 3rd Ed., McGraw-Hill

Course Code	Course/Subject Name	Credits
MEC406	**Industrial Electronics$**	**3+1**

Objectives:

1. To learn industrial electronics in applied manner with perspective of mechanical engineering.
2. To introduce the design philosophy for mechanical processes control based on analog and digital electronics and electrical machines.

Outcomes: Learner should be able to ….

1. Understand the applications of power electronic converters.
2. Understand concept of OPAMP.
3. Demonstrate the knowledge of basic functioning of digital circuits and microcontrollers.
4. Understand speed-torque characteristics of electrical machines for implementation of speed control methods using electrical drives.

Modules	Details	Hrs
1	**Semiconductor Devices:** **Review of diodes: rectifier diode , zener diode, LED, photodiode** SCR V-I characteristics , R,R-C,UJT triggering circuits, turning-off of a SCR (preliminary discussion), basics of Gate Turn Off (GTO) Structure and V-I characteristics of Triac (modes of operation not needed) and Diac , Applications of Triac-Diac circuit, Characteristics and principle of Power BJT, power MOSFET,IGBT, comparison of devices	6
2	**Phase controlledrectifiers and Bridge inverters:** Full wave controlled rectifier using SCR's(semi controlled, fully controlled) with R load only. Derivation of output voltage, Concept of R-L and R-L-E load, Block diagram of closed loop speed control of DC motors, Necessity of inner current control loop, current sensing Basic principle of single phase and three phase bridge inverters , block diagrams including rectifier and inverter for speed control of AC motors(frequency control only)	8
3	**Operational amplifiers and 555 Timer:** Operational amplifier circuits, Ideal OPAMP behavior , common OPAMP ICs, Basic OPAMP circuits- Inverting amplifier, Noninverting amplifier ,Voltage follower (Buffer), Instrumentation Amplifier, Summing amplifier, Schmitt triggers Active first order filter: Low pass and high pass filter Power Op Amps, Optical Isolation amplifier 555 timer-Operating modes: monostable, astablemultivibrator	4
4	**Digital logic and logic families:** Digital signals, combinational and sequential logic circuits, clock signals, Boolean algebra and logic gates Integrated circuits and logic families : Logic Levels, Noise Immunity, Fan Out, Power Dissipation, Propagation Delay, TTL logic family : TTL Designations, TTL Versions, Output Configuration, TTL characteristic, The CMOS family,, comparison with TTL family Flip flops: Set Reset(SR),Trigger(T),clocked D F/Fs; Buffer and drivers Registers, decoders and encoders, Multiplexer and Demultiplexer	5
5	**Microprocessor and Microcontrollers:**	8

	Overview of generic microprocessor, architecture and functional block diagram, Comparison of microprocessor and microcontroller, MSP430Functional block diagram and architecture, assembly language programming, C compiler programming, basics of interfacing with external input / output devices (like reading external analog voltages, digital input output)	
6	**Motors:** Review and comparison of Torque–speed characteristics of DC motors and AC induction motors. Basic principles of speed control of AC/DC motors Basics of BLDC motor, Linear Actuator motor, Servo Motor Suitability of each motor for various industrial applications, Selection and sizing of motors for different applications. Applications for pumps, conveyors, machine tools etc.	5

[$]Coursecommon to Mech/Auto

Term Work:

List of Experiment: Minimum six out of 1-9 and four from 10-15. (Total ten experiments)

1. BJT as a switch
2. V-I characteristics of SCR
3. Triggering circuit of SCR (R,RC,UJT)
4. Full wave Rectifier using SCR
5. Single phase Bridge inverter with rectifier load
6. OPAMP as integrator
7. 555 timer as astablemultivibrator
8. Implementing study of gates and Logic Operations like , NOT, AND, OR,
9. Realization of basic gates using universal gates
10. Light dimmer circuit using Diac-Triac
11. Characteristics of DC shunt motor
12. Speed control of DC motor
13. Speed control of induction motor
14. Simple programs using microcontroller
15. Simple programs for microcontroller based applications

Distribution of marks for Term work shall be as follows:

Laboratory work (experiments/assignments): 20 marks
Attendance (Theory and practical's): 05 marks

Theory Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

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

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:

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

i. Practical performance …… 15 marks
ii. Oral …… 10 marks

2. Evaluation of practical examination to be done based on the experiment performed and the output of the experimentduring practical examination
3. Students work along with evaluation reportto be preserved till the next examination

ReferenceBooks:

1. Power Electronics M.H.Rashid, Prentice-Hall of India
2. Power Electronics, P S Bhimbra
3. Power Electronics ---VedamSubramanyam, New Age International
4. Jain R.P., "Modern Digitals Electronic "Tata McGraw Hill, 1984.
5. Fundamentals of Microcontrollers and Embedded System, Ramesh Gaonkar, PENRAM
6. Electrical drives by G K Dubey, Narosapublications
7. Power Electronics, Ned Mohan, Undeland, Robbins, John Wiley Publication
8. Digital principal and Application, Malvino& Leach, Tata McGraw Hill, 1991.
9. Digital design, Morris M. Mano, Prentice Hall International – 1984.
10. Electronic Devices and Circuits, Robert Boylestad and Louis Nashelsky, Prentice-Hall of India.
11. Electronic Devices and Circuits, Millman and Halkias, Tata McGraw-Hill.
12. MSP430 Microcontroller Basics, John H. Davies, Newnes; 1 edition (September 4, 2008)

Course Code	Course/Subject Name	Credits
MEL407	**Machine Shop Practice – II[$]**	**2**

Objectives:

1. To understand basic machining processes.
2. To understand various machining operations and machine protocols.

Outcomes: Learner should be able to ….

1. Operate various machines like lathe, shaper, grinding machine, milling machine etc.
2. Perform precision turning, boring etc.

Module	Details	Hrs
1	One composite job consisting minimum four parts employing operations on lathe like precision turning screw cutting, boring etc. This job shall involve use of shaping, milling and grinding operations	**48**

[$] Course common to Mech/Auto

Term Work:

1. Composite job mentioned above
2. Complete Work-Shop Book which give details of drawing of the job and time sheet

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

Job Work with complete workshop book ……. 40 marks
Attendance (Practical's) ……. 10 marks

Practical Examination:

Practical examination will be held for 4 hours. Job shall consist of minimum four operations such as precision turning, boring, screw cutting, drilling, milling, shaping, grinding etc.

AC 7/6/2014

Item No.4.32 & 4.33

UNIVERSITY OF MUMBAI

Bachelor of Engineering

Mechanical Engineering

Third Year (Sem. V & VI) and Final Year (Sem. VII & VIII)

Revised Syllabus (REV- 2012) w. e. f. Academic Year 2014 - 15 and 2015-2016 respectively

Under

FACULTY OF TECHNOLOGY

(As per Semester Based Credit and Grading System)

Deans Preamble

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education.The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty of Technology, University of Mumbai, in one of its meeting unanimously resolved that, each Board of Studies shall prepare some Program Educational Objectives (PEO's) and give freedom to affiliated Institutes to add few (PEO's) and course objectives and course outcomes to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. It was also resolved that, maximum senior faculty from colleges and experts from industry to be involved while revising the curriculum. I am happy to state that, each Board of studies has adhered to the resolutions passed by Faculty of Technology, and developed curriculum accordingly. In addition to outcome based education, semester based credit and grading system is also introduced to ensure quality of engineering education.

Semester based Credit and Grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes and Faculty of Technology has devised a transparent credit assignment policy and adopted ten points scale to grade learner's performance. Credit and grading based system was implemented for First Year of Engineering from the academic year 2012-2013. Subsequently this system will be carried forward for Second Year Engineering in the academic year 2013-2014, for Third Year and Final Year Engineering in the academic years 2014-2015 and 2015-2016 respectively.

Dr. S. K. Ukarande
Dean,
Faculty of Technology,
Member - Management Council, Senate, Academic Council
University of Mumbai, Mumbai

Chairman Preamble

Engineering education in India is expanding and is set to increase manifold. The major challenge in the current scenario is to ensure quality to the stakeholders along with expansion. To meet this challenge, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education and reflects the fact that in achieving recognition, the institution or program of study is committed and open to external review to meet certain minimum specified standards. The major emphasis of this accreditation process is to measure the outcomes of the program that is being accredited. Program outcomes are essentially a range of skills and knowledge that a student will have at the time of graduation from the program. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating the philosophy of outcome based education in the process of curriculum development.

As the Chairman, Board of Studies in Mechanical Engineering of University of the Mumbai, I am happy to state here that, the Program Educational Objectives were finalized in a brain storming session, which was attended by more than 20 members from different affiliated Institutes of the University. They are either Heads of Departments or their senior representatives from the Department of Mechanical Engineering. The Program Educational Objectives finalized for the undergraduate program in Mechanical Engineering are listed below;

1. To prepare the Learner with a sound foundation in the mathematical, scientific and engineering fundamentals.
2. To prepare the Learner to use modern tools effectively in order to solve real life problems.
3. To prepare the Learner for a successful career in Indian and Multinational Organisations and to excel in their Postgraduate studies.
4. To encourage and motivate the Learner in the art of self-learning.
5. To inculcate a professional and ethical attitude, good leadership qualities and commitment to social responsibilities in the Learner's thought process.

In addition to the above, 2 to3 more program educational objectives of their own may be added by affiliated Institutes.

In addition to Program Educational Objectives, for each course of undergraduate program, objectives and expected outcomes from the point of view of a learner are also included in the curriculum to support the philosophy of outcome based education. I strongly believe that even a small step taken in the right direction will definitely help in providing quality education to the major stake holders.

Dr. S. M. Khot

Chairman, Board of Studies in Mechanical Engineering, University of Mumbai

Program Structure for B E Mechanical Engineering
T. E. Mechanical -(Semester V)

Subject Code	Subject Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract.	Theory	Pract.	Total
MEC501	I C Engines &	4	2	4	1	5
MEC502	Mechanical Measurements and Control	4	2	4	1	5
MEC503	Production Process-III &	4	2	4	1	5
MEC504	Theory of Machines- II&	4	2	4	1	5
MEC505	Heat Transfer &	4	2	4	1	5
MEL5O1	Business Communication and Ethics #	-	2$+2	-	2	2
Total		**20**	**14**	**20**	**7**	**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.					
MEC501	I C Engines &	20	20	20	80	03	25	25	150
MEC502	Mechanical Measurements and Control	20	20	20	80	03	25	25	150
MEC503	Production Process-III &	20	20	20	80	03	25	--	125
MEC504	Theory of Machines- II&	20	20	20	80	03	25	--	125
MEC505	Heat Transfer &	20	20	20	80	03	25	25*	150
MEL5O1	Business Communication and Ethics #	--	--	--	--	--	50	--	50
Total		**--**	**--**	**100**	**400**	**--**	**175**	**75**	**750**

$ Theory for entire class to be conducted **# common for all engineering programs**
& Common with Automobile Engineering *** Only ORAL examination based on term work and syllabus**

T. E. Mechanical -(Semester VI)

Subject Code	Subject Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract.	Theory	Pract.	Total
MEC601	Metrology and Quality Engineering	3	2	3	1	4
MEC602	Machine Design I &	4	2	4	1	5
MEC603	Mechanical Vibrations &	4	2	4	1	5
MEC604	Thermal and Fluid Power Engineering &	4	2	4	1	5
MEC605	Mechatronics	4	2	4	1	5
MEC606	Finite Element Analysis &	3	2	3	1	4
Total		**22**	**12**	**22**	**6**	**28**

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.					
MEC601	Metrology and Quality Engineering	20	20	20	80	03	25	25	150
MEC602	Machine Design I &	20	20	20	80	03	25	--	125
MEC603	Mechanical Vibrations &	20	20	20	80	03	25	25*`	150
MEC604	Thermal and Fluid Power Engineering &	20	20	20	80	03	25	--	125
MEC605	Mechatronics	20	20	20	80	03	25	--	125
MEC606	Finite Element Analysis &	20	20	20	80	03	25	25	150
Total		**--**	**--**	**120**	**480**	**--**	**150**	**75**	**825**

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

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**

B. E. Mechanical-(Semester VIII)

Subject Code	Subject Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract.	Theory	Pract.	Total
MEC801	Design of Mechanical Systems	4	2	4	1	5
MEC802	Industrial Engineering and Management	4	2	4	1	5
MEC803	Refrigeration and Air Conditioning	4	2	4	1	5
MEE802X	Elective- II	3	2	3	1	4
MEP802	Project- II	--	12#	--	6	6
Total		**15**	**20**	**15**	**10**	**25**

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.					
MEC801	Design of Mechanical Systems	20	20	20	80	03	25	25	150
MEC802	Industrial Engineering and Management	20	20	20	80	03	25	--	125
MEC803	Refrigeration and Air Conditioning	20	20	20	80	03	25	25	150
MEE802X	Elective -II	20	20	20	80	03	25	--	125
MEP802	Project- II	--	--	--	--	--	50	100	150
Total		**--**	**--**	**80**	**320**	**--**	**150**	**150**	**700**

* Only ORAL examination based on term work and syllabus

# indicates work load of Learner (Not faculty) in VII and VIII 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**	Course codes	**Elective II**
MEE7011	Product Life Cycle Management (PLM)	MEE8021	Micro Electro Mechanical Systems (MEMS)
MEE7012	Power Plant Engineering [&]	MEE8022	Renewable Energy Sources
MEE7013	Energy Management	MEE8023	Project Management [&]
MEE7014	Supply Chain Management [&]	MEE8024	Business Process Reengineering
MEE7015	Computational Fluid Dynamics [&]	MEE8025	Cryogenics
MEE7016	Advanced Turbo Machinery	MEE8026	Automobile Engineering
MEE7017	Piping Engineering	MEE8027	Process Equipment Design
MEE7018	Emission and Pollution Control	MEE8028	Alternative Fuels
MEE7019	Operations Research	MEE8029	Enterprise Resource Planning
MEE70110	Total Productive Maintenance (TPM)	MEE80210	World Class Manufacturing [&]
MEE70111	Robotics	MEE80211	Nanotechnology
MEE70112	Digital Prototyping for Product Design –I	MEE80212	Digital Prototyping for Product Design –II

[&] Common with Automobile Engineering

Course Code	Course/Subject Name	Credits
MEC501	**Internal Combustion Engines&**	**4+1**

&Common with Automobile Engineering

Objectives

1. Study of air standard and actual engine cycles.
2. Study of SI and CI engine components and processes involved
3. Study and analysis of engine performance characteristics and engine emissions

Outcomes: Learner will be able to…

1. Differentiate SI and CI engines
2. Identify and explain working of engines components/systems
3. Plot and analyze engine performance characteristic
4. Perform exhaust gas analysis and comment on adverse implications on environment

Module	Detailed Contents	Hrs.
01	**Introduction** Heat engines; Internal and external combustion engines; Classification of I.C. Engines; Cycle of operations in four strokes and two-stroke IC engines and their comparative study; Scavenging and scavenging blowers, Air standard cycles and Fuel air cycles, Variable specific heat and its effects, Dissociation and other losses, Actual cycles, Deviation of actual engine cycle from ideal cycle	06
02	**Spark Ignition Engines** **A. Carburetors and fuel injection system in S I Engines :**Theory of carburetion, Simple carburetor, Essential parts of modern carburetor, Types of carburetors, Types of fuel injection systems in S I engines, Continuous injection system, Timed injection system, Electronic Fuel-Injection systems (EFIs), Advantages and disadvantages of SI engine fuel injection system **B. Ignition Systems :** Spark Plug and its requirements, Battery, Magneto, Electronic ignition systems **C. Combustion:** Combustion phenomenon in SI Engines, Ignition delay, Flame propagation, Pressure-Crank angle diagram, Abnormal combustion, Auto ignition, Detonation and Knocking, Factors affecting combustion and detonation, Types of combustion chambers	12
03	**Compression Ignition Engines** A. **Fuel Injection Systems :** Types i.e. Air injection systems, Airless/solid injection systems, Common rail, individual pump, distributor and unit injector etc, Injection pumps, Fuel injector, Types of nozzle, Electronically controlled unit fuel injection system, C I Engine Governors: necessity and characteristics B. **Combustion :** Combustion phenomenon in C I engines, Stages of combustion, Delay period, Knocking, Pressure-Crank angle diagram, Factors affecting combustion and knocking, Types of combustion chambers	12
04	**Engine lubrication :** Types of lubricants and their properties, SAE rating of lubricants, Types of lubrication systems **Engine Cooling :** Necessity of engine cooling, disadvantages of overcooling, Cooling systems and their comparison: Air cooling, Liquid cooling **Supercharging/Turbo-charging :** Objectives, Effects on power output and engine efficiency, Methods, Types, Limits	08

05	**Engine Testing and Performance:** Measurement of Break Horse Power, Indicated Power, Fuel Consumption, Air flow, BMEP, Performance characteristic of SI and CI Engines, Effect of load and Speed on mechanical, indicated thermal, break thermal and volumetric efficiencies, Heat balance sheet **Exhaust Emissions:** Exhaust gas analysis and methods, necessity, constituents, Air pollution due to engine exhaust, Pollution control devices and EURO, BHARAT standards **Fuels:** SI and CI engine fuels, Rating of fuels, Non conventional fuels: CNG, LPG, Bio-fuels, Hydrogen, Alcohol etc	06
06	**Alternative Potential Engines:** Stratified charge engine, Wankel engine, Free-piston engine, Stirling engine, VCR engine, Dual fuel engines, Multi fuel engines **Modern Trends in I C Engines**	04

List of Experiments

Part A: Study of physical systems in terms of constructional details and functions

1] 2 Stroke and 4 Stroke Engines
2] Carburetor.
3] Ignition system.
4] Fuel injection system.

Part B: Students shall perform at least 5 experiments from the list

1] Morse Test on petrol engine.
2] Speed Test on petrol or/and diesel engine.
3] Load Test on diesel engine (engines).
4] Heat Balance test on diesel or petrol engines.
5] Experimental determination of Air fuel ratio and volumetric efficiency of the engine
6] Exhaust Gas/Smoke analysis of S.I./ C.I. engines
7] Effect of Supercharging on Performance Characteristics of an engine

Term Work

Term work shall consist of minimum 6 experiments from the list out of which 4 must be actual trials on IC Engines and 1 case study/report (in group of not more than 3 students) on latest trends/developments in IC Engines

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

- Laboratory work (Experiments) **: 15 marks**
- Case Study/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.

Practical/Oral examination

1. Practical examination shall be conducted in a group of not more than 5 students. Examination shall be based on actual trials performed during the semester. Students are expected to actually take reading and plot the performance characteristics and comment.
2. Examiners are expected to evaluate results of each group and conduct oral based on the same
3. The distribution of marks for practical/oral examination shall be as follows:
    i. Practical performance …… 15 marks
    ii. Oral …… ……. .10 marks
4. 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. Internal Combustion Engines, Willard W.Pulkrabek, Pearson Education.
2. Internal Combustion Engines, Shyam Agrawal, New Age International
3. Internal Combustion Engine, Mathur and Sharma
4. Internal Combustion Engines, Mohanty, Standard Book House
5. Internal Combustion Engine, Gills and Smith
6. Internal Combustion Engines Fundamentals, John B. Heywood
7. Internal Combustion Engines, Gupta H N, 2nd ed, PHI
8. Internal Combustion Engine, V Ganesan - *TataMcGraw Hill*
9. Internal Combustion Engines, Richard Stone - *Palgrave Publication*
10. Internal Combustion Engine, S.L. Beohar
11. Internal Combustion Engine, P.M Heldt.
12. Internal Combustion Engines, V.L. Maleeve
13. Internal Combustion Engine, E.F. Oberi.
14. Internal Combustion Engine, Domkundwar

Course Code	Course/Subject Name	Credits
MEC502	**Mechanical Measurement and Control**	**4+1**

Objectives

1. To impart knowledge of architecture of the measurement system
2. To deliver working principle of mechanical measurement system
3. To study concept of mathematical modelling of the control system
4. To Analyse control system under different time domain

Outcomes: Learner should be able to…

1. Identify and select proper measuring instrument for specific application
2. Illustrate working principle of measuring instruments
3. Explain calibration methodology and error analysis related to measuring instruments
4. Mathematically model and analyze system/process for standard input responses

Modules.	Details	Hrs.
01	1.1 Significance of Mechanical Measurements, Classification of measuring instruments, generalized measurement system, types of inputs: Desired, interfering and modifying inputs. 1.2 Static characteristics: Static calibration, Linearity, Static Sensitivity, Accuracy, Static error, Precision, Reproducibility, Threshold, Resolution, Hysteresis, Drift, Span & Range etc. 1.3 Errors in measurement: Types of errors, Effect of component errors, Probable errors.	08
02	**2.1 Displacement Measurement** : Transducers for displacement, displacement measurement, potentiometer, LVDT, Capacitance Types, Digital Transducers (optical encoder) , Nozzle Flapper Transducer **2.2 Strain Measurement** : Theory of Strain Gauges, gauge factor, temperature Compensation, Bridge circuit, orientation of strain gauges for force and torque, Strain gauge based load cells and torque sensors **2.3 Measurement of Angular Velocity**: Tachometers, Tachogenerators, Digital tachometers and Stroboscopic Methods. **2.4 Acceleration Measurement**, theory of accelerometer and vibrometers, practical accelerometers, strain gauge based and piezoelectric accelerometers.	08
03	**3.1 Pressure Measurement:** Elastic pressure transducers viz. Bourdon tubes, diaphragm, bellows and piezoelectric pressure sensors, High Pressure Measurements, Bridge man gauge. Vacuum measurement: Vacuum gauges viz. McLeod gauge, Ionization and Thermal Conductivity gauges. **3.2 Flow Measurement**: Bernoullis flowmeters, Ultrasonic Flowmeter, Magnetic flow meter, rotameter. **3.3 Temperature Measurement**: Electrical methods of temperature measurement Resistance thermometers, Thermistors and thermocouples, Pyrometers. **3.3 Sensitivity analysis of sensor**-influence of component variation, **Signal conditioning**: Amplifier, Conversion, Filtering, Impedance Buffering, Modulation / Demodulation, Linearization, Grounding and Isolation.	08

04	4.1 Introduction to control systems. Classification of control system. Open loop and closed loop systems. 4.2 Mathematical modelling of control systems, concept of transfer function, Block diagram algebra.	06
05	**5.1 Transient and steady state analysis of first and second order system.** Time Domain specifications. Step response of second order system. Steady-state error, error coefficients, steady state analysis of different type of systems using step, ramp and parabolic inputs.	06
06	**Stability analysis** 6.1 Introduction to concepts of stability. The Routh criteria for stability. 6.2 Experimental determination of frequency response, Stability analysis using Root locus, Bode plot and Nyquist Plots. 6.3 State space modeling. 6.4 Process control systems, ON-OFF control. P-I-D Control.	12

List of Experiments

1. Calibration of Displacement sensors like LVDT, Potentiometers etc.
2. Calibration of Pressure Gauges
3. Calibration of Vacuum Gauges
4. Torque measurement using strain gauges
5. Calibration of tachometers
6. Vibration Measurement & Calibration of Accelerometers.
7. Experiments on feedback control systems and servomechanisms
8. System Identification of any one of the sensor
9. Experiment on frequency response system identification
10. Experiment on transient state response of a control system.
11. Experiment on design of PID controller for a system.

(Design based experiments shall be encouraged using standard National Instrument/ texas instrument/ dSPACE Gmbh/ Arduino or any other platform)

Term Work

Term work shall consist of minimum **08** experiments (04 from the measurement group and 04 from the control group), assignments on each module.

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.

Practical/Oral examination

1. Experiment for the examination shall be based on the list of experiments mentioned in the term work.
2. The distribution of marks for practical/oral examination shall be as follows:
   iii. Practical performance …… 15 marks
   iv. Oral …… …….. .10 marks
3. Evaluation of practical examination to be done based on the experiment performed and the output of the experiments during practical examination.
4. 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. Measurement Systems (Applications and Design) 5th ed.- E.O. Doebelin - *McGraw Hill.*
2. Mechanical Engineering Measurement - Thomas Beckwith, N.Lewis Buck, Roy Marangoni - *Narosa Publishing House, Bombay.*
3. Mechanical Engineering Measurements - A. K. Sawhney - *DhanpatRai& Sons, New Delhi.*
4. Instrumentation Devices & Systems - C.S. Rangan&G.R.Sarrna - *Tata McGraw Hill.*
5. Instrumentation & Mechanical Measurements - A.K. Thayal.
6. Control System Engineering: by Nagrath IJ. and Gopal .M., *Wiley EasternLtd.*
7. Modem Control engineering: by K.Ogata, *Prentice Hall*
8. Control systems: Dhanesh Manik, Cengage Learning
9. Automatic Control System, Benjamin Kuo, Prentice Hall
10. Control system theory with engineering applications, Lysherski, Sergey E, Springer
11. Instrumentation and Control System, W. Bolton, Elsevier
12. Experimental Methods for Engineers - J. P. Holman. - McGraw Hills Int. Edition.
13. Engineering Experimentation - E.O. Doebelin - McGraw Hills Int. Edition
14. Mechanical Measurements- S.P.Venkateshan, Ane books, India
15. Theory and Design for Mechanical Measurements, 3rd ed., Wiley
16. Control System Engineering: Norman Nise, John Wiley and Sons
17. Feedback Control System, Charles Phillips, R. D. Harbor

Course Code	Course/Subject Name	Credits
MEC503	**Production Process - III[&]**	**4+1**

[&] Common with Automobile Engineering

Objectives

1. To study sheet metal forming as well as mechanical behavior of stress system in metal forming processes.
2. To develop capability to design jigs and fixtures.
3. To give exposure to Non-traditional machining operations.
4. To study concepts regarding modern manufacturing techniques like rapid prototyping, rapid tooling, agile manufacturing technologies etc.

Outcome: Learner will be able to..

1. Demonstrate understanding of sheet metal forming and various stress systems involved in metal forming operations.
2. Design jigs and fixtures for a given applications.
3. Get knowledge about non-conventional machining operations and its application areas.
4. Illustrate advanced concepts such as rapid prototyping and Agile manufacturing.

Module	Details	Hrs.
01	Introduction to High speed machines, special purpose machines, transfer line and other mass production machines. Types of automats and its tooling.	**04**
02	**Sheet Metal Forming** : Elementary treatment of press working, Operation on presses, Press devices Classification of presses, Constructional features of blanking, piercing, compound, combination, progressive, bending, forming and drawing dies, Load calculations, development of blanks, scrap strip layout, punches, selection of die sets, stock guides, strippers, pilots, stops etc. selection of presses, capacities and other details.	**10**
03	**Design of Jigs and Fixtures**: Need for jigs and fixtures, elements of Jigs and fixtures, principles of location, design of locating elements, locating pins support pins spring back, vee blocks, etc. principles of clamping simple hand operated clamps, like screw clamp, lever clamps and other types of clamps. Drill bushes-their types and applications indexing devices, auxiliary elements. Design of drill jigs like plate, leaf solid and box types for drilling combined with reaming, spot facing etc. design of milling fixtures such as plain, string, gang and indexing types. Design of turning fixtures.	**12**
04	**Non-traditional Machining** Ultrasonic Machining (USM), Abrasive Jet Machining (AJM),Water Jet Machining, Electrochemical Machining (ECM),Chemical Machining (CHM)Electrical Discharge Machining (EDM),Plasma Arc Machining (PAM),Laser Beam Machining (LBM),Electron Beam Machining (EBM), Arc cutting processes and Oxy fuel cutting process.	**08**
05	**Plastics Injection Mold Design:** General arrangement of an injection mold, Basic systems of the mold – Feeding system, cooling system and ejection systems, Concepts of three plate molds and tooling for moulding articles with undercuts, Concepts of split molds, hot runner systems – Their advantages and limitation over conventional systems. Basic concepts of mold standardization and innovative mold components.	**08**

06	**Agile Manufacturing Technologies:** Introduction, Developing agile manufacturing, Integration of Product/Process Development, Application of IT/IS concepts, Agile supply chain management, Design of skill and knowledge and Computer control of Agile manufacturing. Flexible manufacturing systems.	**06**

Term Work

1. At least six assignments on concepts, Case studies and analysis based on the topics mentioned above.
2. Term work shall consist of minimum 6 assignments. The distribution of marks for term work shall be as follows

- Lab work (Case Studies): **10 marks**
- Assignments: **10 marks**
- Attendance: **05marks**

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. *Mechanical Metallurgy*, G E Dieter ,McGraw Hill.
2. *Jigs and Fixtures,* P H Joshi, Mc Graw Hill.
3. *Production Technology,* R C Patel & C G Gupte.
4. *Production Technology*, HMT, Tata Mc Graw Hill.
5. *Introduction to Jigs and Tool design*, HA Kempster, Butterworth Heinemann Ltd.
6. *Manufacturing Process*, R A Lindberg, PHI India.
7. *Agile Manufacturing- Forging Mew Frontiers*, Poul T Kidd,Amagow Co. UK.
8. *Agile Manufacturing*, AGunasekharan, the 21st Century Competitive strategy, Elsevier Press,India.
9. *Stereo Lithography and other RP & M Technologies*, Paul F.Jacobs: SME, NY 1996.
10. *Rapid Manufacturing*, Flham D.T &Dinjoy S.S Verlog London2001.
11. *Fundamentals of modern Manufacturing*, Fourth Edition, Mikell P Groover, John Wiley & Sons.
12. *Metals handbook* ,Forming and Forging, Vol. 14, ASM.

Course Code	Course/Subject Name	Credits
MEC504	**Theory of Machines-II[&]**	**4+1**

[&] Common with Automobile Engineering

Objectives

1. To acquaint with working principles of clutches and its constructional details.
2. To study working and types of brakes and dynamometers.
3. To acquaint with working principles and applications of gyroscope and governors.
4. To demonstrate different types of gear trains and its applications.

Outcomes: Learner will be able to…

1. Apply the working principles of clutches and its constructional details.
2. Analyze working of brakes and dynamometers.
3. Demonstrate working mechanism of different types of governors.
4. Analyze and select gear trains.
5. Analyze gyroscopic effect on various applications

Module	Details	Hrs.
01	**1.1 Clutches:** Requirements of Clutches, Types of Clutches and Clutch materials, Positive clutches, friction clutches, Friction Clutches - Analysis of frictional torque, power transmission .Power loss in Friction in single plate, multiple plate clutch, and cone clutch, Centrifugal Clutches - construction, working	**08**
02	**2.1 Brakes:** Requirement of brake, Types of Brakes, Analysis of Block brakes - external and internal, Band brake-simple and differential, Band and block brake - simple and differential, Braking of vehicles - front wheels, rear wheels, all wheels on level and inclined roads, **2.2 Dynamometers** - Absorption and transmission dynamometers, Study and analysis of absorption type dynamometer - Proney brake, Rope brake, dynamometers, Study and analysis of transmission type dynamometers - Belt transmission, epicyclical, torsion dynamometers, Froude hydraulic dynamometer	**08**
03	**3.1 Governors:** Comparison between governors and flywheel, Types - centrifugal governors, inertia governors, **3.2 Force analysis of gravity loaded governors** - Watt, Porter, Proell, Force analysis of spring loaded governors - Hartnell, hartung, Wilson Hartnell, Force analysis of spring and gravity loaded governor, Performance characteristics of governors- stability, sensibility, isochronisms, Hunting, governor effort and governor power, coefficient of insensitiveness.	**08**
04	**4.1 Gyroscope:** Introduction - Gyroscopic couple and its effect on spinning bodies, Gyroscopic effect on naval ships during steering, pitching and rolling., Ship stabilization with gyroscopic effect **Two wheeler and four wheeler on curved path** - effect of gyroscopic and centrifugal couples, maximum permissible speeds on curve paths, Gyroscopic effect due to lateral misalignment of rigid disc mounted on shaft	**08**
05	**5.1 Gear Trains:** Kinematics and dynamic analysis of - simple gear trains, compound gear trains, reverted gear trains, epi-cyclic gear trains with spur or bevel gear combination. 5.2 **Transmissions:** Necessity of gear box, Sliding mesh, Constant mesh, Synchromesh and epicyclic gear box,	**08**

06	**6.1 Static and Dynamic force analysis** in slider crank mechanism (neglecting mass of connecting rod and crank), Engine force analysis, Turning moment on crank shaft. **6.2 Dynamically equivalent systems** to convert rigid body to two mass with and without correction couple. **6.3 Flywheel and its applications**, Fluctuation in energy, function of flywheel , estimating inertia of flywheel for reciprocating prime movers and machines.	**08**

List of Experiments

1. Study of Clutches
2. Study of Brakes
3. Experiments on Dynamometers - Rope Brake Dynamometer, Torsion Dynamometer
4. Experiments on Governors - Proell Governor, Hartnell Governor,
5. Experiments on Gyroscope
6. Study of power transmission system in automobile
7. At least two numerical simulations using C++/MATLAB based on systems discussed in syllabus

Term Work

Term work shall consist of experiments listed above and at least 3 assignments consisting numerical from each module.

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. Theory of Machines - Thomas Bevan - C. B. S. Publishers
2. Theory of Machines - S. S. Ratan - Tata McGraw Hill
3. Theory of Machines - P. L. Ballaney, Khanna Publishers, Delhi
4. Dynamics of Machines – Norton, *McGraw Hill Publication*
5. Theory of Mechanisms and Machines - A. Ghosh and A. Malik - *Affiliated East – West Press Pvt. Ltd., New Delhi*
6. Theory of Machines - W. G. Green – *Bluckie & Sons Ltd.*
7. Mechanics & Dynamics of Machinery - J. Srinivas, *Scitech*
8. Kinematics, Dynamics and Design of Machinery, 2nd ed., Kenneth Waldron, Gary Kinzel, *Wiley India Edition*
9. Essential MATLAB for Engineers and Scientist - Brian D. Hanhn, Daniel Valentine,

Course Code	Course/Subject Name	Credits
MEC505	**Heat Transfer &**	**4+1**

& Common with Automobile Engineering

Objectives

1. Study and analysis of basic heat transfer concepts applicable for steady state and transient conditions
2. Study mathematical modeling and designing concepts of heat exchangers

Outcomes: Learner should be able to…

1. Identify & explain the three modes of heat transfer (conduction, convection and radiation).
2. Develop mathematical model for each mode of heat transfer
3. Demonstrate and explain mechanism of boiling and condensation
4. Design and analyze different heat exchangers

Module	Detailed Contents	Hrs.
01	**Introduction** Typical heat transfer situations, Modes of heat transfer, heat transfer parameters, various thermo physical properties	02
02	**Conduction** Fourier's law of heat conduction, thermal conductivity, differential equation of heat conduction with heat generation in unsteady state in the Cartesian coordinate system, Boundary and initial conditions, Solution to three dimensional steady heat conduction problems, Steady heat conduction in plane walls, composite walls, Concept of thermal resistance and thermal resistance network, Heat conduction in cylinders and spheres, Differential equation of heat conduction in cylindrical co-ordinates, Conduction through Cylindrical and Spherical composite walls (Derivation NOT INCLUDED for Spherical walls), Critical thickness/radius of insulation and its importance.	10
03	**Extended Surfaces** Heat transfer from finned surfaces, Types of fins, Fin equation for rectangular fin and its solution, Fin efficiency, Fin effectiveness **Transient Heat Conduction** Lumped system analysis, One dimensional transient problems analytical solutions, One dimensional Heisler charts **Numerical Methods in Conduction** Importance of numerical methods, Finite difference formulation of one dimensional steady heat conduction equations	08
04	**Convection** Physical mechanism of convection, Natural and Forced convection, Velocity/hydrodynamic and Thermal boundary layer, Velocity and temperature profile, Differential equation of heat convection, Laminar flow heat transfer in circular pipe, constant heat flux and constant wall temperature, thermal entrance region, Turbulent flow heat transfer in circular pipes, Pipes of other cross sections, Heat transfer in laminar and turbulent flow over a flat plate, Heat pipe introduction and applications, Principles of dimensional analysis and its application in convective heat transfer, Empirical correlations for convection, Physical significance of various dimensionless numbers useful in natural and forced convection	10

05	**Radiation** Thermal radiation, Blackbody radiation, Radiation intensity, Radiative properties, Basic laws of radiation (Plank's law, Kirchoff's law, Stefan-Boltzman law, Wien's displacement law, Lambert's cosine law, Radiation exchange between black surfaces, Shape factor, Radiation exchange between gray surfaces, Radiosity-Irradiation method, Radiation shield and the radiation effect	08
06	**Boiling and Condensation** Boiling heat transfer, Pool boiling, Flow boiling, Condensation heat transfer, Film condensation, Drop wise condensation **Heat Exchangers** Types of heat exchangers, Overall heat transfer coefficient, Analysis of heat exchangers, LMTD method, Effectiveness-NTU method, Correction factor and effectiveness of heat exchangers	10

List of Experiments

1. Thermal conductivity of metal bar /composite wall / liquid /Insulating Material
2. Determination of contact resistance
3. Effect of area on Heat transfer
4. Radial heat conduction
5. Determination of fin efficiency and fin effectiveness
6. Unsteady state heat transfer
7. Heat pipe
8. Natural and Forced convection for flow over flat plate /through a circular pipe
9. Comparison of Overall heat transfer coefficient and effectiveness for double pipe/plate type /shell & tube heat exchanger
10. Determination of emissivity of a grey surface

Term Work

Term work shall consist of minimum 7 experiments from the list, 3 assignments containing numerical based on modes of heat transfer and One Assignment based on live problem relevant to heat exchanger analysis

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

- Laboratory work (Experiments) **:** **10 marks**
- Numerical Assignments : **05 marks**
- Live problem assignment**:** **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.

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. Introduction to Thermodynamics and Heat Transfer, 2nd ed., Yunus A Cengel, McGraw Hill International.
2. Fundamentals of Heat and Mass Transfer, F. P. Incropera and D. P.DeWitt, Wiley India
3. Heat and Mass Transfer, 2nd ed., R Rudramoorthy and L Mayilsamy, PEARSON
4. Fundamentals of Engineering Heat and Mass Transfer, 4th ed., R C Sachdeva, New Age International
5. Heat Transfer, 2nd ed., A F Mills and V Ganesan, PEARSON
6. Heat Transfer, 9th ed., J P Holman, McGraw Hill
7. Engineering Heat and Mass Transfer, Mahesh M Rathore, Laxmi Publication
8. Principles of Heat Transfer, 6th ed., Frank Kreith, CENGAGE Learning
9. Heat and Mass transfer, 6th ed.,D S Kumar, S K Kataria and Sons
10. Heat Transfer, S P Sukhatme, University Press
11. Heat and Mass Transfer, 2nd ed., P K Nag, Tata McGraw Hill
12. Fundamentals of Heat and Mass Transfer, Thirumaleshwar, Pearson Education
13. Engineering Heat Transfer, N V Suryanarayana, Penram Publication
14. Heat and Mass transfer, C P Arora, Dhanpatrai and Co.
15. Heat Transfer, Y V C Rao, University Press
16. Heat and Mass Transfer, R K Rajput, S.Chand and Company
17. Elements of Heat Transfer, Jakole and Hawkins
18. Heat Transfer, James Sueee, JAICO Publishing House
19. Heat Transfer, Donald Pitts & L E Sisson, Schaums Series, Mc Graw Hill International
20. Engineering Heat Transfer, Shao Ti Hsu
21. Heat Transfer, M Necati Ozisik, McGraw Hill International edition
22. Heat Transfer, Ghosdastidar, Oxford University Press

Course Code	Course/Subject Name	Credits
MEL501	**Business Communication & Ethics[&]**	**2**

[&] Common with All Engineering Programs

Pre-requisite

- FEC206 Communication Skills

Objectives

1. To inculcate in students professional and ethical attitude, effective communication skills, teamwork, skills, multidisciplinary approach and an ability to understand engineer's social responsibilities.
2. To provide students with an academic environment where they will be aware of the excellence, leadership and lifelong learning needed for a successful professional career.
3. To inculcate professional ethics and codes of professional practice
4. To prepare students for successful careers that meets the global Industrial and Corporate requirement' provide an environment for students to work on Multidisciplinary projects as part of different teams to enhance their team building capabilities like leadership, motivation, teamwork etc.

Outcomes: A learner will be able to …..

1. communicate effectively in both verbal and written form and demonstrate knowledge of professional and ethical responsibilities
2. Participate and succeed in Campus placements and competitive examinations like GATE, CET.
3. Possess entrepreneurial approach and ability for life-long learning.
4. Have education necessary for understanding the impact of engineering solutions on Society and demonstrate awareness of contemporary issues.

Module	Unit No.	Topics	Hrs
1.0	**1.0**	**Report Writing**	**07**
	1.1	Objectives of report writing	
	1.2	Language and Style in a report	
	1.3	Types of reports	
	1.4	Formats of reports: Memo, letter, project and survey based	
2.0	**2.0**	**Technical Proposals**	**02**
	2.1	Objective of technical proposals	
	2.2	Parts of proposal	
3.0	**3.0**	**Introduction to Interpersonal Skills**	**07**
	3.1	Emotional Intelligence	
	3.2	Leadership	
	3.3	Team Buliding	
	3.4	Assertiveness	
	3.5	Conflict Resolution	
	3.6	Negotiation Skills	
	3.7	Motivation	
	3.8	Time Management	
4.0	**4.0**	**Meetings and Documentation**	**02**
	4.1	Strategies for conducting effective meetings	
	4.2	Notice	
	4.3	Agenda	
	4.4	Minutes of the meeting	

5.0	**5.0**	**Introduction to Corporate Ethics and etiquettes**	**02**
	5.1	Business Meeting etiquettes, Interview etiquettes, Professional and work etiquettes, Social skills	
	5.2	Greetings and Art of Conversation	
	5.3	Dressing and Grooming	
	5.4	Dinning etiquette	
	5.5	Ethical codes of conduct in business and corporate activities (Personal ethics, conflicting values, choosing a moral response, the process of making ethical decisions)	
6.0	**6.0**	**Employment Skills**	**06**
	6.1	Cover letter	
	6.2	Resume	
	6.3	Group Discussion	
	6.4	Presentation Skills	
	6.5	Interview Skills	
		Total	**26**

List of Assignments

1. Report Writing (Synopsis or the first draft of the Report)
2. Technical Proposal (Group activity, document of the proposal)
3. Interpersonal Skills (Group activity and Role play)
4. Interpersonal Skills (Documentation in the form of soft copy or hard copy)
5. Meetings and Documentation (Notice, Agenda, Minutes of Mock Meetings)
6. Corporate ethics and etiquettes (Case study, Role play)
7. Cover Letter and Resume
8. Printout of the PowerPoint presentation

Term Work

Term work shall consist of all assignments from the list.

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

- Assignments **:** **20 marks**
- Project Report Presentation**:** **15 marks**
- Group Discussion**:** **10 marks**
- Attendance **:** **05 marks**

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

References

1. Fred Luthans, "*Organizational Behavior"* , Mc Graw Hill, edition
2. Lesiker and Petit, "*Report Writing for Business"* , Mc Graw Hill, edition
3. Huckin and Olsen, "*Technical Writing and Professional Communication"*, McGraw Hill
4. Wallace and Masters, "*Personal Development for Life and Work"* , Thomson Learning, 12th edition
5. Heta Murphy, "*Effective Business Communication"* , Mc Graw Hill, edition
6. R.C Sharma and Krishna Mohan, "*Business Correspondence and Report Writing",*
7. B N Ghosh, "*Managing Soft Skills for Personality Development*", Tata McGraw Hill. Lehman,
8. Dufrene, Sinha, "*BCOM*", Cengage Learning, 2nd edition
9. Bell . Smith, "Management Communication" Wiley India Edition,3rd edition.
10. Dr. K. Alex ,"Soft Skills", S Chand and Company
11. Dr.KAlex,"SoftSkills",S Chand and Company
12. R.Subramaniam, "Professional Ethics" Oxford University Press 2013.

Course Code	Course/Subject Name	Credits
MEC601	**Metrology and Quality Engineering**	**3+1**

Objectives

1. To study the fundamentals of modem quality concepts and statistical techniques.
2. To study fundamentals of inspection methods and systems.
3. To acquaint with operation of precision measurement tools and equipment's.

Outcomes: Learner will be able to…

1. Apply inspection gauge and checking systems.
2. Demonstrate the understanding of purpose of critical dimensions in manufacturing.
3. Analyse simple parts for dimensional accuracy and functionality.

Module	Details	Hrs.
01	1.1 Introduction to Metrology, Fundamental principles and definitions, measurement standards / primary and tertiary standards, distinction between precision and accuracy. 1.2 Limits, fits and tolerances, Tolerance grades, Types of fits, IS919, GO and NO GO gauges- Taylor's principle, design of GO and NO GO gauges, filler gauges, plug gauges and snap gauges.	**04**
02	2.1 Comparators: Constructional features and operation of mechanical, optical, electrical/electronics and pneumatic comparators, advantages, limitations and field of applications. 2.2 Principles of interference, concept of flatness, flatness testing, optical flats, optical interferometer and laser interferometer. 2.3 Surface texture measurement: importance of surface conditions, roughness and waviness, surface roughness standards specifying surface roughness parameters- Ra, Ry, Rz, RMS value etc., surface roughness measuring instruments – Tomlinson and Taylor Hobson versions, surface roughness symbols.	**09**
03	3.1 Screw Thread measurement: Two wire and three wire methods, floating carriage micrometer. 3.2 Gear measurement: Gear tooth comparator, Master gears, measurement using rollers and Parkinson's Tester. 3.3 Special measuring Equipments: Principles of measurement using Tool Maker's microscope, profile projector & 3D coordinate measuring machine.	**09**
04	**Quality Control** Introduction, definition and concept of quality & quality control, set up policy and objectives of quality control, quality of design and quality of conformance, compromise between quality & cost, quality cost and planning for quality.	**05**
05	**SQC and SQC tools** Importance statistical methods in QC, measurement of statistical control variables and attributes, pie charts, bar charts/ histograms, scatter diagrams, pareto chart, GANT charts, control charts, X chart, X bar charts, R charts, P charts, np charts their preparation, analysis and applications. Elementary treatment on modern SQC tools.	**06**
06	**Sampling Techniques** Sampling inspection and basic concepts, OC curves, consumer & producer risk, single & double sampling plans and use of sampling tables.	**03**

List of Experiments

1. Use of comparators.
2. Thread measurement.
3. Gear measurement.
4. Use of Profile projectors.
5. Use of linear and angular measuring instruments.
6. Measurement of surface roughness.
7. Measurement of flatness.

Term Work

Term work shall consist of minimum 5 experiments from the list and presented with inferences and one assignment on each module

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.

Practical/Oral examination

1. Experiment for the examination shall be based on the list of experiments mentioned in the term work.

2. The distribution of marks for practical/oral examination shall be as follows:
   i. Practical performance: 15 marks
   ii. Oral: 10 marks

3. Evaluation of practical examination to be done based on the experiment performed and the output of the experiments during practical examination.

4. 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. *Practical Engineering Metrology*, K.W.B.Sharp, Pitman Publication
2. *Engineering Metrology*, K.J.Hume, Kalyani publication
3. *Engineering. Metrology*, I.C. GUPTA, DhanpatRai Publications.
4. *Statistical quality control*, A.L. Grant, McGraw Hill International, New York.
5. *Engineering. Metrology*, R.K.Jain, Khanna Publisher.
6. *Metrology*,Taher.
7. *Statistical Quality control*, R.C. Gupta
8. *I.S. 919/1963.*
9. *I.S. 2709/1964.*
10. *Engineering. Metrology*, Hume K.G., M C Donald, Technical &Scientific ,London.
11. *Quality Control and Industrial Statistics*, – Duncon A.J., D.B. Taraporevela& Co. Bombay.
12. *Statistical quality Control*, Mahajan M., DhanpatRai& Sons, Delhi.
13. *Engineering Metrlogy*-2nd Ed.,P. Narayana, Scitech Publication.
14. *Metal working & Metrology*, P. Narayana et.al ,Scitech Publication.
15. *Quality control* 7 ed.,D.H. Besterfield Pearson education.
16. *Juran's Quality Control Handbook*.

Course Code	Course/Subject Name	Credits
MEC602	**Machine Design-I[&]**	**4+1**

[&] Common with Automobile Engineering

Objectives

1. To study basic principles of machine design
2. To acquaint with the concepts of strength design related to various components.
3. To familiarize with use of design data books & various codes of practice.
4. To make conversant with preparation of working drawings based on designs.

Outcomes: Learner will be able to…

1. Demonstrate understanding of various design considerations
2. Apply basic principles of machine design
3. Design machine elements on the basis of strength concept
4. Use design data books and various standard codes of practices.
5. Acquire skill in preparing production drawings pertaining to various designs.

Modules	Details	Hrs.
01	Mechanical Engineering Design, Design methods, Aesthetic and Ergonomics consideration in design Material properties and their uses in design Manufacturing consideration in design Design considerations of casting and forging Basic principles of Machine Design, Modes of failures, Factor of safety, Design stresses, Principal stresses and strains, Theories of failures Standards, I. S. codes, Preferred Series and Numbers.	**06**
02	Curved Beams: Assumptions made in the analysis of curved beams. Design of curved beams: Bending stresses in curved beams, such as crane hook, C-frame, etc. Thick cylinders: Design of thick cylinders subjected to an internal pressure using Lame's equation.	**06**
03	Design against static Loads: Cotter joint, knuckle joint, Turn Buckle Bolted and welded joints under eccentric loading. Power Screw - Screw Presses, C- Clamps along with the Frame, Screw Jack	**12**
04	Design against Fluctuating Loads: Variables stresses, reversed, repeated, fluctuating stresses Fatigue Failure: Static and fatigue stress concentration factors Endurance limit - estimation of endurance limit Design for finite and infinite life, Soderberg and Goodman design criteria, Fatigue design under combined stresses	**06**
05	Design of shaft - power transmitting, power distribution shafts Module (excluding crank shaft) under static and fatigue criteria. Keys - Types of Keys and their selection based on shafting condition. Couplings- Classification of coupling. Design of Split muff couplings, Flange couplings, Bush pin flexible couplings	**11**
06	Design of Springs: Helical compression, tension springs under static and variable loads, Leaf springs.	**07**

List of Assignments

Design exercises in the form of design calculations with sketches and or drawings on following machine system

1. Knuckle joint,
2. Turn Buckle
3. Screw Jack
4. Flexible flange couplings

Term Work

Term work shall consist of

A. Minimum 3 design exercises from the list which may include computer aided drawing on A3 size sheets

B. Stress analysis of any machine element mentioned in the syllabus using any application software and programming language

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

- Part A **:** **15 marks**
- Part B : **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.

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 college.

References

1. Design of machine elements -- V. B. Bhandari. Tara Mc-Graw Hill Pub.
2. Design of machine elements -- Sharma,Purohil. Prentice Hall India Pub.
3. Machine Design - An Integrated Approach -- Robert L. Norton – PearsonEducation.
4. Machine Design - Pandya & Shah- Charotar PI/blishing.
5. Mechanical Engineering Design - J. E. Shigley - McGraw Hill
6. Recommended Data Books - PSG, K. Mahadevan
7. Machine Design - Reshetov - Mir Publication
8. Machine Design - Black Adams-Mcgraw Hill
9. Fundamentals of Machine Elements - Hawrock, Jacobson Mcgraw Hill
10. Machine Design - Patel, Pandya, Sikh, Vol. - I & II, C.
11. Jamnadas& Co. Educational & Law Publishers
12. Design of Machine Elements - V.M. Faires
13. Design of Machine Elements - Spotts.

Course Code	Course/Subject Name	Credits
MEC603	**Mechanical Vibration[&]**	**4+1**

[&] Common with Automobile Engineering

Objectives

1. To study basic concepts of vibration analysis
2. To acquaint with the principles of vibration measuring instruments
3. To study balancing of mechanical systems

Outcomes: Learner will be able to…

1. Develop mathematical model to represent dynamic system
2. Estimate natural frequency of mechanical element/system
3. Analyze vibratory response of mechanical element/system
4. Estimate the parameters of vibration isolation system

Modules	Details	Hrs
01	**1.1 Basic Concepts of Vibration** Vibration and oscillation, causes and effects of vibrations, Vibration parameters – spring, mass, damper, Damper models, Motion – periodic, non periodic, harmonic, non- harmonic, Degree of freedom, static equilibrium position, Vibration classification, Steps involved in vibration analysis. **1.2 Free Undamped Single Degree of Freedom Vibration System** Longitudinal, transverse, torsinal vibration system, Methods for formulation of differential equations by Newton, Energy, Lagrangian and Rayleigh's Method,.	**08**
02	**2.1 Free Damped Single Degree of Freedom Vibration System** Viscous damped system – under damped, critically damped, over damped; Logarithmic decrement; Coulomb's damping; Combined viscous and coulomb's damping. **2.2 Equivalent Single Degree of Freedom Vibration System** Conversion of multi-springs, multi masses, multi – dampers into a single spring and damper with linear or rotational co-ordinate system	**08**
03	**3.1 Free Undamped Multi Degree of Freedom Vibration System** Eigen values and Eigen vectors for linear system and torsional two degree of freedom; Holzer method for linear and torsional unbranched system; Two rotors, Three rotors and geared system; Dunkerley's and Rayleigh's method for transverse vibratory system	**09**
04	**4.1 Forced Single Degree of Freedom Vibratory System** Analysis of linear and torsional systems subjected to harmonic force excitation and harmonic motion excitation (excluding elastic damper) **4.2 Vibration Isolation and Transmissibility** Force Transmissibility, Motion Transmissibility Typical isolators& Mounts **4.3 Rotor Dynamics:** Critical speed of single rotor, undamped and damped.	**09**
05	**5.1 Vibration Measuring Instruments:** Principle of seismic instruments, vibrometer, accelerometer - undamped, damped **5.2** Introduction to Conditioning Monitoring and Fault Diagnosis.: At least two case studies in detail based on Conditioning Monitoring and Fault Diagnosis.	**06**

06	**6.1 Balancing** Static and dynamic balancing of multi rotor system, Balancing of reciprocating masses In - line engines, V - engines (excluding radial engines)	**08**

List of Experiments

1. Experimental prediction of natural frequency of compound pendulum, prediction of equivalent simple pendulum system.
2. Experimental prediction of natural frequency for longitudinal vibrations of helical springs, and springs in series and parallel
3. Experimental prediction of natural frequencies, and nodal points for single rotor and two-rotor vibratory system, and comparison with theoretical results
4. Experimental and theoretical investigation of whirling of shaft (i.e. . comparison of experimental and theoretical natural frequency and justification of discrepancy between experiment and theory)
5. Experimental investigation of viscous and coulomb damping, prediction of system parameter (spring stiffness, damping coefficient) from damped oscillations
6. Experimental and theoretical investigation of frequency response of mechanical system, and comparing both and justification of discrepancy between theory and experiments
7. Experiments' on distributed parameter system: Transverse vibrations of beam (Dunkerley's Rule Expt.)
8. Experimental balancing of single and multi-rotor system.
9. Introduction to FFT analyzer, and prediction of spectral response of vibrating machine from workshop.
10. Experiments on vibration isolation system and prediction of force transmissibility, motion transmissibility of system.
11. Vibration analysis of mechanical system using MATLAB

Term Work

Term work shall consist of minimum 8 experiments from the list and one assignment on each module containing at least 5 numerical.

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.

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. Mechanical Vibrations 4th ed- S. S. Rao - *Pearson Education*
2. Mechanical Vibrations - G. K. Grover
3. Fundamentals of Mechanical Vibration - S.Graham Kelly - *Tata McGraw Hill* 4.
4. Vibration Analysis - P. Srineevasan - Tata McGraw Hill
5. Mechanical Vibrations - Schaum's outline series - S.Graham Kelly- *McGraw Hill*
1. Mechanical Vibrations - Schaum's outline series - William W. Seto- *McGrmvHill* .
2. Theory and Practice of mechanical vibrations - J. S. Rao, K. Gupta - *New Age International Publications.*
3. Mechanical Vibrations - Den; Chambil, Hinckle
4. Mechanical Vibrations, J.P. Den Hartog, McGrawhill Book Company Inc.
5. Leonard Meirovitch, Introduction to Dynamics and Conti'oJ. *Wiley, New York,*
6. Leonard Meirovitch, Elements of Vibration Analysis. *McGrmv-Hill, New York,*
7. Leonard Meirovitch, Dynamics and Control of Structures. *Wiley, New York.* 4. Antony J. Pettofrezzo, Matrices and Transformations. Dover, New York.
8. Benson H. Tongue, Principles of Vibration. *Oxford University Press.*
9. W. Thomson, Theory of Vibrations with Applications, Second Edition, *Pearson Education*
10. Vibrations-BalakumarBalachandan, Edward Magrab, *CENGAGAE Learning.*

Course Code	Course/Subject Name	Credits
MEC604	**Thermal and Fluid Power Engineering[&]**	**4+1**

[&] Common with Automobile Engineering

Objectives

1. To study boilers, boiler mountings and accessories
2. To study utilization of thermal and hydraulic energy
3. To study gas turbine and its applications

Outcomes: Learner will be able to…

1. Identify utilities of thermal and hydraulic energy
2. Differentiate impulse and reaction turbines
3. Analyze performance of turbines

Module	Detailed Contents	Hrs.
01	**Steam Generators** Fire tube and Water tube boiler, Low pressure and high pressure boilers, once through boiler, examples, and important features of HP boilers, Mountings and accessories. Layout of a modern HP boiler. Equivalent evaporation of boilers. Boiler performance. Boiler efficiency	08
02	**Steam Nozzle and Turbines** Flow through steam nozzle-velocity at exit and condition for maximum discharge, nozzle efficiency **Steam Turbine-** Basic of steam turbine, Classification, compounding of turbine, Impulse turbine – velocity diagram. Condition for max efficiency. Reaction turbine - velocity diagram, degree of reaction, Parson's turbine. Condition for maximum efficiency	10
03	**Impact of Jets and Water Turbines** Impact of jet on flat and curved plates Types of hydro turbines - impulse and reaction, definition of various turbine parameters like gross head, discharge, work done, input power, output power, efficiencies etc., Eulers' equation applied to a turbine, turbine velocities and velocity triangles, expression for work done. **Pelton Turbine:** Components of Pelton turbine, definition of design parameters like speed ratio, jet ratio, and estimation of various parameters like head, discharge, and efficiency etc., determination of number of buckets. **Reaction Turbines:** Types of reaction turbines - inward and outward flow, radial mixed and axial; elements of the turbine, estimation of various parameters.	10
04	Similarity relations in turbines, definition of unit quantities and specific quantities, selection of turbines. Prediction of results of prototypes from the model test. Cavitations in turbines - causes, effects and remedies, Thoma's cavitations parameter G. Use of G v/s specific speed graphs. Determination of safe height of installation for the turbine. Characteristics of turbines, governing of turbines.	06

05	**Gas Turbines** Applications of gas turbine, Actual Brayton cycle, open and closed cycle gas turbine, methods to improve efficiency and specific output, open cycle with intercooling, reheat, and regeneration. Effect of operating variable on thermal efficiency and work ratio,	08
06	**Jet Propulsion Engines** Classification of jet propulsion engines, Thrust, Thrust power, Propulsive efficiency and thermal efficiency, Afterburner, Introduction to Turbojet, Turbofan, Ram jet, Turboprop and Rocket engine	06

List of Experiments

1. Study/Demonstration of Boilers
2. Study/Demonstration of Boiler mountings and accessories
3. Study of Steam Turbine
4. Trial on Impulse turbine
5. Trial on reaction turbine
6. Study of gas turbines
7. Study of Jet propulsion engines
8. Visit to Thermal Power Plant/Hydroelectric Power Plant/Gas Turbine Power Plant

Term Work

Term work shall consist of minimum 6 experiments from the list, 3 assignments containing numerical based on maximum contents of the syllabus and a visit report

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. Practical Boiler Operation Engineering and Power Plant, A R Mallick, 3rd ed, PHI Learning
2. Thermal Engineering, Ballaney, Khanna Publishers, Reprint 1994
3. Thermal Engineering, Kothandraman, Domkundwar, Khajuria, Arora, Dhanpatrai& Sons.
4. Turbines, Compressors & Fans, S M Yahya, TMH
5. Thermal Engineering, R K. Rajput, Laxmi Publication
6. Steam and gas turbine, R Yadav
7. Fluid Mechanics and Hydraulic Machinery, Modi and Seth, Standard Book House
8. Hydraulic Machinery, JagdishLal
9. Hydraulic Machines, Vasandani
10. Fluid Mechanics and Machinery-B C S Rao, McGraw Hill
11. Fluid Mechanics and hydraulic Machines, Gupta, Pearson Education
12. Principles of Thermodynamics, H.A. Sorensen, Amerimal Publications, 1972.
13. Applied Thermodynamics for Engineers and Technologists, Eastop and Mcconky Longman,1978
14. Hydraulic Turbines - Nechleba

Course Code	Course/Subject Name	Credits
MEC605	**Mechatronics**	**4+1**

Objectives

1. To present architecture of the mechatronics system
2. To study various actuators applicable to Mechatronics system
3. To study interfacing of the electromechanical devices.

Outcomes: Learner will be able to…

1. Identify the suitable sensor and actuator for a mechatronics system
2. Develop the skill required for interfacing the electromechanical system
3. Indigenously design and develop a mechatronic system

Modules	Details	Hrs.
01	**1.1 Introduction to Mechatronics**. Key element of mechatronics. mechatronics systems in factory, home and business applications. Basic Components of mechatronics systems. Mechatronics Design process, objectives, advantages of mechatronics	05
02	**Actuators.** **2.1 Electrical Actuating systems** DC motors : Principles of operation of DC motor, Modelling of DC motor behavior, Heat dissipation in DC motor, Velocity Profile Optimization, Inertia matching, Servo Amplifier, DC motor service drive. Stepper Motors: Characteristics of a Stepper motor, Classification of a Stepper motor, Principle of Operation, Step Angle, Electrical model of energized coil, Drive method, Stepper motor performance, AC Induction motors: Three phase motor. **2.2 Voice coil actuator.**	08
03	**Actuators.** **3.1 Pneumatic and Hydraulic actuating systems** Components of pneumatic and hydraulic systems, pumps, compressor, filter, control valves, pressure regulation, relief valves, accumulator. **3.2 Harmonic drive, Comb drive.** **3.3 Piezoelectric drives.** **3.4 Selection of actuator**	08
04	**Development of circuits for industrial automation.** 4.1 Electro-pneumatic systems, Electro-hydraulic system, hydro-pneumatic system, Development of circuits for Industrial automation. **4.2 Programmable Logic Controller (PLC) in automation**: Basic structure, I/O processing. Ladder logic diagram, PLC for industrial process control, Selection of PLC.	08
05	**5.1 System Interfacing and Data Acquisition:** Data Acquisition systems (DAQs), data loggers, supervisory control and data acquisition, interfacing requirements, buffers, handshaking, polling and interrupt, digital communication, parallel communication, serial communication interface, universal asynchronous receiver and transmitter (UART), peripheral interface device (PIA), analog interfacing, Component interconnection and impedance matching, interfacing sensors and motor drives with microcomputer system.	10
06	**6.1 Mechatronics case studies:** Autonomous Mobile Root, Wireless Surveillance Balloon, Fire Fighting robots, Cantilever beam vibration control using piezo sensors and actuators, Car engine management, pick and place robot, automatic camera, CNC machine	09

List of Experiments

1. Study of basic principles of sensing and actuation techniques used in Mechatronics systems
2. Study of Electro-pneumatic Logic Trainer kit, and experiments on Electro-pneumatic circuits
3. Study of Electro-hydraulic Logic Trainer kit, and experiments on Electro-hydraulic circuits
4. Experiments on Ladder programming for Mechatronics system (e.g. bottle filling plant)
5. Experiments on interfacing of mechanical system
6. Experiment based on waveform generation, interfacing and control of motors etc.
7. System Identification of any one of the actuator
8. Experimental Identification by frequency response approach of Mechanical, Electrical, Chemical system
9. Development of transfer function based on experimentally identified data, Stability analysis of predicted transfer function, and PID tuning and implementation on experimental setup
10. Experimental identification of mechanisms such as flexural based systems etc.

(Design based experiments shall be encouraged using standard National Instrument/ texas instrument/ dSPACEGmbh/ Arduino or any other platform)

Note: Error analysis is recommended.

Course Project

In course project students shall integrate and apply the knowledge gained during the course. The projects shall be developed by team of maximum four students. Further, course project shall demonstrate design, setup, and implementation of a simple mechatronics system.

Term Work

Term work shall consist of minimum 6 experiments from the list, one assignment on first three modules, one each on module 4 and module 5 respectively and a report on course project

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

- Laboratory work (Experiments) **:** **10 marks**
- Assignments : **05 marks**
- Course project: **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. Mechatronics, Kenji Uchino and Jayne R. Giniewicz, publication: Marcel Dekker, Inc.
2. Applied Mechatronics- A. Smaili and F. Mrad, *OXFORD university press.*
3. Mechatronics System Design , Shetty and Kolk, *Cengage Learning, India Edition*
4. Introduction to Mechatronics and Measurement Systems, Alciatore and Histand*Tata McGraw-Hill*
5. Mechatronics,Necsulescu, *Pearson education.*
6. Mechatronics - Electromechanics and Control Mechanics , Mill *Springer-Verlag*
7. Mechatronics - Electronic Control Systems in Mechanical Engineering , Bolton *Pearson eduaction*
8. Mechatronics - Electronics in products and processes , Bradley, et al. *Chapman and Hall*
9. Mechatronics - Mechanical System Interfacing , Auslander and Kempf, *Prentice Hall*
10. Introduction to Mechatronics, AppuKuttan K.K., *OXFORD Higher Education*
11. Pneumatic Circuits and Low Cost Automation: by Fawcett J.R.
12. The Art of Electronics, Horowitz and Hill Cambridge, *University Press*
13. Electromechanical Design Handbook , Walsh, *McGraw-Hill*
14. Electro-mechanical Engineering - An Integrated Approach , Fraser and Milne
15. Handbook of Electromechanical Product Design , Hurricks Longman, John Wiley, *Addison Wesley*
16. Principles and Applications of Electrical Engineering , Rizzoni, *Irwin Publishing*
17. Understanding Electro-Mechanical Engineering - An Introduction to Mechatronics , Kamm*IEEE*
18. Modeling and control of Dynamic Systems, Macia and Thaler, *Cengage Learning, India Edition*
19. Mechatronics, A. Smaili, F. Mrad, *OXFORD Higher Education.*
20. Pneumatic and Hydraulic Control Systems: Aizerman. M.A.
21. Industrial Hydraulics: Pippenger
22. Vickers Manual on Hydraulics
23. Computer Numerical Control of Machine Tools: Thyer. G.R.
24. Pneumatic Applications: Deppert Warner & Stoll Kurt
25. Mechanization by Pneumatic Control: Vol. 1 & 2 Deppert Warner & Stoll kurt
26. Hydraulics and Pneumatics for Production: Stewart
27. Hydraulic Valves and Controls: Pippenger
28. Fundamentals of pneumatics: Festo series
29. Automatic Control Engineering: Francis. H. Raven.
30. Mechatronics, NitaigourMahalik, *Tata McGraw-Hill*
31. Mechatronics, *HMT*
32. *System Identification*: Theory for the User (2nd Edition) , Lennart Ljung
33. Design with Microprocessors for Mechanical Engineers, Stiffler*McGraw-Hill*

Course Code	Course/Subject Name	Credits
MEC606	**Finite Element Analysis[&]**	**3+1**

[&] Common with Mechanical Engineering

Objectives

1. To introduce the concepts of Mathematical Modeling of Engineering Problems.
2. To study the applicability of FEM to a range of Engineering Problems.
3. To acquaint with applications of numerical techniques for solving problems.

Outcomes: Learner will be able to…

1. Solve ordinary and partial differential equations using the Galerkin method.
2. Develop the finite element equations to model engineering problems governed by 2nd order partial differential equations.
3. Apply the basic finite element formulation techniques to solve engineering problems.
4. Use commercial FEA software, to solve problems related to mechanical engineering.

Module	Detailed Contents	Hrs.
01	**Introduction** 1.1 Introductory Concepts: Introduction to FEM, Historical Background, General FEM procedure. Applications of FEM in various fields. Advantages and disadvantages of FEM. 1.2 Mathematical Modeling of field problems in Engineering, Governing Equations, Differential Equations in different fields. 1.3 Approximate solution of differential equations-- Weighted residual techniques, Least squares, Galerkin methods, Boundary Value problems.	06
02	**FEA Procedure** 2.1 Discrete and continuous models, Weighted Residual Methods – Ritz Technique – Basic concepts of the Finite Element Method. 2.2 Definitions of various terms used in FEM like element, order of the element, internal and external node/s, degree of freedom, primary and secondary variables, boundary conditions. 2.3 Minimization of a functional. Principle of minimum total potential. Piecewise Rayleigh-Ritz method. Formulation of "stiffness matrix"; transformation and assembly concepts.	06
03	**One-Dimensional Problems** 3.1 One Dimensional Second Order Equations – Discretization – Element types- Linear and Higher order Elements – Derivation of Shape functions and Stiffness matrices and force vectors. 3.2 Assembly of Matrices - solution of problems in one dimensional structural analysis, heat transfer and fluid flow (Stepped and Taper Bars, Fluid Network, Spring-Cart systems) 3.3 Analysis of Plane Trusses, Analysis of Beams. 3.4 Solution of one Dimensional structural and thermal problems using FE Software, Selection of suitable Element Type, Modeling, Meshing, Boundary Condition, Convergence of solution, Result analysis, Case studies.	06
04	**Two Dimensional Finite Element Formulations** 4.1 Introduction, Three nodded triangular element, four nodded rectangular element, four nodded quadrilateral element, eight nodded quadrilateral element. 4.2 Natural coordinates and coordinates transformations: serendipity and Lagranges methods for deriving shape functions for triangular and quadrilateral element 4.3 Sub parametric, Isoperimetric, super parametric elements. Compatibility, Patch Test, Convergence criterion, Sources of errors.	06

05	**Two Dimensional Vector Variable Problems** 5.1 Equations of elasticity – Plane stress, plane strain and axisymmetric problems. 5.2 Jacobian matrix, stress analysis of CST and four node Quadratic element 5.3 Solution of 2-D Problems using FE Software (structural and Thermal), selection of element type, meshing and convergence of solution. (Can be covered during practical hours).	06
06	**Finite Element Formulation of Dynamics and Numerical Techniques** 6.1 Applications to free vibration problems of rod and beam. Lumped and consistent mass matrices. 6.2 Solutions Techniques to Dynamic problems, longitudinal vibration frequencies and mode shapes. Fourth Order Beam Equation, Transverse deflections and Natural frequencies of beams. 6.3 Finding frequencies of beam using FE Software (Can be covered during practical hours).	06

List of Assignment

Students should use the commercial software or programmes from the text-books or self-developed programs, to verify the results obtained by manual calculations. The input data and output results of the problem solved using the computer programs should be included in the Journal. The proposed list is as given below;

1 Any two problem using bar element
2 Any two problems using truss element
3 Any two problems using CST element
4 Any one problem using axisymmetric element
5 Any one problem of free vibration analysis using bar element
6 Any one problem on Steady State Heat conduction.

Course Project

A group of not more than four (04) students, shall do Finite Element Analysis of any mechanical engineering element/system, which involves element selection, assigning properties, meshing, assigning loads and boundary conditions, analysis and result interpretation.

Term Work

Term work shall consist of minimum **06** assignments and course project. The distribution of marks for term work shall be as follows:

- Laboratory work (experiments/assignments): 10 Marks.
- Course project: 10 Marks.
- Attendance: (Theory and Practicals): 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.

Practical/Oral examination

1. Practical examination duration is 2 hours.
2. Assignment for the examination shall be based on the list of assignment mentioned in the term work.
3. The distribution of marks for practical/oral examination shall be as follows:
   i. Practical performance: 15 marks
   ii. Oral: 10 marks
4. Evaluation of practical examination to be done based on the experiment performed and the output of the experiments during practical examination.
5. 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. Seshu. P. "Textbook of Finite Element Analysis" Prentice Hall of India, 2003.
2. J.N. Reddy, "Finite Element Method" Tata McGraw Hill, 2003.
3. Chandrupatla and Belegundu, "Introduction to Finite Elements in Engineering" PHI / Pearson Education, 2003.
4. Logan. D.L. "A first course in Finite Element Method", Thomson Asia Pvt. Ltd., 2002.
5. Cook R.D., Malkus. D.S. Plesha, ME., "Concepts and Applications of Finite Element Analysis", John – Wiley Sons 2003.
6. S.S. Rao, "The Finite Element Method in Engineering "Butter worth Heinemann, 2001.
7. M. Asghar Bhatti, " FUNDAMENTAL Finite Element Analysis and Applications with Mathematica and MATLAB Computations", Wiley India Pvt. Ltd.

Course Code	Course/Subject Name	Credits
MEC701	**Machine Design- II**	**4+1**

Objectives

1. To study functional and strength design of important machine elements
2. To study selection of rolling element bearing and design of hydrodynamic bearing.

Outcomes: Learner will be able to…

1. Select appropriate gears for power transmission on the basis of given load and speed.
2. Design gears based on the given conditions.
3. Select bearings for a given applications from the manufacturers catalogue.
4. Select and/or design belts for given applications.
5. Design cam and follower and clutches

Modules	Detailed Content	Hrs.
01	Design of spur, helical, bevel and worm gears with strength, wear and thermal considerations. Two stage Gear box with fixed ratio consisting of spur, helical and bevel gear pairs: gear box housing layout and housing design.	**16**
02	Types of bearing and designation, Selection of rolling contact bearings based on constant / variable load & speed conditions (includes deep groove ball bearing, cylindrical roller, spherical roller, taper roller, self aligning bearing and thrust bearing).	**05**
03	Design of hydro dynamically lubricated bearings (Self contained) Introduction to hydro static bearings Types and selection of Mechanical Seals	**05**
04	Design of cam and roller follower mechanisms with spring and shaft.	**06**
05	Design and selection of Belts:- Flat and V belt with Pulley construction. Design and selection of standard roller chains.	**08**
06	Design of single plate, multiplate and cone clutches, with spring, lever design and thermal, wear considerations.	**08**

Term Work

Term work shall comprise of

1. Exercises on the above topics in the form of design calculations with sketches and or drawings.
2. Design and detailed assembly drawing of minimum two design problems, from the module 1, 4, 5 and 6. (Computer aided drawing on **A- 3 size sheets).**
3. **Course project**: Students in a group of two to four will be able to design and prepare working drawings of any system having minimum 5 to 6 components by applying the knowledge gained during the course.

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

- Exercises & Drawing Sheets : 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.

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 **<u>03</u>** 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 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

Course Code	Course/Subject Name	Credits
MEC801	**Design of Mechanical Systems**	**4+1**

Objectives

1. To study system concepts and methodology of system design.
2. To study system design of various systems such as snatch block, belt conveyors, engine system, pumps and machine tool gearbox.

Outcomes: Learner will be able to…

1. Design material handling systems such as hoisting mechanism of EOT Crane, belt conveyors.
2. Design engine components such as cylinder, piston, connecting rod and crankshaft from system design point of view.
3. Design pumps for the given applications.
4. Prepare layout of machine tool gear box and select number of teeth on each gear.

Modules	Detailed Content	Hrs.
01	Methodology & Morphology of design. Optimum design, System concepts in design.	**04**
02	Design of Hoisting mechanism: Design of Snatch Block assembly including Rope selection, Sheave, Hook, Bearing for hook, cross piece, Axle for sheave and shackle plate, Design of rope drum, selection of motor with transmission system.	**10**
03	Design of belt conveyors-- Power requirement, selection of belt, design of tension take up unit, idler pulley.	**06**
04	Engine Design (Petrol & Diesel): Design of Cylinder, Piston with pin and rings, Connecting Rod & Crank Shaft with bearings.	**10**
05	**Design of pump :** **Design of main components of gear pump:** 1. Motor selection 2. Gear design 3. Shaft design and bearing selection 4. Casing and bolt design 5. Suction and delivery pipe. **Design of main components of centrifugal pump:** 1.Motor selection 2. Suction and delivery pipe 3.Design of Impeller, Impeller shaft, 4. Design of Volute casing.	**10**
06	Design of gear boxes for machine tool applications (Maximum three stages and twelve speeds): Requirements of gear box, determination of variable speed range, graphical representation of speeds, structure diagram, ray diagram, selection of optimum ray diagram, estimation of numbers of teeth on gears, deviation diagram, layout of gear box.	**08**

Term Work

Term work shall comprise of

1. Exercises on the above topics in the form of design calculations with sketches and or drawings.
2. Design and detailed assembly drawing (Computer aided drawing on **A- 3 size sheets**) of minimum two design problem, from the module 2, 3 and 5.
3. **Course project**: There will be a course project where the students will be able to apply and integrate the knowledge gained during the course. The projects will be developed by teams of Two to Four students and will consist of design of any system studied during the course.

The distribution of term work marks shall be as follow:

- Exercises & Drawing Sheets : 15 Marks
- Course Projects : 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.

Note

Use of standard design data books like PSG Data Book , Design Data by Mahadevan, Engine Design data book by Kale & Khandare are permitted at the examination and shall be supplied by the college.

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

Students will be given small task of design which may be the part of term work, which will be assessed by examiners and 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 reportto 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) Shigley J.E. and Mischke C.R., "Mechanical Engineering Design", McGraw Hill Pub. Co. Ltd.
2) M.F.Spotts – 'Mechanical design analysis' Prentice Hall Inc.
3) Bhandari V.B., "Design of Machine Elements", Tata McGraw Hill Pub. Co. Ltd.
4) Black P.H. and O. Eugene Adams, "Machine Design", McGraw Hill Book Co. Inc.
5) "Design Data", P.S.G. College of Technology, Coimbatore.
6) I.S. : 2825 Code for unfired pressure vessels.
7) Johnson R.C., "Mechanical Design Synthesis with Optmisation Applications", Von-Nostrand-Reynold Pub.
8) Dieter G.E., "Engineering Design", McGraw Hill Inc.
9) S.K. Basu and D.K. Pal – 'Design of machine tools', Oxford and IBH Pub. Co.
10) N.K.Mehta – 'Machine tool design' Tata McGraw Hill Pub. Co.
11) S.P. PATIL – 'Mechanical System Design' JAICO students Ed., JAICO Publishing House, Delhi
12) Rudenko – 'Material Handling Equipment' M.I.R. publishers, Moscow

Course Code	Course/Subject Name	Credits
MEC802	**Industrial Engineering and Management**	**4+1**

Objectives

1. To introduce the students to the concept of integration of various resources and the significance of optimizing them in manufacturing and allied Industries.
2. To acquaint the students with various productivity enhancement techniques.
3. To introduce the concepts of various cost accounting and financial management practices as applied in industries.

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

1. Illustrate the need for optimization of resources and its significance in manufacturing industries, in order to enhance overall productivity.
2. Develop capability in integrating knowledge of design along with other aspects of value addition in the conceptualization and manufacturing stage of various products.
3. Demonstrate the concept of value analysis and its relevance.
4. Manage and implement different concepts involved in methods study and understanding of work content in different situations.
5. Describe different aspects of work system design and facilities design pertinent to manufacturing industries.
6. Identify various cost accounting and financial management practices widely applied in industries.

Modules	Detailed contents	Hrs.
01	**Introduction to Industrial Engineering.** History and contribution, Industrial engineering approach, techniques of industrial engineering, objectives of industrial engineering, system approach to industrial engineering, definition and concept of productivity, productivity measurements, factors influencing productivity and productivity improvement techniques.	**06**
02	**Value Engineering and Value Analysis:** Distinction between value engineering & value analysis and their significance. Steps in value engineering & analysis and Check lists.	**05**
03	**Work study:** Method study, micro-motion study and principles of motion economy. Work measurement: time study, work sampling, standard data, PMTS; MOST.	**10**
04	**Work system design:** Introduction to ergonomics and its scope in relation to work. Outline of the discipline of anatomy, physiology and psychology, with respect to ergonomics building blocks such as anthropometry and biomechanics. Job evaluation, merit rating, incentive schemes, wage administration and business process reengineering.	**08**
05	**5.1 Facility Design:** Facility location factors and evaluation of alternate locations; types of plant layout and their evaluation; computer aided layout design techniques; assembly line balancing; materials handling systems. 5.2 **Concepts of Group Technology and cellular manufacturing**	**09**

06	**6.1 Cost accounting:** Elements of cost, cost sheet, job costing and marginal costing. **6.2 Financial management:** Methods of depreciation, time value of money and techniques for evaluation of capital investments. Introduction to financial statements only.	**10**

Term Work

Term work shall consist of

1. One seminar presentation on a topic selected from the syllabus, with its significance explained as in a live situation in the industry, as applicable.
2. Assignments: On topics drawn from syllabus [At least 1 assignment per module].
3. Course Project: One Case study on value analysis of a live component from industry in a group of not more than 3 students.

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

- Laboratory work (Experiment/ programs and journal): 10 marks
- Course Project: 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 Work study, ILO, Geneva, and Oxford & IBH Pub. Co. Pvt. Ltd.
2. Ergonomics at Work, Murrell.
3. Plant Layout and Material Handling, James M. Apple, John Wiley & Sons.
4. Facility Layout and Location – An Analytical Approach, Richard L. Francis & John A. White, Prentice Hall.
5. Production Systems Planning Analysis & Control, James L. Riggs, John Wiley & Sons.
6. Modern Production / Operations Management, Elwood S. Buffa, Rakesh K. Sarin, John Wiley & Sons.
7. Production Planning and Control, Samuel Elion.
8. Production and Operations Management, Joseph G. Monks

Course Code	Course/Subject Name	Credits
MEC803	**Refrigeration and Air Conditioning**	**4+1**

Objectives

1. To study working and operating principles of Vapour Compression and Vapour Absorption system
2. To study components of refrigeration and air conditioning systems
3. To Design air conditioning systems using cooling load calculations.

Outcomes: Learner will be able to…

1. Discuss fundamental refrigeration and air conditioning principles
2. Identify and locate various important components of the refrigeration and air conditioning system
3. Illustrate various refrigeration and air conditioning processes using psychometric chart
4. Design and analyze complete air conditioning system

Module	Detailed Contents	Hrs.
01	**Introduction to Refrigeration:** Methods of refrigeration, First and Second Law applied to refrigerating machines, Carnot refrigerator, Carnot heat pump, unit of refrigeration, Co-efficient of Performance, Energy Efficiency Ratio (EER), BEE star rating **Air refrigeration systems:** Bell Colemon cycle, applications. **Aircraft air refrigeration systems:** Need for aircraft refrigeration, Simple, Bootstrap including evaporative cooling, Reduced ambient, Regenerative air cooling system, Comparison of these systems based on DART rating.	08
02	**Vapor Compression Refrigeration System:** Simple vapor compression cycle, Effect of liquid subcooling & superheating, effect of evaporator and condenser pressures, methods of subcooling, use of P-h charts, Actual VCR cycle, Two stage VCR cycle with Water intercooler, flash intercooler & liquid sub-cooler, multi-evaporators at different temperatures with individual/compound compressors and individual/multiple expansion valves. Types of condensers, evaporators, expansion devices and Compressors. Use of enhanced surface tubes in Heat Exchangers. Cooling tower: Types of cooling towers, tower approach, tower range, tower efficiency, tower losses, tower maintenance. **Refrigerants**- Desirable properties of refrigerants, ASHRAE numbering system for refrigerants. Thermodynamic, Chemical and Physical properties. Secondary refrigerants, ODP and GWP, Montreal protocol and India's commitment, Recent substitutes for refrigerants.	12
03	**Vapor Absorption Refrigeration.** Importance of VAR system, COP of ideal VAR system, Amonia-water VAR system, Lithium Bromide – Water VAR system, Single and double effect, Electrolux refrigeration system. Solar VAR system. **Nonconventional Refrigeration Systems** : Thermoelectric Refrigeration, Thermoacoustic Refrigeration, Vortex Tube Refrigeration	06

04	**Psychrometry** Need for air conditioning, Principle of psychromerty, Psychrometric properties, chart and processes, air washers, requirements of comfort air conditioning, summer and Winter Air conditioning.	05
05	**Design of air conditioning systems** Different Heat sources,- Adiabatic mixing of two air streams, Bypass factor, sensible heat factor, RSHF, GSHF, ERSHF, Room apparatus dew point and coil apparatus dew point, Ventilation and infiltration, Inside and Outside Design condition, Cooling Load estimation , Introduction to Unitary Products viz. Room/Split and Packaged Air Conditioners, Introduction to recent developments viz. Variable Refrigerant Flow systems, VAV control systems, Inverter Units. Human Comfort, Thermal exchange of body with environment, Effective temperature, Comfort chart, Comfort zone.	08
06	**Duct Design and Applications** Friction chart for circular ducts. Equivalent diameter of a circular duct for rectangular ducts, Static pressure regain and equal pressure drop methods of duct design,Factors considered in air distribution system, Air distribution systems for cooling & heating, Controls – LP/HP cutoff, Thermostats, Humidistats, Interlocking control, Electronic Controllers. Applications Refrigeration & A/C Ice plant – food storage plants – diary and food processing plants, Food preservation ,Freeze Drying, A/c in textile ,printing pharmaceutical industry and Hospitals , Liquefaction of LNG, Liquefaction of gases (cryogenics), Deep sea water air-conditioning.	09

List of Experiments

1. Study of domestic refrigerator along with wiring diagram
2. Study of the procedure of leak detection, evacuation and charging of refrigerant
3. Trial on window air conditioner or Air Conditioning Test Rig
4. Trial on water cooler or Refrigeration Test Rig
5. Trial on cooling tower
6. Study of humidification and dehumidification, heating and cooling, mixing of two air streams.
7. Report on different protocols to regulate global warming
8. Visit report- Refrigeration establishment like Cold storage plant or ice plant or air-conditioning plant
9. Steady state Simulation of VCR system with developed code or any analytical software

Term Work

Term work shall consist of minimum **six** experiments, assignments consisting numerical based on above syllabus, at least 3 numerical from each module.

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

- Laboratory work **: 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.

Practical/Oral examination

1. Practical examination shall be conducted in a group of not more than 5 students. Examination shall be based on actual trials performed during the semester. Students are expected to actually take reading and plot the performance characteristics and comment.
2. Examiners are expected to evaluate results of each group and conduct oral based on the curriculum of the course.
3. The distribution of marks for practical/oral examination shall be as follows:
    i. Practical performance …… 15 marks
    ii. Oral …… ……. .10 marks
4. 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. Refrigeration and air-conditioning – C P Arora, *TMH*
2. Principles of refrigeration – R J Dossat, *Willey Eastern Publication*
3. Refrigeration and air-conditioning – W F Stoker and J W Jones, *TMH*
4. Modern Air-conditioning practice – C P Arora, *TMH*
5. Refrigeration and air-conditioning- Manohar Prasad, *New Age Int (P) Ltd.*
6. Basic Refrigeration and air-conditioning- P.Ananthanarayana, TMH
7. ASHRAE Handbook of Fundamentals
8. ASHRAE Handbook of Systems
9. ASHRAE Handbook of Equipment
10. ISHRAE Air Conditioning Handbook
11. ISHRAE Refrigeration Handbook

Course Code	Course/Subject Name	Credits
MEE8021	**Micro Electro Mechanical Systems (MEMS)**	**3+1**

Objectives

1. To acquaint with micro electro mechanical systems.
2. To study fabrication methodology, modelling and simulation and characterization techniques of MEMS system

Outcomes: Learner will be able to…

1. Illustrate working and importance of MEMS system
2. Describe fabrication methodology of MEMS system
3. Illustrate Modeling and Simulation Techniques of MEMS system
4. Describe Characterization Techniques of MEMS system

Module	Details	Hrs.
01	**Introduction to MEMS & Applications** • Introduction to Micro-Electro-Mechanical Systems, • Applications and Materials, • Advantages & Disadvantages of Micro-sensors, and micro-actuators.	03
02	**Sensors and Actuators in Micro-domain** • Concept of Sensors & Actuators, • Sensing & Actuation Principles: Mechanical Sensing, Capacitive, • Electrostatic, Electromagnetic, Piezo Resistive, Piezo Electric, Thin Films, Shape Memory Alloys • Comb Drive Actuation & Sensing. Micro-mechanisms, Air-Bag Sensors, Chemical Sensors • Sensors & Actuators for Automotive, Biomedical, Industrial applications • Design of sensor and actuator for few applications such as automobile accelerometer, bimetallic temperature sensor, etc.	06
03	**Fabrication Methods** Microfabrication Methods (VLSI Techniques) • Positive and Negative Photoresists, • Bulk Micromachining, • Surface Micromachining, • Etching (Isotropic and Anisotropic), • Deposition techniques such as CVD (Chemical Vapor Deposition),Metallization Techniques. 3D High Aspect Ratio Techniques • LIGA,AMANDA, • Microstereolithography, • IH-Process, • X-Ray Techniques, • Ion-beam Lithography, Bulk Lithography (layer-less 3D microfabrication)	09
04	**Modelling and Simulation Techniques** • Scaling Laws, Governing Equations • Modelling of Mechanical Structures via classical methods, Newtons Laws, Thermal Laws, Fluid Flow Analysis • Micro-mechanism modelling and analysis techniques : Lumped Parameter Modelling and Distributed Parameter Modeling • Modelling of Micro-channel as heat exchanger, accelerometers, microhinges, compound microstructures. • Numerical Methods used for MEMS analysis.	08

05	**Characterization Techniques** **Topography Methods** (Optical, Electrical and Mechanical Methods) • Microscopy, STM (Scanning Tunneling Microscopes), • SEM (Scanning Electron Microscopes), AFM (Atomic Force Microscopes) **Mechanical Structure Analysis** • Deformation & Vibration Measurement Techniques (Piezo resistive and piezo electric) **Interferometry Techniques,** • ESPI (Electronic Speckle Pattern Interferometry), • Laser Techniques, Laser Doppler Vibro-meters, **Fluid, Thermal and Chemical Techniques** • Fluid Flow Pattern Analysis, Electro-chemical Analysis, • PIV Techniques • Spectroscopy	06
06	**Introduction to Nanotechnology** • CNT (Carbon Nano Tubes) Applications, its properties, and Fabrication Method, • Nano-mechanical Systems (NEMS), • Nano-tribology, & nano-indentation techniques, • Domestic and Industrial Applications of nanotechnology	04

Term Work

Term work shall consist of 06 design based assignment (one assignment on each module) and two case studies of MEMS.
(Design based assignment shall encourage use of recent literature for the development of MEMS or microstructure.)

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

- Assignments : 15 Marks
- Case studies : 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.

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. Julian W. Garden, Vijay K. Varadan and Osama O. Awadelkarim “Microsensors MEMS and Smart devices”, John Wiley and sons, Ltd.
2. NadimMulaf and Kirt Williams, “An Introduction to Microelectromechanical systems Engineering”, Artech House.
3. NicolaeLobontiu and Ephrahim Garcia, “Mechanics of Microelectromechanical systems”, Kluwer Academic Publication.
4. Stanley Wolf and Richard Tauber, “Silicon Processing for the VLSI era Volume -1 Technology”, Lattice press.
5. Vijay K. Varadan, K.J.Vinoy and S. Gopalkrishnan, “Smart Material Systems and MEMS: Design and Development Methodologies”, John Wiley and sons Ltd.
6. Bhushan, “Springer Handbook of Nanotechnology”, Springer Inc.

Course Code	Course/Subject Name	Credits
MEE 8022	**Renewable Energy Sources**	**3+1**

Objectives

1. Study working principles of various renewable energy sources and their utilities
2. Study economics of harnessing energy from renewable energy sources

Outcomes: Learner will be able to…

1. Demonstrate need of different renewable energy sources and their importance
2. Calculate and analyse utilization of solar and wind energy
3. Illustrate design of biogas plant
4. Estimate alternate energy sources India

Module	Detailed Contents	Hrs.
01	**Introduction to Energy Sources**: Renewable and non-renewable energy sources, energy consumption as a measure of Nation's development; strategy for meeting the future energy requirements Global and National scenarios, Prospects of renewable energy sources.	04
02	**Solar Energy**: Solar radiation - beam and diffuse radiation, solar constant, earth sun angles, attenuation and measurement of solar radiation, local solar time, derived solar angles, sunrise, sunset and day length. flat plate collectors, concentrating collectors, Solar air heaters-types, solar driers, storage of solar energy-thermal storage, solar pond , solar water heaters, solar distillation, solar still, solar cooker, solar heating & cooling of buildings, photo voltaic - solar cells & its applications.	06
03	**Wind Energy**: Principle of wind energy conversion; Basic components of wind energy conversion systems; wind mill components, various types and their constructional features; design considerations of horizontal and vertical axis wind machines: analysis of Aerodynamic forces acting on wind mill blades and estimation of power output; wind data and site selection considerations.	08
04	**Energy from Biomass**: Biomass conversion technologies, Biogas generation plants, classification, advantages and disadvantages, constructional details, site selection, digester design consideration, filling a digester for starting, maintaining biogas production, Fuel properties of bio gas, utilization of biogas.	06
05	**Geothermal Energy**: Estimation and nature of geothermal energy, geothermal sources and resources like hydrothermal, geo-pressured hot dry rock, magma. Advantages, disadvantages and application of geothermal energy, prospects of geothermal energy in India. **Energy from the ocean**: Ocean Thermal Electric Conversion (OTEC) systems like open cycle, closed cycle, Hybrid cycle, prospects of OTEC in India. Energy from tides, basic principle of tidal power, single basin and double basin tidal power plants, advantages, limitation and scope of tidal energy. Wave energy and power from wave, wave energy conversion devices, advantages and disadvantages of wave energy	08
06	**Energy Management**: Energy economics, energy conservation, energy audit, general concept of total energy system, scope of alternative energy system in India.	04

List of Experiments

1. Demonstration of solar collector for air/water heating
2. Visit to wind farm/biogas plant

Term Work

Term work shall consist of experiments from the list, 5 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) **:** **05 marks**
- Assignments : **10 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. Non-conventional energy sources by G.D. Rai, Khanna Publishers
2. Solar Energy: Principles of Thermal Collection and Storage by S,P Sukhatme, Tata McGraw Hill
3. Solar Engineering of Thermal processes, J.A.Duffie and W.A.Beckman, 2nd edition, John Wiley, New York, 1991.
4. Fuel Cells by Bockris and Srinivasan; McGraw Hill.
5. Solar Energy: Fundamentals and Applications by H.P. Garg& Jai Prakash, Tata McGraw Hill.
6. Wind Power Technology, Joshua Earnest, PHI Learning, 2014
7. Non Conventional Energy Resources by S. Hasan Saeed and D. K. Sharma, S. K. Kataria& Sons.
8. Renewable Energy Sources, J W Twidell& Anthony D. Weir. ELBS Pub.
9. Energy Conversion Systems, R D Begamudre, New Age International (P) Ltd., Publishers, New Delhi ,2000.
10. Principles of Solar Engineering, D.Y.Goswami, F.Kreith and J.F.Kreider, Taylor and Francis, Philadelphia, 2000.
11. Solar Photovoltaics: Fundamentals, Technologies and Applications, C S Solanki, 2nd Edition, PHI Learning, 2013
12. Biomass Regenerable Energy, D. D. Hall and R. P. Grover, John Wiley, New York,1987.
13. Wind and Solar Power Systems, Mukund R Patel, CRC Press, 1999.
14. Wind Energy Explained: Theory, Design and Application, J F Manwell, J.C.McGowan, A.L.Rogers, John Wiley and Sons, May 2002.
15. Magneto Hydrodynamics by Kuliovsky and Lyubimov, Addison.

Course Code	Course/Subject Name	Credits
MEE8023	**Project Management[&]**	**3+1**

[&] Common with Mechanical Engineering

Objectives

1. To familiarize the students with the use of a structured methodology/approach for each and every unique project undertaken, including utilizing project management concepts, tools and techniques.
2. To apprise the students with the project management lifecycle and make them knowledgeable about the various phases from project initiation through closure.

Outcomes: Learner will be able to..

1. Apply selection criteria and select an appropriate project from different options.
2. Write work break down structure for a project and develop a schedule based on it.
3. Identify opportunities and threats to the project and decide an approach to deal with them strategically.
4. Use Earned value technique and determine & predict status of the project.
5. Capture lessons learned during project phases and document them for future reference.

Module	Details	Hrs.
01	**Project Management Foundations** Definition of project management, project manager and project. Project types, project phases and knowledge areas.	**04**
02	**Initiating Projects** How to get a project started; Your project sponsor and creating charter; The project team and team dynamics; running meetings	**06**
03	**Planning Projects** Project estimating and scheduling techniques. PERT, CPM, GANTT chart. Introduction to any one project scheduling software.	**08**
04	**Planning Projects** Risk planning methods; Cost planning; Communication plan and Final project plan.	**04**
05	**Executing Projects** 5.1 Team management; communicating and engaging with all stakeholders of the projects. **Controlling Projects** 5.2 Earned Value Management techniques for measuring your work completed; Using milestones for measurement; change requests and scope creep. Keeping up with the project, Updating the project, Project Issues management and Dealing with troubled projects.	**08**
06	**Closing the Project** Customer acceptance; completing a final report; doing a lessons learned analysis; acknowledging successes and failures; Project management templates and other resources; Managing without authority; Areas of further study.	**06**

Term Work

Term work shall consist of,

1. Assignments: On topics drawn from syllabus [At least 1 assignment per module].
2. One scheduling exercise on any project management software where writing WBS and Scheduling on PMIS software for a simple project or a Case Study on project selection/ risk management.
3. Case Studies (at least 2 with inferences).

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

- Assignments: **10** marks
- Scheduling on PMIS software: **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. Project Management and Control,Narendra Singh; Himalaya Publishing House
2. Preparation, Appraisal, Budgeting, Implementing and Review, Prasanna Chandra TMGH
3. Project Management: A managerial approach, Jack Meredith & Samuel Mantel, Wiley India, 7th Ed.
4. Project Management, Dennis Lock, Gower Publishing England, 9th Ed.
5. Project Management, Gido Clements & Cengage Learning.
6. Project Management, Gopalan, Wiley India
7. Projects- Planning, Analysis, Selection, Financing, Implementation and Review, Prasanna Chandra, TMGH

Course Code	Course/Subject Name	Credits
MEE8024	**Business Process Reengineering (BPR)**	**3+1**

Objectives

1. To understand the role and need of Business Process Reengineering in an organization.
2. To develop an insight as to how BPR tool/techniques are used strategically for business excellence and for the betterment of an organization.

Outcomes: Learner will be able to..

1. Demonstrate the use of BPR practices in an organization to enhance its competitiveness and overall productivity.
2. Identify the need and when to implement BPR in an organization.
3. Develop an understanding of how BPR helps in aspects like customer focus, innovation and quality management in various organizations.

Module	Details	Hrs.
01	Introduction to BPR: Concept, Philosophy of BPR, Fundamental tenets of BPR, Benefits & pitfalls of BPR, myths of BPR and Drivers of BPR.	**05**
02	Process reengineering framework: Opportunity assessment, planning the process re-engineering project. Organizing for process reengineering.	**05**
03	3.1 Process analysis and design: a) Process analysis (b) Process design. 3.2 Planning and implementing the transition: Planning the transition, implementing the transition, tracking and measuring process performance.	**05**
04	Tools and techniques used in BPR: Case tools, Work flow systems, Imaging technology, Floware, Business design facility tools, and Change management tools. BPR in Manufacturing industry, BPR &ERP.	**08**
05	BPR implementation methodology, Success factors of BPR and Barriers to BPR. Risk and Impact measurement.	**06**
06	Change management in BPR: Introduction, Nature, process of change, Management of Change in BPR. Strategic aspects of BPR.	**07**

Term Work

Term work shall consist of assignments (at least one assignment per module), case discussion (at least 3) covering a cross section of strategic advantages to be gained by applying BPR tools and techniques and a seminar presentation based on the topics mentioned in syllabus.

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

- Assignments: **10** marks
- Seminar/ case discussion: **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. Process Re-engineering: The Key to Achieving Breakthrough Success, Lon Roberts, Amer Society for Quality.
2. Business Process Reengineering: Breakpoint Strategies for Market Dominance, Henry J. Johansson, Patrick McHugh, A. John Pendlebury, William A. Wheeler, Wiley.
3. Business Process Reengineering, R Radhakrishnan, S. Balasubramanian, PHI.
4. Business Process Reengineering And change management, B R Dey, Wiley.
5. Organizational transformation through BPR,Sethi, King, Pearson.
6. Business Process Management, Second Edition: Practical Guidelines to Successful Implementations, Johan Nelis, John Jeston, oxford.
7. Business Process Change,Paul Harmon, Morgn Kaufmann.
8. A Practical Guide to Business Process Re-Engineering, Mike Robson, Philip Hllah, Gower.

Course Code	Course/Subject Name	Credits
MEE8025	**Cryogenics**	**3+1**

Objectives

1. Study fundamental concepts of cryogenics
2. Study gas liquefaction and purification
3. Study operating in low temperature

Outcomes: Learner will be able to…

1. Explain historical developments in cryogenic systems
2. Describe gas liquefaction and purification systems/methods
3. Analyze system parameters and performance

Module	Detailed Contents	Hrs.
01	**Introduction to cryogenic systems** – Chronology of cryogenic technology & Present areas involving cryogenic engineering. **Low temperature properties of engineering materials**:-Mechanical, thermal and magnetic properties of cryogenic fluids	04
02	**Gas Liquefaction systems:** System performance parameters, Thermodynamically ideal systems, Liquefaction systems for Neon, Hydrogen & Helium, critical components of liquefaction systems. **Gas purification methods**:-Refrigeration purification, Physical adsorption.	06
03	**Cryogenic Refrigeration system**: Ideal Refrigeration systems, **Refrigerators for temperatures above 2K**:-Joule-Thomson refrigeration system, Expansion engine refrigeration system, Philips refrigerator, V-M refrigerator, Gifford-McMahon refrigerator, Regenerators, **Refrigerators for temperatures below 2K**:-Magnetic cooling, Magnetic refrigeration system	08
04	**Measurement systems for low temperature:** Introduction, Metallic resistance thermometer, semiconductor resistance thermometer, Thermocouples, Constant-volume gas thermometer, vapour pressure thermometer	06
05	**Liquid Level Measurement**: Hydrostatic gauges, Electric resistance gauges, Thermodynamic liquid level gauge	04
06	**Application of Cryogenics:** Cryogenic Fluid Storage systems, Insulations, Importance of vacuum technology in cryogenics, Application of cryogenics system, superconducting devices, Space Technology, Cryogenics in Biology and Medicine.	08

List of Experiments

1. Study of gas liquefaction and purification systems
2. Study of cryogenic refrigeration systems
3. Study of cryocoolers
4. Case study on applications of cryogenics
5. Visit report to gas liquefaction plant

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) **:** **10 marks**
- Assignments : **05 marks**
- Factory 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. Cryogenics Systems, R. Barron Oxford University Press
2. Cryo-Cooler: Fundamentals Part-I, G. Walker Plenum Press New York
3. Cryo-Cooler: Fundamentals Part-II, G. Walker Plenum Press New York
4. Cryogenic Engineering, T.M.Flynn , Marcel Dekker
5. Cryogenic: Application and progress, A.Bose and P.Sengupta, Tata McGraw Hill
6. Sterling cycle design manual, Martini W. NASA Report, 1978

Course Code	Course/Subject Name	Credits
MEE8026	**Automobile Engineering**	**3+1**

Objectives

1. Study basic principles of actual automobile systems
2. Study important systems in an automobile
3. Study recent and modern trends in automobile sector

Outcomes: Learner will be able to…

1. Demonstrate & explain various systems in an automobile
2. Describe importance and features of different systems like axle, differential, brakes, steering, suspension, wheel and balancing etc.
3. Explain principle of operation, construction and applications of various sensors used in modern automobile

Module	Detailed Contents	Hrs.
01	**Introduction** **Transmissions:** Necessity of gear box, Sliding mesh, Constant mesh, Synchromesh and epicyclic gear box, Overdrives and hydrodynamic torque converter, Trouble shooting and remedies. **Live axle and differential**: Final drive, spiral, bevel, Hypoid and worm drives, Types of live axles, semi, three quarter and full floating axles. Necessity of differential, Conventional and non-slip differential, Trouble shooting and remedies.	05
02	**Brakes** Requirement of brake, Classification of brakes, Mechanical, Hydraulic, Pneumatic, Electro and vaccum brakes. Disc brakes, Braking of front wheel, Rear wheel and four wheel brakes, Brake trouble shooting. Introduction to antilock braking system (ABS). **Steering and Front axles** Steering geometry, Steering requirements, Steering linkages and steering gears, over steer and under steer, Cornering power, Reversibility of steering gears, Types of front axles and their constructions. Trouble shooting and remedies.	06
03	**Suspension** Objects of suspension, Basic requirements, Air suspension and its features, Independent suspension, Forces acting in independent suspension, Sprung and un-sprung mass, Pitching, rolling and bouncing, Shock absorbers. **Wheels and Tyres** Requirements of wheels and tyres, Constructional features, Types of tyres, Inflation Pressure and its importance, Application to ride and stability, Trouble shooting and remedies.	07
04	**Electrical system** Battery: Types of battery, Lead-Acid, Alkaline, ZEBRA, Sodium Sulphur and Swing, Ratings, charging, Maintenance and testing of Lead-Acid battery. **Starting system**: Requirements, Various torque terms used, Starter motor drives; Bendix, Follo through, Barrel, Rubber compression, Compression Spring, Friction Clutch, Overrunning Clutch, Dyer. Starter motor solenoids and switches, Glow plugs. **Alternator:** Principle of operation, Construction, Working, Rectification from AC to DC.	06

05	**Body Engineering** Importance of Body design, Materials for body construction-Styling forms-Coach and bus body style, layouts of passenger cars, Bus and truck bodies. Aerodynamic drag - Aerodynamic lifts and pitching moments, Side force, Yawing moments and rolling moments. **Chassis types and structure types**: Open, Semi integral and integral bus structure.	06
06	**Recent trends in Automobiles** Electronic Control module (ECM), operating modes of ECM (closed loop and open loop) Inputs required and output signals from ECM, Electronic Spark control, Air Management system, Idle speed control. Construction, working & application of temperature sensors, inductive sensors, Position sensors (rotary, linear). Hot wire and thin film air flow sensors, vortex flow/turbine fluid sensors, Optical sensor, Oxygen sensors, Light sensors, methanol sensors ,Rain sensor, New developments in the sensor technology	06

List of Exercises

1. Dismantling and assembly of gear boxes.
2. Dismantling and assembly of brakes.
3. Dismantling and assembly of steering mechanisms.
4. Dismantling and assembly of rear axle and differential.
5. Dismantling and assembly of suspension systems
6. Demonstration of battery charging and starting systems.

Term Work

Term work shall consist of at least 3 exercises from the list with the report, case study presentation covering recent trends in automobile report and a report on automotive factory/service center visit.

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

- Laboratory work (Exercises) **:** **10 marks**
- Case study: **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. Automotive Mechanics, William Cruose& Donald L. Anglin, Tata Mcgraw Hill
2. Automotive Mechanics , Joseph Heitner, East-West press pvt .Ltd
3. The Automobile Engineering, T. R. Banga&Nathu Singh, Khanna Publishers
4. The Automobile, Harbans Singh Reyat, S. Chand & Co.
5. Automobile Engineering, R. K. Rajput, Laxmi Publication
6. Basic Automobile Engineering, C.P.Nakra, DhanpatRai Publishing CO.
7. Automobile Engineering, Kirpal Singh Vol I & II, Standard publishers Distributors ,Delhi
8. Automobile Engineering, K. K. Jain & R.B. Asthana, Tata Mcgraw Hill
9. Automotive Mechanics, S. Srinivasan, Tata Mcgraw Hill
10. Automobile Engineering, Vol I & II, R.K. Mohanty, Standard Book House
11. Automobile Electrical and Electronics, Tom Denton
12. Vehicle Body Engineering, J Pawlowski, Century publisher.
13. Computerised Engine Control, Dick King, Delmar publisher.
14. System Approach to Automobile Technology, Jack Erjavec, Cengage Learning
15. Light & Heavy Vehical technology, M. J. Nunney, Elsevier.

Subject Code	Subject Name	Credits
MEE8027	**Process Equipment Design**	**3+1**

Objectives

1. To acquaint with process of designing using codes
2. To study design of process equipment such as pressure vessel, storage tank, heat exchanger etc.

Outcomes: Learner will be able to…

1. Illustrate understanding of process design parameters.
2. Design and develop pressure vessels.
3. Demonstrate capabilities developed for designing storage tank, agitators.

Module	Detailed content	Hours
1	**Process Design Parameters** Introduction to Basic process requirement of plants and projects, Importance of codes and standards and their applications. P&ID, Process Data Sheet, PFD and other documents used for designing. Introduction to various design codes required in Process Equipment Design such as; ASME, Section VIII; API; ASTM; TEMA, etc. and their significance. Review of Design pressures, temperatures, design stresses, factor of safety, minimum shell thickness and corrosion allowance, weld joints efficiency, design loading, stress concentration and thermal stresses, failure criteria. Selection of material for process equipment's using ASME Codes.	06
2	**Design of Pressure Vessels** Types of pressure vessels, selection of various parameters for their design Pressure vessel subjected to Internal Pressure: Complete design as per ASME code of Cylindrical and spherical shells. Design of various end closures such as: Flat, Hemispherical, Torrispherical, Elliptical and conical. Design of openings : nozzles and manholes. Design of Flanged joints; Gasket selection and design Design of supports for process vessels. Pressure vessel subjected to External Pressure: Design of shell, heads, nozzles, flanged joints and stiffening rings. Design of Tall Vessels / Tall Columns: Determination of equivalent stress under combined loadings including seismic and wind loads application of it to vertical equipment like distillation column.	08
3	**Vessel Supports** Introduction and classification of supports. Design of skirt support considering stresses due to dead weight, wind load, seismic load and periodic vibration. Design of base plate, skirt bearing plate, anchor bolts. Design of Lug and bracket support.	06
4	**Design of Storage Tanks** Study of various types of storage vessels and applications. Atmospheric vessels, vessels for storing volatile and non-volatile liquids. Various types of roofs used in storage vessels. Manholes, nozzles and mounting design. Design of Rectangular tanks.	06
5	**Heat Exchangers** Heat exchangers: Design of vessels, Design of Shell and Tube Heat Exchanger, Study and design of various types of jackets like plain half coil, channel, limpet coil.	05

6	**Agitator** Study of various types of agitators and their applications. Baffling, Power requirement of agitation. General design of agitator including blades, shaft, blade assembly.	05

List of assignments

1. Explain types of process equipments (static and rotary)
2. Explain inspection and testing requirement for pressure vessel
3. Breifly explain design of storage tank
4. Discuss types of heat exchangers

Design assignment on pressure vessel: Design of shell, formed heads for internal and external pressure, flanges, supports of pressue vessel and preparation of general arrangement drawing and detailed fabrication drawing with bill of materials

Term Work

Term work shall consist of assignments from the list and design of pressure vessel with report containing working drawing.

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

- Assignment **:** **10 marks**
- Design assignment: **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. Dr. M.V. Joshi, “Process Equipment Design”, Mc-Millan
2. Browell and Young, “Process Equipment Design:, John Wiley
3. B.C. Bhattacharya, “Introduction to Chemical Equipment Design – Mechanical Aspects”, CBS Publications
4. Standard Codes such as: ASME SEC-VIII, Div I & II; ASTM; API; TEMA.

Course Code	Course/Subject Name	Credits
MEE 8028	**Alternative Fuels**	**3+1**

Objectives

1. Study various alternatives for conventional fuel used in SI and CI engines
2. Study electrically driven and solar driven vehicles

Outcomes: Learner will be able to…

1. Identify & explain future trends and development in IC engine fuel
2. Analyze engine performance using blended fuel
3. Explain working of electrical and solar powered vehicle

Module	Detailed Contents	Hrs.
01	Introduction: Working processes in I.C. engine, fuel efficiency, fuel requirement, ignition quality, volatility, sources of fossil fuels, scope of availability of fossil fuels, need for alternative fuels, engine life.	04
02	Alcohols: Sources, methanol & ethanol, production methods, properties of methanol & ethanol as engine fuels, Use of alcohols in S.I. & C.I. engines, performance of methanol & gasoline blends, alcohol diesel emulsions, dual fuel systems, emission characteristics.	06
03	Hydrogen: Properties of hydrogen with respect to its utilization as a renewable forms of energy, sources of hydrogen, production, transportation, storage, application & economics of hydrogen. Fuel Cells: Hydrogen, methanol fuel cells, power rating and performance. Heat dissipation, layout of a fuel cell vehicle.	08
04	Gaseous Fuel: L.P.G., C.N.G., bio-gas, their properties as engine fuels, fuel metering systems, combustion characteristics, effect on performance & emission, cost, safety.	06
05	Bio-Diesels: Jatropa oil, Karanji oil, Neem oil, Rice bran oil, Linseed oil, Sunflower oil, properties, diesel & biodiesel blends, engine performance.	06
06	Electric Vehicles: Layout of an electric vehicles, advantages & limitations, significations, systems components, electronic controlled systems, hybrid vehicles. Solar Power: Solar cells for energy collection, layout of solar powered automobiles	06

List of Experiments

1. Study of physical & chemical properties of fuels
2. Study of Ethanol Production, properties of ethanol as S.I. engine fuel
3. Study of Methanol Production, properties of methanol as C.I. engine fuel
4. Study of fuel cell and fuel cell powered vehicle
5. Trial on SI/CI engine using alternate gaseous fuel
6. Study of solar powered vehicle
7. Layout preparation for Hybrid vehicles.

Term Work

Term work shall consist of minimum 7 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) **:** **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. Introduction to Internal Combustion Engines, Richard Stone, McMillan, London
2. Internal Combustion Engines, Shyam Agrawal, New Age International
3. Internal Combustion Engines & Air Pollution, Edward F. Obert, Int. Text Book Co., Pennsylvania
4. Internal Combustion Engines, Litchty L. C., McGraw Hill Book Co., New Delhi.
5. Non Conventional Energy Sources, G. D. Rai, Khanna Publications, Delhi
6. H. P. Garg& J. Prakash, "Solar Energy", Tata McGraw Hill Pub. Co. Ltd., Delhi
7. Fuel Cells, Vishwanathan B and M AuliceScibioh, Universities Press, Hyderabad, India, 2006
8. Handbook of Hydrogen Storage: New Materials for Future Energy Storage, Hirscher, Michael, Weinheim : WILEY-VCH Verlag GmbH & Co. KGaA, 2009
9. Hydrogen fuel: Production, transport and storage, Gupta R B, Boca Raton, CRC Press, 2008
10. Energy Conversion Systems, R D Begamudre, New Age International (P) Ltd., Publishers, New Delhi ,2000.
11. Renewable Energy Resources, J. Twidell and T. Weir, Taylor and Francis (special Indian edition), 2006
12. Biofuels from Agricultural Wastes and Byproducts, Hans P. Blaschek, Thaddeus Ezeji, Jürgen Scheffran, Wiley Blackwell, 2010
13. Renewable Energy Engineering And Technology: Principles And Practice,V. V. N. Kishore (Editor), Earthscan Publications (Apr 2009)
14. Biofuels Engineering Process Technology, Caye M. Drapcho, Nghiem PhuNhuan, Terry H. Walker, McGraw Hill, 2008

Course Code	Course/Subject Name	Credits
MEE8029	**Enterprise Resource Planning**	**3+1**

Objectives

1. To help the students acquire the basic understanding of major enterprise wide business processes and their integration through IT enabled applications.
2. To develop a managerial perspective to leverage them for competitive advantage.

Outcomes: Learner will be able to…

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

Module	Details	Hrs.
01	**Process View of Organization** Introduction to functional areas and business processes, Functional areas and business processes of a very small business, Functional area information systems, Process modeling, Process improvement, ERP workflow tools, Implementing ERP systems, Implementation and change management.	**06**
02	**Approaches to process improvement** Managerial implications of Process Reengineering efforts, Kaizen, Total Quality Management, Implementing new process, Critical success factors of reengineering project and Comparison of different approaches.	**06**
03	**Introduction to Enterprise Resource Planning(ERP)** ERP - Introduction, Evolution of Enterprise applications, Reasons for the growth of the ERP market, Operational advantages of Enterprise Wide Applications, Failure of ERP packages, ERP packages, Enterprise application implementation projects: Rationale for ERP, Enterprise Architecture planning, Selection of an ERP vendor, Advantages of and problems in ERP implementation, Overview of ERP modules, ERP and related technologies.	**08**
04	**ERP – Manufacturing Perspective** Material requirement planning (MRP-I), closed loop MRP, Manufacturing Resource Planning (MRP-II), Distribution Requirements Planning and Product Data Management.	**04**
05	**Supply Chain and CRM Applications** Overview of Supply and demand chain, SCM framework, Advanced planning systems, Introduction to CRM applications and Growth of CRM Applications.	**05**
06	**Introduction to SAP R/3** SAP R/3 basics, Cross-Sectional analysis of other ERP systems with SAP R/3, SAP R/3 Client Server Architecture, Understanding SAP R/3 Business Process Reference Model and Business Process Integration on SAP R/3. Case studies of businesses, implementing IT enabled ERP systems.	**07**

Term Work

Term work shall consist of at least six assignments on concepts, case studies and analysis based on the topics mentioned above.

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

- Lab work (Case Studies: at least 2): **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. *Enterprise Resource Planning,* Alexis Leon, Tata McGraw Hill publication.
2. *Concepts in Enterprise Resource Planning*, Brady, Monk and Wagner, Thomson Learning.
3. *CRM at the speed of Light*, Greenberg, Paul, TMH.
4. *The E-Marketplace: Strategies for success in B2B commerce*, Raisch, Warren D, McGraw Hill inc.2000.
5. *ERP strategy*, Vinod Kumar Garg, Bharat Vakharia and Jaico.

Course Code	Course/Subject Name	Credits
MEE80210	World Class Manufacturing(WCM)[&]	3+1

[&] Common with Mechanical Engineering

Objectives

1. To familiarize the students with the concepts of Business excellence and competitiveness.
2. To apprise the students with the need to meet the current and future business challenges.
3. To prepare the students to understand the current global manufacturing scenario.

Outcomes: Learner will be able to..

1. Demonstrate the relevance and basics of World Class Manufacturing.
2. Identify the factors of competitiveness and performance measures based on which, global manufacturing success is bench marked
3. Draw current Status of Indian Manufacturing scenario and design and develop a roadmap to achieve world class manufacturing status.

Module	Details	Hrs.
01	**Historical Perspective** World class organizations: Meaning of world class. Competitiveness and Performance measures. Criteria for world class organizations in Manufacturing. Competing in World markets. Review of frameworks in World Class Manufacturing (WCM). Models for manufacturing excellence: Schonberger, Halls, Gunn & Maskell models and Business Excellence.	05
02	**Benchmark, Bottlenecks and Best Practices** Concepts of benchmarking, Bottleneck & best practices. Best performers, Gaining competitive edge through world class manufacturing, Value added manufacturing, Value Stream mapping, Eliminating different types of waste. Lean Thinking (Toyota Production System), Six Sigma, Theory of Constraints.	07
03	**System and Tools for World Class Manufacturing** Improving Product & Process Design: SQC, Statistical Process Control, Quality Function Deployment (QFD), Seven Basic Quality Tools, FMS, Poka Yoke, 5-S, Optimizing Procurement & stores practices, Total Productive maintenance and Visual Control.	07
04	**HR Dimensions in WCM – WCM Strategy Formulation** 4.1 Adding value to the organization: Organizational learning, techniques of removing Root cause of problems, People as problem solvers, New organizational structures. 4.2 Associates: Facilitators, Teams man ship, Motivation and reward in the age of continuous improvement.	05
05	**Characteristics of WCM Companies** Performance indicators like POP, TOPP and AMBITE systems. Other features of WCM : Supply Chain Management & key issues in SCM, Agile Manufacturing, Green Manufacturing, Role of Information system in WCM, Introduction to Knowledge management, Study of various performance measures in world class organization.	06
06	**Total Quality Management (TQM)** Definition, Understanding quality, Evolution of TQM, Framework for TQM, Commitment and leadership, Customer satisfaction, Employee involvement, Continuous process improvement, Supplier partnership, Performance measures, Formulation and implementation of TQM: Case Study.	06

Term Work

Term work shall consist of at least six assignments on topics drawn from the syllabus [1 assignment per module] and at least 3 case studies and analysis based on the topics mentioned above.

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

- Assignments: **10** marks
- Lab work (Case Studies: at least 3, with inferences): **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. World Class Manufacturing – Strategic Perspective, Sahay B.S., Saxena K B C and Ashish Kumar, Mac Milan Publications, New Delhi.
2. World Class Manufacturing - The Lesson of Simplicity, Schonberger R. J, Free Press, 1986
3. Management strategy: achieving sustained competitive advantage, Marcus, A. A.,New York: McGraw-Hill/Irwin, 2011.
4. Manufacturing Strategy: Process and Content, Voss C. A., Chapman & Hall, London, 1992.
5. Lean production simplified, Pascal. D., 2nd Edition, Productivity Press, 2007
6. Total Quality Management, Besterfield, D. H., Pearson Education, 1999.
7. Advanced Operations Management, Mohanty R. P., Deshmukh S. G., Pearson Education,2003.
8. "Managing Technology and Innovation for Competitive Advantage", Narayanan V.K, Prentice Hall, 2000.
9. "Making Common Sense Common Practice – Models for manufacturing Excellence", Ron Moore, Butter worth Heinmann.
10. The Toyota Way – 14 Management Principles", Jeffrey K.Liker, Mc-Graw Hill, 2003.
11. "Operations Management for Competitive Advantage", Chase Richard B., Jacob Robert., 11th Edition , McGraw Hill Publications, 2005.

Course Code	Course/Subject Name	Credits
MEE80211	**Nanotechnology**	**3+1**

Objectives

1. To acquaint learner with fundamental multidisciplinary nature of nanotechnology
2. To study applications and implementation of nanotechnology

Outcomes: Learner will be able to…

1. Discuss basics of nanotechnology
2. Identify various nanostructured materials
3. Illustrate characterization techniques and properties of nanomaterials

Modules	Detailed Content	Hrs.
01	**Introduction to Quantum mechanics, Nanostructural Materials and Low dimensional structures:** Basic principles of Quantum mechanics (why and how classical mechanics fails), probability amplitude, wave functions, eigen states and eigen values, Quantum wells, Quantum wires, Quantum dots, Nano clusters and Nano crystals.	**06**
02	**Quantum mechanical application of Nanotechnology:** Quantum well and quantum dot lasers, ultra-fast switching devices, nano magnets for sensors and high density data storage, photonic integrated circuits, long wave length detectors, carbon nanotube, luminescence from porous silicon, spin-tronic devices.	**06**
03	**Nanstructured materials, Zero-Dimensional Nanostructures: Nanoparticals:** Introduction , Nanoparticles through Homogeneous Nucleation, Fundamentals of Synthesis of semiconductor nanoparticles, Synthesis of oxide,nanoparticles, Vapor phase reactions, Solid state phase segregation, Heterogeneous Nucleation and Growth, i.Fundamentals of heterogeneous nucleation, ii.Synthesis of nanoparticles, Kinetically Confined Synthesis of Nanoparticles, i. Synthesis inside micelles or using microemulsions, ii. Aerosol synthesis, iii. Growth homogeneous nucleation, ii.Subsequent growth of nuclei, iii.Synthesis of metallic nanoparticles,iv termination, iv. Spray pyrolysis, v. Template-based synthesis, Epitaxial Core-Shell Nanoparticles. **One-Dimensional Nanostructures: Nanorods and Nanowires :** Introduction, Spontaneous Growth, Evaporation (or dissolution) condensation, Vapor (or solution or solid)–liquid–solid growth, Stress-induced recrystallization, Template-Based Synthesis, Electrochemical deposition, Electrophoretic deposition, Template filling, Electrospinning, Lithography **Two-Dimensional Nanostructures: Thin Film:** Introduction, Fundamentals of Film Growth, Vacuum Science, Physical Vapor Deposition (PVD) i.Evaporation, ii. Molecular beam epitaxy, iii. Sputtering; Chemical Vapor Deposition (CVD), i. Types of chemical reactions, ii. Reaction kinetics, iii. Transport phenomena, iv. CVD methods, v. Diamond films by CVD; Atomic Layer Deposition (ALD), Superlattices, Self-Assembly, Langmuir-Blodgett Films, Electrochemical Deposition, Sol-Gel Films, Solution growth, SILAR films. **Special Nanomaterials and applications:** Introduction; Carbon Fullerenes and Nanotubes: Carbon fullerenes, Fullerene- derived crystals, Carbon nanotubes; Micro and Mesoporous Materials: Ordered mesoporous materials, Random mesoporous materials, Crystalline porous materials (zeolites); Core-Shell Structures: Metal-oxide structures, Metal-polymer structures, Oxide-polymer structures; Organic-Inorganic Hybrids: Class I hybrids, Class II hybrids; Intercalation Compounds; Nanocomposites	**10**

	and Nanograined Materials. Molecular Electronics and Nanoelectronics; Nanobots; Biological Applications of Nanoparticles; Catalysis of Gold Nanocrystals; Bandgap Engineered Quantum Devices: Quantum well devices, Quantum dot devices; Nanomechanics; Carbon Nanotube Emitters; Photoelectrochemical Cells; Photonic Crystals and Plasmon Waveguides.	
04	**Synthesis and types of nano particles** Nanocontainers, Nanoshells, Nanohorns, Nanowires, Nanosprings, Nanorods, Nanofilters, Nanopens, Nanopencils, Nanopipettes, Nanopens, Nanoplotter, Nanobalance, Nanobeads, Nanoguitar	**06**
05	**Characterization and Properties of Nanomaterials** Introduction, Structural Characterization, X-ray diffraction (XRD), Small angle X-ray scattering (SAXS), Scanning electron, microscopy(SEM), Transmission electron microscopy (TEM), Scanning probe microscopy (SPM) Gas adsorption. Chemical Characterization, Optical spectroscopy, Electron spectroscopy, Ionic spectroscopy, Physical Properties: Thermal stability and lattice constant, Mechanical properties, Optical properties, Electrical conductivity, Ferroelectrics and dielectrics, Superparamagnetism, Emission spectroscopy, luminescence spectroscopy.	**05**
06	**Application of nano chemistry** Semiconductor and Microelectronics including MEMS, Optical Magnetic including memory, readwrite, flash, bubble memories etc. Mechanical including Nanocomposites, thermal barriers etc.Biomedical including Pharmacology, Virology etc.	**03**

Term Work

Term work shall consist of at least six assignments covering complete syllabus. One group seminar by maximum 3 members in a group on topic relevant to syllabus contents

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

- Assignments: : **10** marks
- Seminar : **10** 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. Introduction to nanotechnology, Charles P Poole Jr and Frank J Owens, Wiely
2. Introduction to Nanosciences and Nanotechnology, Chattopadhyay K K, Banerjee A N, PHI Learning
3. Nanotechnology: The science of small, Shah K A and Shah M A, Wiely
4. Nanotechnology, Rathi R K, S Chand
5. Nano: The essentials Understanding Nanosciences and Nanotechnology, TMH
6. Nanotechnology, Lynn E Foster, Pearson
7. Micromanufacturing and Nanotechnology, Mahalik N P, New Age International
8. Handbook of Nanoscience, Engineering, and Technology, William A Goddard, Donald Brenner, Sergey Edward Lyshevski, Goddard III, CRC Press

Course Code	Course/Subject Name	Credits
MEE80212	**Digital Prototyping for Product Design –II**	**3+1**

Objectives

1. To acquaint learner with basic process of Product engineering and visualization.
2. To study linear and non-linear structural analysis
3. To acquaint with kinematic motion study analysis
4. To study design optimization using simulation

Outcomes: Learner will be able to…

1. Render and animate the appearance and functionality of a product
2. Perform linear and non-linear structural analysis
3. Perform kinematic motion study analysis
4. Design optimization using simulation
5. Cloud-based mechanical simulation

Modules	Detailed Content	Hrs.
01	**Introduction** Digital prototyping process; Introduction to product engineering, Introductions to design changes and Automation. Visualization Extending Design Data	**02**
02	**Product Engineering & Visualization** Designing for change Automating Design and configuration, Design parameters, engineering calculators, Automation using illogic for parts & assemblies, Model relationships,Design visualization throughout product development, Benefits of design visualization, Utilizing Engineering Data throughout Organization. Design approval, Sales and Marketing support & plastic part visualization.	**08**
03	**Simulation & Validation - Linear & Nonlinear Analysis** Role of simulation and validation in product development process. FEM (Theory and requirements) Meshing load and constraints, part material selection and optimization, Linear Structural Analysis Benefits of nonlinear simulation, Theory and requirements, Advanced Meshing, Advanced Material Properties contact types, result reviews. Kinematics role in simulation and optimization	**08**
04	**Kinematics Motion & Mechanical Event** Theory benefits & kinematic requirement: Joints, Forces, Assembly Structure & results. Benefits of combining analysis information, Design Optimization, Motion forces, Component FEA from motion forces, Design optimization, Results	**08**
05	**Design Optimization and Change** Design Changes, Design Optimization; Model Relationships Simulation Results; Manufacturing & service, Leveraging engineering data throughout the organization, Benefits for field service and manufacturing, Story Board, Annotations and Descriptions, Snapshots & Assembly instruction video	**05**
06	**Design Optimization and CFD Analysis** The role of CFD within the product design cycle, CFD Analysis General Theory, Benefits of CFD simulation Model Setup, Meshing Fluid flow loads & Analysis results	**05**

List of Digital Prototyping Projects

1. General engineering calculators and rule based design project
2. Implementation of design changes and rules for automotive seat switches and gears
3. Showcase design visualization of automotive seat
4. General linear component analysis project
5. Automotive single component simulation and validation
6. General nonlinear analysis project
7. General mechanical kinematics motion projects
8. General mechanical event simulation project
9. General design optimization and change workflow projects
10. Automotive cooling airflow or lumbar value study
11. General Cloud-based mechanical simulation

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 Showcase Fundamentals: ASCENT official Training Guide
8. Design of machine elements -- V. B. Bhandari. Tara Mcgraw Hill Pub.
9. Autodesk Simulation Multiphysics ASCENT official training guide
10. Autodesk Student & Educator Learning Center
11. Autodesk SIM 360 Learning resources

Course Code	Course/Subject Name	Credits
MEP701 / MEP802	**Project I/ II**	**3 / 6**

Objective

1. To acquaint with the process of undertaking literature survey/industrial visit and identifying the problem
2. To familiarize the process of solving the problem in a group
3. To acquaint with the process of applying basic engineering fundamental in the domain of practical applications
4. To inculcate the process of research

Outcome: Learner will be able to…

1. Do literature survey/industrial visit and identify the problem
2. Apply basic engineering fundamental in the domain of practical applications
3. Cultivate the habit of working in a team
4. Attempt a problem solution in a right approach
5. Correlate the theoretical and experimental/simulations results and draw the proper inferences
6. Prepare report as per the standard guidelines.

Guidelines for Project

- Students should do literature survey/visit industry/analyze current trends and identify the problem for Project and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the problem.
- Students should attempt solution to the problem by experimental/simulation methods.
- The solution to be validated with proper justification and report to be compiled in standard format.

Guidelines for Assessment of Project I

- Project I should be assessed based on following points
  - Quality of problem selected
  - Clarity of Problem definition and Feasibility of problem solution
  - Relevance to the specialization
  - Clarity of objective and scope
  - Breadth and depth of literature survey
- Project I should be assessed through a presentation by the student project group to a panel of Internal examiners appointed by the Head of the Department/Institute of respective Programme.

Guidelines for Assessment of Project II

- Project II should be assessed based on following points
  - Quality of problem selected
  - Clarity of Problem definition and Feasibility of problem solution
  - Relevance to the specialization / Industrial trends
  - Clarity of objective and scope
  - Quality of work attempted
  - Validation of results
  - Quality of Written and Oral Presentation
- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Project II should be assessed through a presentation by the student project group to a panel of Internal and External Examiners approved by the University of Mumbai
- Students should be motivated to publish a paper based on the work in Conferences/students competitions