UNIVERSITY OF MUMBAI

Bachelor of Engineering

in

Mechanical Engineering

Second Year with effect from AY 2020-21

Third Year with effect from AY 2021-22

Final Year with effect from AY 2022-23

(REV- 2019 'C' Scheme) from Academic Year 2019 – 20

Under

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2019–2020)

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 Science and Technology (in particular Engineering)of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty resolved that course objectives and course outcomes are 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. Choice 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. 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 2-3 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 170, wherein focus is not only on providing knowledge but also on building skills, attitude and self learning. Therefore in the present curriculum skill based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for Second Year of Engineering from the academic year 2020-21. Subsequently this will be carried forward for Third Year and Final Year Engineering in the academic years 2021-22, 2022-23, respectively.

Dr. S. K. Ukarande
Associate Dean
Faculty of Science and Technology
Member, Academic Council, RRC in Engineering
University of Mumbai

Incorporation and implementation of Online Contents from NPTEL/ Swayam Platform

The curriculum revision is mainly focused on knowledge component, skill based activities and project based activities. Self learning opportunities are provided to learners. In the revision process this time in particular Revised syllabus of 'C ' scheme wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme 'A' and 'B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum overall credits are reduced to 171, to provide opportunity of self learning to learner. Learners are now getting sufficient time for self learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD's/ Faculties of all the institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

Dr. S. K. Ukarande
Associate Dean
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Member, Academic Council, RRC in Engineering
University of Mumbai

Program Structure for Second Year Engineering
Semester III & IV
UNIVERSITY OF MUMBAI
(With Effect from 2020-2021)

Semester III

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
MEC301	Engineering Mathematics-III	3	--	1	3	--	1	4
MEC302	Strength of Materials	3		--	3		--	3
MEC303	Production Processes	4	--	--	4	--	--	4
MEC304	Materials and Metallurgy	3	--	--	3	--	--	3
MEC305	Thermodynamics	3	--	--	3	--	--	3
MEL301	Materials Testing	--	2	--	--	1	--	1
MEL302	Machine Shop Practice	--	4	--	--	2	--	2
MESBL301	CAD –Modeling	--	4	--	--	2	--	2
MEPBL301	Mini Project – 1A	--	4[$]	--	--	2	--	2
Total		**16**	**14**	**1**	**16**	**07**	**1**	**24**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem. Exam	Exam. Duration (in Hrs)			
		Test1	Test2	Avg.					
MEC301	Applied Mathematics-III	20	20	20	80	3	25	--	125
MEC302	Strength of Materials	20	20	20	80	3	--	--	100
MEC303	Production Processes	20	20	20	80	3	--	--	100
MEC304	Materials and Metallurgy	20	20	20	80	3	--	--	100
MEC305	Thermodynamics	20	20	20	80	3	--	--	100
MEL301	Materials Testing	--	--	--	--	--	25	25	50
MEL302	Machine Shop Practice	--	--	--	--	--	50	--	50
MESBL301	CAD – Modelling	--	--	--	--	--	25	25	50
MEPBL301	Mini Project – 1A	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	--	**150**	**75**	**725**

$ indicates work load of Learner (Not Faculty), for Mini Project
SBL – Skill Based Laboratory
PBL – Project Based Learning

Semester IV

Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
MEC401	Engineering Mathematics-IV	3	--	1	3	--	1	4
MEC402	Fluid Mechanics	3	--	--	3	--	--	3
MEC403	Kinematics of Machinery	3	--	--	3	--	--	3
MEC404	CAD/CAM	3	--	--	3	--	--	3
MEC405	Industrial Electronics	3	--	--	3	--	--	3
MEL401	Industrial Electronics	--	2	--	--	1	--	1
MEL402	Kinematics of Machinery	--	2	--	--	1	--	1
MEL403	Python Programming	--	2	--	--	1	--	1
MESBL401	CNC and 3-D Printing	--	4	--	--	2	--	2
MEPBL401	Mini Project – 1B	--	4$	--	--	2	--	2
Total		**15**	**14**	**1**	**15**	**7**	**1**	**23**

Course Code	Course Name	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	3	25	--	125
MEC402	Fluid Mechanics	20	20	20	80	3	--	--	100
MEC403	Kinematics of Machinery	20	20	20	80	3	--	--	100
MEC404	CAD/CAM	20	20	20	80	3	--	--	100
MEC405	Industrial Electronics	20	20	20	80	3	--	--	100
MEL401	Industrial Electronics	--	--	--	--	--	25	25	50
MEL402	Kinematics of Machinery	--	--	--	--	--	25	--	25
MEL403	Python Programming	--	--	--	--	--	25	25	50
MESBL401	CNC and 3-D Printing	--	--	--	--	--	25	25	50
MEPBL401	Mini Project – 1B	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	--	**150**	**100**	**750**

$ indicates work load of Learner (Not Faculty), for Mini Project
SBL – Skill Based Laboratory
PBL – Project Based Learning

Course Code	Course Name	Credits
MEC301	**Engineering Mathematics-III**	**4**

Pre-requisite: Engineering Mathematics-I, Engineering Mathematics-II,

Course Objectives:

1. To familiarize with the Laplace Transform, Inverse Laplace Transform of various functions, its applications.
2. To acquaint with the concept of Fourier Series, its complex form and enhancethe problemsolvingskills.
3. To familiarize with the concept of complex variables, C-R equations with applications.
4. To study the application of the knowledge of matrices and numerical methods in complex engineering problems.

Course Outcomes: Learner will be able to….

1. Apply the concept of Laplace transform to solve thereal integrals in engineering problems.
2. Apply the concept of inverse Laplace transform of various functions in engineeringproblems.
3. Expand the periodic function by using Fourier series for real life problemsand complex engineeringproblems.
4. Find orthogonal trajectories and analyticfunction by using basic concepts of complex variable theory.
5. Apply Matrix algebra to solve the engineeringproblems.
6. Solve Partial differential equations by applying numerical solution and analytical methods for one dimensional heat and waveequations.

Module	Detailed Contents	Hrs.
01	**Module: Laplace Transform** 1.1 Definition of Laplace transform, Condition of Existence of Laplacetransform, Laplace Transform (L) of Standard Functions like $e^{at}, sin(at), cos(at), sinh(at), cosh(at)$ and t^n, *where* $n \geq 0$. 1.2 Properties of Laplace Transform: Linearity, First Shifting theorem, Second Shifting Theorem, change of scale Property, multiplication by *t*, Division by *t, 1.3. 1.3* Laplace Transform of derivatives and integrals (Properties without proof).	**06**
	1.4 Evaluation of integrals by using Laplace Transformation. **Self-learning topics:** Heaviside's Unit Step function, Laplace Transform. OfPeriodic functions, Dirac Delta Function.	

02	**Module: Inverse Laplace Transform** 2.1 Inverse Laplace Transform, Linearity property, use of standard formulae to find inverse Laplace Transform, finding Inverse Laplace transform using derivative 2.2 Partial fractions method & first shift property to find inverse Laplace transform. 2.3 Inverse Laplace transform using Convolution theorem (without proof) **Self-learning Topics:** Applications to solve initial and boundary value problems involving ordinary differential equations.	**06**
03	**Module: Fourier Series:** *3.1* Dirichlet's conditions, Definition of Fourier series and Parseval'sIdentity (without proof) 3.2 Fourier series of periodic function with period 2π and$2l$, Fourier series of even and odd functions, Half range Sine and Cosine Series. **Self-learning Topics:** Complex form of Fourier Series, orthogonal and orthonormal set of functions, Fourier Transform.	**06**
04	**Module: Complex Variables:** 4.1 Function $f(z)$ of complex variable, limit, continuity and differentiability of $f(z)$, Analytic function, necessary and sufficient conditions for $f(z)$ to be analytic (without proof) 4.2 Cauchy-Riemann equations in Cartesian coordinates (without proof) 4.3 Milne-Thomson method to determine analytic function $f(z)$ when real part (u) or Imaginary part (v) or its combination (u+v or u-v) is given. 4.4 Harmonic function, Harmonic conjugate and orthogonal trajectories **Self-learning Topics:** Conformal mapping, linear, bilinear mapping, cross ratio, fixed points and standard transformations	**06**
05	**Module: Matrices:** 5.1 Characteristic equation, Eigen values and Eigen vectors, Properties ofEigen values and Eigen vectors. (**No theorems/proof**) 5.2 Cayley-Hamilton theorem (without proof): Application to find the inverse of the given square matrix and to determine the given higher degreePolynomialmatrix. 5.3 Functions of squarematrix, Similarity of matrices, Diagonalization of matrices **Self-learning Topics:** Verification of Cayley Hamilton theorem, Minimal polynomial and Derogatory matrix & Quadratic Forms (Congruent transformation & Orthogonal Reduction)	**06**
06	**Module: Numerical methods for PDE** 6.1 Introduction of Partial Differential equations, method of separation of variables, Vibrations of string, Analytical method for one dimensional heatand wave equations. (onlyproblems) 6.2 Crank Nicholsonmethod, Bender Schmidt method	**06**
	Self-learning Topics: Analytical methods of solving two and three dimensional problems.	

Assessment:

Term Work:
General Instructions:

1. Batch wise tutorials are to be conducted. The number of student'sperbatch should be as per University pattern for practicals.
2. Students must be encouraged to write at least 6 class tutorials on entiresyllabus.
3. A group of 4-6 students should be assigned a self-learning topic. Students should prepare a presentation/problem solving of 10-15 minutes. This should be consideredas mini project in Engineering Mathematics. This project should be graded for 10 marks depending on the performance of thestudents.

The distribution of Term Work marks will be as follows –

1.	Attendance (Theory and Tutorial)	05 marks
2.	Class Tutorials on entire syllabus	10 marks
3.	Mini project	10 marks

Internal Assessment for 20 marks: Consisting Two Compulsory Class Tests First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I). Duration of each test shall be one hour.

End Semester Examination: Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
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 any module other than module 3)
4. Only Four questions need to be solved.

References:

1. Engineering Mathematics, Dr. B. S. Grewal, Khanna Publication
2. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley Eastern Limited,
3. Advanced Engineering Mathematics, R. K. Jain and S.R.K. Iyengar, Narosa Publication
4. Advanced Engineering Mathematics, H.K. Das, S. Chand Publication
5. Higher Engineering Mathematics B.V. Ramana, McGraw Hill Education
6. Complex Variables and Applications, Brown and Churchill, McGraw-Hill Education,
7. Text book of Matrices, Shanti Narayan and P K Mittal, S. ChandPublication
8. Laplace transforms, Murray R. Spiegel, Schaum's Outline Series

Course Code	Course Name	Credits
MEC302	**Strength of Materials**	**03**

Objectives:

1. To acquaint with the concepts of nature of stresses developed in simple geometries subjected to various types of simple loads.
2. To familiarize the concept of an elastic deformation occurring in various simple geometries for different types ofLoading.
3. To study distribution of various stresses in the mechanical elements under different types of loads.

Outcomes: Learner will be able to…

1) Demonstrate fundamental knowledge about various types of loading and stresses induced.
2) Draw the SFD and BMD for different types of loads and support conditions.
3) Analyze the bending and shear stresses induced in beam.
4) Analyze the deflection in beams and stresses in shaft.
5) Analyze the stresses and deflection in beams and Estimate the strain energy in mechanical elements.
6) Analyze buckling phenomenon in columns.

Module	Detailed Contents	Hrs
1.	**Introduction-Concept of Stress** Deformation in solids- Hooke's law, stress and strain- tension, compression and shear stresses, Stress Strain Diagram, elastic constants and their relations- volumetric, linear and shear strains. Composite sections, Thermal stress and strain. Principal stresses and Principal planes- Mohr's circle. Moment of inertia about an axis and polar moment of inertia	**8**
2.	**Shear Force and Bending Moment in Beams:** Introduction to types of beams, supports and loadings. Definition of bending moment and shear force, Sign conventions, relationship between load intensity, bending moment and shear force. Shear force and bending moment diagrams for statically determinate beams subjected to points load, uniformly distributed loads, uniformly varying loads, couple and their combinations.	**6**
3.	**Stresses in Beams:** Theory of bending of beams, bending stress distribution, shear stress distribution for point and distributed loads in simply supported and over-hanging beams, cantilevers.	**8**
4.	**Deflection of Beams:** Deflection of a beam: Double integration method, Maxwell's reciprocal theorems for computation of slopes and deflection in beams for point and distributed loads. **Torsion:** Stresses in solid and hollow circular shafts.	**6**
5.	**Thin Cylindrical and Spherical Shells:** Stresses and deformation in Thin Cylindrical and Spherical Shells subjected to internal pressure **Strain Energy:** Strain energy stored in the member due to gradual, sudden and impact	**6**

	loads, Strain energy due to bending and torsion.	
6.	**Columns:** Buckling load, Types of end conditions for column, Euler's column theory and its limitations and Rankine formula.	**5**

Assessment:

Internal Assessment for 20 marks: Consisting Two Compulsory Class Tests First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I). Duration of each test shall be one hour.

End Semester Examination: Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
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 any module other than module 3)
4. Only Four questions need to be solved.

References:

1. Strength of Materials by Ryder, Macmillan
2. Mechanics of Materials by James M. Gere and Barry J. Goodno, Cengage Learning, 6thEd, 2009
3. Mechanics of Materials by Gere and Timoshenko, CBS 2nd Edition
4. Elements of Strength of Materials by Timoshenko and Youngs, Affiliated East -West Press
5. Mechanics of Materials by Beer, Jhonston, DEwolf and Mazurek, TMHPvt Ltd., New Delhi
6. Mechanics of Structures by S.B.Junnarkar, Charotar Publication
7. Mechanics of Materials by S.S.Ratan, Tata McGraw Hill Pvt. Ltd
8. Introduction to Solid Mechanics by Shames, PHI
9. Strength of Materials by S. Ramamrutham, Dhanpat Rai Pvt. Ltd
10. Strength of Materials by W.Nash, Schaum's Outline Series, McGraw Hill Publication, Special Indian Edition
11. Strength of Materials by R. Subramanian, Oxford University Press, Third Edition 2016

Course Code	Course Name	Credits
MEC303	**Production Processes**	**04**

Objectives:

1. To familiarize with the various production processes used on shop floors
2. To study appropriate production processes for a specific application.
3. To introduce to the learner various machine tools used for manufacturing
4. To familiarize with principle and working of non-traditional manufacturing
5. To introduce to them the Intelligent manufacturing in the context of Industry 4.0

Outcomes: Learnerwill be able to….

1. Demonstrate an understanding of casting process
2. Illustrate principles of forming processes.
3. Demonstrate applications of various types of welding processes.
4. Differentiate chip forming processes such as turning, milling, drilling, etc.
5. Illustrate the concept of producing polymer components and ceramic components.
6. Illustrate principles and working of non-traditional manufacturing
7. Understand the manufacturing technologies enabling Industry 4.0

Module	Details	Hours
1	**Introduction to Production Processes and Metal Casting** 1.1. Classification of Production Processes and applications areas 1.2. Pattern making materials, Types of pattern and allowances. 1.3. Sand moulding and Machine moulding 1.4. Gating system :Types of riser, types of gates, solidification 1.5.**Special casting processes** : CO2 and shell moulding, Investment casting, Die casting, Vacuum casting, Inspection & casting defects and remedies	**08**
2	**Joining Processes** 2.1.Classification of various joining processes; Applicability, advantages and limitations of Adhesive bonding, Mechanical Fastening; Welding and allied processes, Hybrid joining processes. 2.2.Classification and Working of various welding methods: Gas, Arc, Chemical, Radiant, Solid State etc. 2.3.Welding Joints, Welding Positions, Welding defects and their remedies.	**08**
3	**3.1. Forming processes** • Introduction and classification of metalworking processes, hot and cold working processes • Introduction, classification and analysis of forging and rolling operations, Defects in rolled and forged components, • Extrusion process, Classification and analysis of wire and tube drawing processes. **3.2. Sheet metal working processes** • Classification of Sheet metal operations, types of Presses used in sheet metal operations, types of dies.	**08**

4	**4.1. Machine Tools, Machining Processes**. • **Machine Tools and Machining Processes:** Lathe Machines, Milling Machines, Drilling Machines, and Grinding Machines and selection of grinding wheel (Dressing and Truing), Broaching machines, Lapping/Honing machines (Super Finishing Operations) and shaping/slotting/planning Machines. • **Gear Manufacturing** Gear milling, standard cutters and limitations, Gear Hobbing, GearShaping, Gear Shaving and Gear Grinding processes **4.2. Tool Engineering** • Geometry and nomenclature of single point cutting tool, Speed, feed, depth of cut, Taylor's tool life equation, Concept of chip formation and types of chips.Introduction to Jigs and Fixtures and types.	**12**
5	**5.1Non Traditional Machining Processes**: • Electro-chemical machining (ECM) • Electric-discharge machining (EDM) • Ultrasonic machining (USM) • Laser Beam Machining (LBM)	**04**
6.	**6.1 Polymer Processing:** • Polymer Molding Techniques for thermoplastic and thermosetting plastics. Applications of Plastics in engineering field. **6.2 Powder Metallurgy**: • Introduction to PM, Powder making processes, Steps in PM. Compaction and Sintering processes. Secondary and finishing operations in PM. **6.3 Intelligent manufacturing in the context of Industry 4.0**, • Cyber-physical systems (CPS) • Internet of Things (IoT) enabled manufacturing • Cloud Manufacturing	**08**

Assessment:

Internal Assessment for 20 marks: Consisting Two Compulsory Class Tests First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I). Duration of each test shall be one hour.

End Semester Examination: Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
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 any module other than module 3)
4. Only Four questions need to be solved.

References:

1. Welding technology by O P Khanna
2. Foundry technology by O P Khanna
3. Elements of workshop technology. Vol. 1 & II by S K HajraChoudhury
4. Manufacturing Science by Ghosh and Malik
5. Rapid Manufacturing –An Industrial revolution for the digital age by N.Hopkinson, R.J.M.Hauge, P M, Dickens, Wiley
6. Rapid Manufacturing by Pham D T and Dimov, Springer Verlag
7. Production Technology by WAJ Chapman Vol I, II, III
8. Production Technology by P C Sharma.
9. Production Technology by Raghuvanshi.
10. Industry 4.0: The Industrial Internet of Things by Alasdair Gilchrist, 2016, Apress.
11. Cyber-Physical Systems: From Theory to Practice by Danda B. Rawat, Joel Rodrigues, Ivan Stojmenovic, 2015, C.R.C. Press.
12. Optimization of Manufacturing Systems using Internet of Things by Yingfeng Zhang, Fei Tao, 2017, Academic Press (AP), Elsevier.

Course Code	Course Name	Credits
MEC304	**Materials and Metallurgy**	**03**

Objectives:

1. To familiarize the structure -property correlation in materials
2. To acquaint with the processing dependency on the performance of the various materials
3. To study the role of alloying in the development of steels.
4. To familiarize with the advances in materials development

Outcomes: Learner will be able to ….

1. Identify the various classes of materials and comprehend their properties
2. Apply phase diagram concepts to engineering applications
3. Apply particular heat treatment for required property development
4. Identify the probable mode of failure in materials and suggest measures to prevent them
5. Choose or develop new materials for better performance
6. Decide an appropriate method to evaluate different components in service

Module	Contents	Hours
1	**1.1 Classification of materials:** Introduction to engineering materials – significance of structure property correlations in all classes of engineering materials **1.2Concepts of crystals-** Crystalline and Non-crystalline Materials Unit cell,Crystal structures of metals, Crystal systems,Crystallographic planes and directions, **1.3Crystal Defects:** Crystal Imperfections-definition, classification and significance of imperfections -point defects,line defects,Surface defects and volume defects. Importance of dislocations in deformation and its mechanisms.Critical Resolved shear stress, Slip systems and deformability of FCC, BCC and HCP lattice systems. **1.4 Cold Working and Recrystallization annealing:** Definition, effects and mechanism of cold work, Need for Recrystallization Annealing, the stages of recrystallization annealing and factors affecting it	**8**
2	**2.1 Mechanism of Crystallization**- Nucleation-Homogeneous and Heterogeneous Nucleation and Growth. Solidification of metals and -alloys– Cooling curves **2.2 Classification of Alloys based on phases and phase diagram**-Binary alloy phase diagram – Isomorphous, Eutectics type I and II, Peritectic **2.3 Iron-Iron carbide phase diagram** – Invariant reactions – microstructural changes of hypo and hyper-eutectoid steel- TTT and CCT diagram-Hardenability and its tests,Graphitization in cast irons.	**8**

3	**3.1 Heat treatment:** Overview – Objectives – Thorough treatments: Annealing and types, normalizing, hardening and tempering, austempering and martempering – microstructure changes **3.2 Surface hardening processes:** Carburizing –, nitriding – cyaniding and carbonitriding, induction and flame hardening, Laser and Electron beam hardening– principles and case depths **3.3 Alloy steels-**Stainless steels, Tool steels, Maraging steels and Ausformed steels	**6**
4	**4.1 Strengthening mechanisms in materials** **4.2 Fracture of metals** – Ductile Fracture, Brittle Fracture, Ductile to Brittle Transition Temperature (DBTT), Griffith's criteria and Orowan's modification **4.3 Fatigue** – Endurance limit of ferrous and non-ferrous metals -Fatigue test, S-N curves, factors affecting fatigue, structural changes accompanying fatigue; **4.4 Creep** – mechanism of creep – stages of creep and creep test,creep resistant materials	**6**
5	**5.1 Composites:** Basic concepts of composites, Processing of composites, advantages over metallic materials, various types of composites and their applications **5.2 Nano Materials:** Introduction, Concepts, synthesis of nanomaterials, examples, applications and Nano composites **5.3 Introduction to Smart materials:** Classification, Shape Memory Alloys and its applications	**6**
6	**6.1 Engineering Polymers and Ceramics**-types and their advantages over metallic materials **6.2 Processing-** of ceramics and composites through Injection Moulding **6.3 Non destructive Testing of Materials-**ultrasonic testing, radiographic methods,magnetic particle testing	**4**

Assessment:

Internal Assessment for 20 marks: Consisting Two Compulsory Class Tests First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I). Duration of each test shall be one hour.

End Semester Examination: Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
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 any module other than module 3)
4. Only Four questions need to be solved.

Textbooks:

1. Callister's Materials Science and Engineering, 2nd edition by R.Balasubramanium Wiley India Pvt. Ltd

References:

1. Introduction to Materials Science for Engineers; 8th Edition by James F. Shackelford Pearson
2. Introduction to Physical Metallurgy,2nd edition by Sidney Avner, TataMcGrawHill
3. Mechanical Metallurgy, 3rd edition by GH Dieter,TataMcGraw Hill
4. Fundamentals of Materials Science and Engineering: An Integrated Approach, 5th Edition by William D. Callister, Jr., David G. Rethwisch, Wiley & Sons.
5. Materials Science and Engineering,5th edition by V.Raghavan, Prentice Hall India

Course Code	Course Name	Credits
MEC305	**Thermodynamics**	**03**

Objectives:

1. To familiarize the concepts of Energy in general and Heat and Work inparticular
2. To study the fundamentals of quantification and grade ofenergy
3. To study the effect of energy transfer on properties of substances in the form of charts anddiagrams
4. To familiarize the application of the concepts of thermodynamics in vapour power, gas power cycles, compressible fluid flow

Outcomes:Learners will be able to….

1. Demonstrate application of the laws of thermodynamics to a wide range ofsystems.
2. Compute heat and work interactions in thermodynamicsystems
3. Demonstrate the interrelations between thermodynamic functions to solve practicalproblems.
4. Compute thermodynamicinteractions using the steam table and Mollier chart
5. Compute efficiencies of heat engines, power cycles.
6. Apply the fundamentals of compressible fluid flow to the relevant systems

Module	Detailed contents	Hrs
1	**Basic Concepts :** Thermodynamics system and types, Macroscopic and Microscopic approach, Thermodynamic properties of the system, state, path, processand cycle, Point and Path functions, Quasi-static process & Equilibrium, Zeroth law of thermodynamics, Characteristic gas equation, Concept of Internal energy, Enthalpy, Heat and Work. Concept of PdV work. **First Law of Thermodynamics:** Statement & Equation, First law for Cyclic process (Joule's experiment), Perpetual Motion Machine of the First Kind, Application of first law to non-flow systems (Ideal gas processes with numerical) First law applied to flow system: Concept of flow process and flow energy, Concept of the steady flow process, Energy balance in a steady flow, Application of steady flow energy equation to nozzle, turbine, compressor, pump, boiler, condenser, heat exchanger, throttling device. Steady flow work, Significance of – VdPwork, Relation between flow and non-flow work	**07**
2	**Second Law of Thermodynamics:** Limitation of the first law of thermodynamics, Thermal reservoir, Concept of heat engine, Heat pump and Refrigerator, Statement of the second law of thermodynamics, Reversible and irreversible Process, Causes of irreversibility, Perpetual Motion Machine of the second kind,Carnotcycle, Carnot theorem. **Entropy:** Clausiustheorem, Entropy is property of a system, Temperature-Entropy diagram, Clausius inequality, Increase of entropy principle, T ds relations, Entropy change During a process.	**08**

3	**Availability:** Highgradeandlow-gradeenergy,AvailableandUnavailableenergy,DeadState, Useful work, Irreversibility, Availability of closed system& steady flow process, Helmholtz & Gibbs function **Thermodynamic Relations:** Maxwell relations, Clausis-Clapeyron Equation, Mayer relation, Joule-Thomson coefficient (Only Theory)	**05**
4	**Properties of Pure Substance:** Advantages and applications of steam, Phase change process of water, Saturation pressure and temperature, Terminology associated with steam, Different types of steam.Property diagram: T-v diagram, p-v diagram, p-T diagram, Critical and triple point, T-s and an h-s diagram for water, Calculation of various properties of wet, dry and superheated steam using the steam table and Mollier chart**.** **Vapour Power cycle:** Principal components of a simple steam power plant, Carnot cycle and its limitations as a vapour cycle, Rankine cycle with different turbine inlet conditions, Mean temperature of heat addition, Reheat Rankine Cycle.	**07**
5	**Gas Power cycles:** Nomenclature of a reciprocating engine, Mean effective pressure, AssumptionsofairStandardCycle,Ottocycle,DieselCycleandDualcycle, Comparison of Otto and Diesel cycle for same compression ratio,BraytonCycle. Sterling Cycle, Ericsson Cycle, Lenoir cycle, and Atkinsoncycle (Only theory).	**06**
6	**Compressible Fluid flow:** Propagation of sound waves through compressible fluids, Sonic velocity and Mach number; Stagnation properties, Application of continuity, momentum and energy equations for steady-state conditions; Steady flow through the nozzle, Isentropic flow through ducts of varying cross-sectional area, Effect of varying back pressure on nozzle performance, Critical pressure ratio.	**06**

Assessment:

Internal Assessment for 20 marks: Consisting Two Compulsory Class Tests First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I). Duration of each test shall be one hour.

End Semester Examination: Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
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 any module other than module 3)
4. Only Four questions need to be solved.

References:

1. Thermodynamics: An Engineering Approach by Yunus A. Cengel and Michael A. Boles, 9th edition, TMH
2. Basic Engineering Thermodynamics by Rayner Joel, 5thedition, Longman Publishers
3. Engineering Thermodynamics by P Chattopadhyay, 2ndedition, Oxford University PressIndia
4. Thermodynamics by P K Nag, 6th Edition,TMH
5. Thermodynamics by Onkar Singh, 4th Edition New AgeInternational
6. Thermodynamics by C P Arora,1stEditionTMH
7. Thermal Engineering By Ajoy Kumar, G. N. Sah, 2nd Edition, Narosa Publishing house
8. Engineering Thermodynamics Through Examples by Y V C Rao, Universities Press (India) Pvt Ltd
9. Fundamentals of Thermodynamics by Moran &Shapiro, Eighth Edition, Wiley
10. Fundamentals of Classical Thermodynamics by Van Wylen G.H. & Sonntag R.E., 9th Edition JohnWiley& Sons
11. Thermodynamics by W.C. Reynolds, McGraw-Hill &Co
12. Thermodynamics by J P Holman, 4th Edition McGraw-Hill & Co

Course Code	Course Name	Credits
MEL301	**Materials Testing**	**01**

Objectives:

1. To familiarize with the use of metallurgical microscope for study of metals
2. To study the microstructures of ferrous (steel and cast iron) metals
3. To acquaint with the material testing by performing experiment related to Hardness , Fatigue, Tension, Torsion, Impact and Flexural Test

Outcomes: Learner will be able to…

1. Prepare metallic samples for studying its microstructure following the appropriate procedure.
2. Identify effects of heat treatment on microstructure of medium carbon steel and hardenability of steel using Jominy end Quench test
3. Perform Fatigue Test and draw S-N curve
4. Perform Tension test to Analyze the stress - strain behaviour of materials
5. Measure torsional strength, hardness and impact resistanceof the material
6. Perform flexural test with central and three point loading conditions

a)List of Experiments: Total eight experiments are required to be performed. Four Experiments from each group

Experiment Number	Detailed Contents		Laboratory Sessions
	Group A		
1.	Study of Characterization techniques and Metallographic sample preparation and etching		2 Hrs
2.	Comparison of Microstructures and hardness before and after Annealing, Normalizing and Hardening in medium carbon steel	**Any two**	2 Hrs
3.	Study of tempering characteristics of hardened steel		
4.	Determination of hardenability of steel using Jominy end Quench Test (Using different hardness testers to measure the Hardness)		
5.	Fatigue test – to determine number of cycles to failure of a given material at a given stress		2 Hrs
	Group B		
6.	Tension test on mild steel bar (stress-strain behaviour, determination of yield strength and modulus of elasticity)		2 Hrs
7.	Torsion test on mild steel bar / cast iron bar		2 Hrs
8.	Impact test on metal specimen (Izod/Charpy Impact test)		2 Hrs
9.	Hardness test on metals – (Brinell/ Rockwell Hardness Number		2 Hrs
10.	Flexural test on beam (central loading)		2 Hrs

b) Assignments: At least one problem on each of the following topics:
1. Simple stress strain
2. SFD and BMD
3. Stresses in beams
4. Torsion and deflection.
5. Thin cylinder and strain energy
6. Buckling of Columns

Note: Preferably, the assignments shall be based on live problems.**Project Based Learning may be incorporated by judiciously reducing number of assignments.**

Assessment:

Term Work: Including Part a and b both
Distribution of marks for Term Work shall be as follows:

Part a: 10 marks.
Part b:10 Marks
Attendance: 05 marks.

End Semester Practical/Oral Examination:
Pair of Internal and External Examiner should conduct practical examination followed by Oral

Course Code	Course Name	Credits
MEL302	**Machine Shop Practice**	**02**

Objectives:

1. To familiarize with basic machiningprocesses.
2. To familiarize various machining operations and machineprotocols

Outcomes: Learner will be able to…

1. Know the specifications, controls and safety measures related to machines and machining operations.
2. Use the machines for making various engineering jobs.
3. Perform various machining operations
4. Perform Tool Grinding
5. Perform welding operations

Module	Details	Hrs
1	One composite job consisting minimum four parts employing operations performed of various machine tools.	**40**
2	Tool Grinding – To know basic tool Nomenclature	**4**
3	One Job on Welding – Application of Metal Arc Welding	**4**

Assessment:

Term Work:

1. **Composite job** mentionedabove and the **Welding Job**
2. Complete Work-Shop Book giving details of drawing of the job and timesheet

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

1. Job Work with completeworkshopbook ……. 40 marks
2. Attendance …… 10marks

Course Code	Course Name	Credits
MESBL303	**Skill Based Lab: CAD – Modeling**	**02**

Prerequisites: Engineering Drawing

Objectives:

1. To impart the 3D modeling skills for development of 3D models of basic engineering components.
2. To introduce Product data exchange among CAD systems.
3. To familiarize with production drawings with important features like GD &T, surface finish, heat treatments etc.

Outcomes: Learnerwill be able to…

1. Illustrate basic understanding of types of CAD model creation.
2. Visualize and prepare 2D modeling of a given object using modelling software.
3. Build solid model of a given object using 3D modeling software.
4. Visualize and develop the surface model of a given object using modelling software.
5. Generate assembly models of given objects using assembly tools of a modelling software
6. Perform product data exchange among CAD systems.

Sr. No.	Exercises	Hrs.
1	**CAD Introduction** CAD models Creation, Types and uses of models from different perspectives. Parametric modeling.	2
2	**2D Modeling** Geometric modeling of an Engineering component, demonstrating skills in sketching commands of creation (line, arc, circle etc.) modification (Trim, move, rotate etc.) and viewing using (Pan, Zoom, Rotate etc.)	8
3	**Solid Modeling** 3D Geometric modeling of an Engineering component, demonstrating modeling skills using commands like Extrude, Revolve, Sweep, Blend, Loft etc.	14
4	**Surface Modeling** Extrude, Sweep, Trim etc and Mesh of curves, free form surfaces etc. Feature manipulation using Copy, Edit, Pattern, Suppress, History operations etc.	10
5	**Assembly** Constraints, Exploded views, interference check. Drafting (Layouts, Standard & Sectional Views, Detailing & Plotting).	10
6	**Data Exchange** CAD data exchange formats Like IGES, PDES, PARASOLID, DXF and STL along with their comparison and applicability.	4

Assessment:

Term work

Using the above knowledge and skills acquired through six modules students should complete Minimum six assignments/Experiments from the given sets of assignments **(Two from each set)** using standard CAD modeler like PTC Creo/CATIA/ Solid work/UG /any other suitable software.

Set 1: Beginner Level:

3D modeling of basic Engineering components likes Nuts, Bolts, Keys, cotter, Screws, Springs etc.

Set 2: Intermediate Level:

3D modeling of basic Machine components like Clapper block, Single tool post, Lathe and Milling tail stock,Shaper tool head slide, jigs and fixtures Cotter, Knuckle joint, Couplings: simple, muff, flanged Protected flange coupling, Oldham's coupling, Universal coupling,element of engine system and Miscellaneous parts.

Set 3: Advance Level:

1) Generation of any Assembly model (minimum five child parts) along with Production drawing for any of the system by creating 3D modeling with assembly constraints, Interference check, Exploded view, GD&T, Bill of material.

2) Reverse Engineering of a physical model: disassembling of any physical model having not less than five parts, measure the required dimensions of each component, sketch the minimum views required for each component, convert these sketches into 3-D model and create an assembly drawing with actual dimensions

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

1. Printouts/Plots : 20 marks
2. Attendance : 05 marks

End Semester Practical/Oral examination:

To be conducted by pair of Internal and External Examiner

1. Practical examination duration is two hours, based on Advance level of the Term work. Oral examination should also be conducted to check the knowledge of CAD Modelling Tools.
2. The distribution of marks for practical examination shall be as follows:
   a. Practical Exam ….15 marks
   b. Oral Exam ……10 marks
3. Evaluation of practical examination to be done based on the printout of students work
4. Students work along with evaluation report to be preserved till the next examination

References:

1. Machine Drawing by N.D. Bhatt.
2. A textbook of Machine Drawing byLaxminarayan and M.L.Mathur, Jain brothers Delhi
3. Machine Drawing by Kamat and Rao
4. Machine Drawing by M.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 and SurinderRaina, Dreamtech Press

Course code	Course Name	Credits
MEPBL301	**Mini Project - 1A**	**02**

Objectives

1. To acquaint with the process of identifying the needs and converting it into the problem.
2. To familiarize the process of solving the problem in a group.
3. To acquaint with the process of applying basic engineering fundamentalsto attempt solutions to the problems.
4. To inculcate the process of self-learning and research.

Outcome: Learner will be able to…

1. Identify problems based on societal /research needs.
2. Apply Knowledge and skill to solve societal problems in a group.
3. Develop interpersonal skills to work as member of a group or leader.
4. Draw the proper inferences from available results through theoretical/ experimental/simulations.
5. Analyse the impact of solutions in societal and environmental context for sustainable development.
6. Use standard norms of engineering practices
7. Excel in written and oral communication.
8. Demonstrate capabilities of self-learning in a group, which leads to life long learning.
9. Demonstrate project management principles during project work.

Guidelines for Mini Project

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students hall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
- With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality to be carried out in two semesters by all the groups of the

students. i.e. Mini Project 1 in semester III and IV. Similarly, Mini Project 2 in semesters V and VI.

- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on case by case basis.

Guidelines for Assessment of Mini Project:

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for both semesters shall be as below;
    - Marks awarded by guide/supervisor based on log book : 10
    - Marks awarded by review committee : 10
    - Quality of Project report : 05

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year project:

- In first semester entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on presentation given by students group.
    - First shall be for finalisation of problem
    - Second shall be on finalisation of proposed solution of problem.
- In second semester expected work shall be procurement of component's/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.
    - First review is based on readiness of building working prototype to be conducted.
    - Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

Half-year project:

- In this case in one semester students' group shall complete project in all aspects including,
    - Identification of need/problem
    - Proposed final solution
    - Procurement of components/systems
    - Building prototype and testing
- Two reviews will be conducted for continuous assessment,
    - First shall be for finalisation of problem and proposed solution
    - Second shall be for implementation and testing of solution.

Assessment criteria of Mini Project.

Mini Project shall be assessed based on following criteria;

1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Innovativeness
8. Cost effectiveness and Societal impact
9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual's as member or leader
13. Clarity in written and oral communication

- In **one year, project**, first semester evaluation may be based on first six criteria's and remaining may be used for second semester evaluation of performance of students in mini project.
- In case of **half year project** all criteria's in generic may be considered for evaluation of performance of students in mini project.

Guidelines for Assessment of Mini Project Practical/Oral Examination:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organisations having experience of more than five years approved by head of Institution.
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Mini Project shall be assessed based on following points;

1. Quality of problem and Clarity
2. Innovativeness in solutions
3. Cost effectiveness and Societal impact
4. Full functioning of working model as per stated requirements
5. Effective use of skill sets
6. Effective use of standard engineering norms
7. Contribution of an individual's as member or leader
8. Clarity in written and oral communication

Course Code	Course Name	Credits
MEC401	**Engineering Mathematics-IV**	**04**

Pre-requisite:

1) Engineering Mathematics-I,
2) Engineering Mathematics-II,
3) Engineering Mathematics-III,

Objectives:

1) To study the concept of Vector calculus & its applications in engineering.
2) To study Line and Contour integrals and expansion of complex valuedfunction in a power series.
3) To familiarize with the concepts of statistics for data analysis.
4) To acquaint with the concepts of probability, random variables with their distributions and expectations.
5) To familiarize with the concepts of probability distributions and sampling theory with its applications.

Outcomes:

Learner will be able to….

1) Apply the concept of Vector calculus to evaluate line integrals, surface integrals using Green's theorem, Stoke's theorem & Gauss Divergence theorem.
2) Use the concepts of Complex Integration for evaluating integrals, computing residues & evaluate various contour integrals.
3) Apply the concept of Correlation, Regression and curve fitting to the engineering problems in data science.
4) Illustrate understanding of the concepts of probability and expectation for getting the spread of the data and distribution of probabilities.
5) Apply the concept of probability distribution to engineering problems& Testing hypothesis of small samples using sampling theory
6) Apply the concepts of parametric and nonparametric tests for analyzing practicalproblems.

Module	Detailed Contents	Hrs.
01	**Module : Vector Calculus** Solenoidal and irrotational (conservative) vector fields. Line integrals – definition andproblems.Green's theorem (without proof) in a plane, Stokes' theorem (withoutProof), Gauss' Divergence theorem (without proof) and problems (onlyevaluation). **Self Learning Topics**: Identities connecting Gradient, Divergence and Curl,Angle between surfaces. Verifications of Green's theorem, Stoke's theorem & Gauss-Divergence theorem, related identities & deductions.	**06**

02	**Module: Complex Integration** Line Integral, Cauchy's Integral theorem for simple connected and multiply connected regions (without proof), Cauchy's Integral formula (withoutproof). Taylor's and Laurent's series (withoutproof). Definition of Singularity, Zeroes, poles of *f(z)*, Residues, Cauchy's Residue Theorem (withoutproof) **Self-learning Topics:** Application of Residue Theorem to evaluate real integrations.	**06**
03	**Module: Statistical Techniques** Karl Pearson's Coefficient of correlation (r) and related concepts withproblems arman's Rank correlation coefficient (R) (Repeated& non repeatedranks problems), Lines of regression, Fitting of first and second degreecurves. **Self-learning Topics:** Covariance, fitting of exponential curve.	**06**
04	**Module: Probability Theory:** Conditional probability, Total Probability and Baye's Theorem. Discrete and Continuous random variables, Probability mass and densityfunction, Probability distribution for randomvariables, Expectation, Variance, Co-variance, moments, Moment generatingfunctions, (Four moments about the origin &about themean). **Self- learning Topics:** Properties variance and covariance,	**06**
05	**Module: Probability Distribution and Sampling Theory-I** Probability Distribution: Poisson and Normal distribution, Sampling distribution, Test of Hypothesis, Level of Significance,Critical region, One-tailed, and two-tailed test, Degree of freedom. Students' t-distribution (Small sample). Test the significance of single samplemean and two independent sample means and paired t-test) **Self -learning Topics: Test** of significance of large samples, Proportion test, Survey based project.	**06**
06	**Module: Sampling theory-II** 6.1 Chi-square test: Test of goodness of fit and independence of attributes (Contingencytable) including Yate's Correction. 6.2 Analysis of variance: F-test (significant difference between variances of two samples) **Self- learning Topics:** ANOVA**:** One way classification, Two-way classification (short- cut method).	**06**

Assessment:

Term Work:

General Instructions:

1) Batch wise tutorials are to be conducted. The number of students per batch should be as per University pattern forpractical.
2) Students must be encouraged to write at least 6 class tutorials on entiresyllabus.
3) A group of 4-6 students should be assigned a self-learning topic. Students should prepare a presentation/problem solving of 10-15 minutes. This should be considered as mini project in Engineering mathematics. This project should be graded for 10 marks depending on the performance of the students.

The distribution of Term Work marks will be as follows –

1.	Attendance (Theory and Tutorial)	05 marks
2.	Class Tutorials on entire syllabus	10 marks
3.	Mini project	10 marks

Internal Assessment for 20 marks: Consisting Two Compulsory Class Tests First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I). Duration of each test shall be one hour.

End Semester Examination: Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
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 any module other than module 3)
4. Only Four questions need to be solved.

References:

1. Higher Engineering Mathematics, Dr. B. S. Grewal, Khanna Publication
2. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley Eastern Limited,
3. Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa publication, 4. Vector Analysis, Murray R. Spiegel, Schaum Series
4. Complex Variables and Applications, Brown and Churchill, McGrawHilleducation
5. Probability, Statistics and Random Processes, T. Veerarajan, McGrawHilleducation.

Course Code	Course Name	Credits
MEC402	**Fluid Mechanics**	**03**

Objectives:

1. To study Fluid Statics and Fluid Dynamics.
2. To acquaint with dimensional analysis of Thermal and Fluid systems.
3. To familiarize with application of mass, momentum and energy equations in fluid flow.
4. To study various flow measurement techniques.
5. To familiarize with the dynamics of fluid flows and the governing nondimensional parameters.

Outcomes: Learner will be able to…

1. **Define** properties of fluids**, classify** fluids and **evaluate** hydrostatic forces on various surfaces.
2. **Illustrate** understanding ofdimensional analysis of Thermal and Fluid systems.
3. **Differentiate** velocity potential function and stream function and solve for velocity and acceleration of a fluid at a given location in a fluid flow.
4. **Formulate** and **solve** equations of the control volume for fluid flow systems and Apply Bernoulli's equation to various flow measuring devices.
5. **Calculate** pressure drop in laminar and turbulent flow, evaluate major and minor losses in pipes.
6. **Calculate** resistance to flow of incompressible fluids through closed conduits and over surfaces.

Module	Detailed Contents	Hours
1.	**1.1 Basic Concepts:** Significance of fluid mechanics, physical properties of fluid, Newton's law of viscosity, Newtonian and non-Newtonian Fluid. **1.2 Fluid Statics:** Pascal's law, hydrostatic law, hydrostatic force on submerged surfaces (vertical, inclined & curved). Archimedes principle, buoyancy.	**06**
2.	**2.1 Fluid Kinematics:** Classification of fluid flow, streamline, path line, streak line, acceleration of fluid particle, differential equation of continuity, rotational flow and vortices, stream function, potential function, concept of circulation. **2.2 Dimensional Analysis:** Introduction to dimensional analysis of thermal and fluid systems, Methods of dimensional analysis - Buckingham π Theorem and Rayleigh's Method (Only derivations, no numerical)	**07**
3.	**3.1 Fluid Dynamics:** Concept of control volume and control surface, Importance of Reynolds Transport theorem (RTT) and its derivation (No numerical). Forces acting on fluid in motion, Euler's equation in Cartesian coordinates, Expression of Bernoulli's equation from principle of energy conservation and by integration of Euler's equation. Application of Bernoulli's equation in Orifice meter, Venturi meter, Rotameter and Pitot tube. Momentum of fluid in motion: impulse momentum relationship and its	**09**

	applications for determination of thrust for pipe bend.	
4.	**4.1 Laminar Viscous flow:** Introduction to Reynolds number, critical Reynolds number, Navier-Stokes equation of motion, Relationship between shear stress and pressure gradient in laminar flow, Laminar flow between parallel plates (Plane Poiseuille&Couette flow), Laminar flow in circular pipe (Hagen-Poiseuille flow).	**06**
5.	**5.1 Flow through pipes** : Reynolds experiment, Head loss in pipes due to friction (Darcy-Weisbach equation), Loss of energy in pipe (major and minor), Hydraulic gradient and Energy gradient line, Pipes in series and parallel, concept of equivalent pipe.	**06**
6.	**6.1 Hydrodynamic Boundary Layer Theory:** Concept of formation of boundary layer, boundary layer parameters, boundary layer along a long thin plate and in pipe, Prandtl boundary layer equation, Separation of boundary layer and its methods of control. **6.2 Flow around submerged objects:** Concept of drag and lift, Types of drag, Streamlined and bluff bodies, Drag and lift on an aerofoil.	**05**

Assessment:

Internal Assessment for 20 marks: Consisting Two Compulsory Class Tests First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I). Duration of each test shall be one hour.

End Semester Examination: Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
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 any module other than module 3)
4. Only Four questions need to be solved.

References:

1. Fluid Mechanics by Yunus A Cengel and John M Cimbala, Tata McGraw Hill Education, 3rd Edition, 2014.
2. Fluid Mechanics and Machinery by C S P Ojha, Chandramouli and R Berndtsson, Oxford University Press, 1st Edition, 2010.
3. Fox and McDonald's Introduction to Fluid Mechanics by Philip J. Pritchard and John W. Mitchell, Wiley Publishers, 9th Edition,2016.
4. A textbook of Fluid Mechanics by R K Bansal, Laxmi Publication, 1st Edition, 2015.
5. Fluid Mechanics by Frank M. White, McGraw Hill Education, 7th Edition, 2011.
6. Fluid Mechanics by Victor Streeter, Benjamin Wylie and K W Bedford, McGraw Hill Education, 9thEdition, 2010.
7. Engineering Fluid Mechanics by K. L. Kumar, Eurasia Publishing House (P) Ltd, 1st Edition and Reprint 2016.
8. Introduction to Fluid Mechanics by James A. Fay, MIT Press, Campbridge, 1st Edition, 1996.
9. Fluid Mechanics and Hydraulics by Suresh Ukarande, Ane Books Pvt.Ltd, Revised & Updated 1st Edition, 2016.

Course Code	Course Name	Credits
MEC403	**Kinematics of Machinery**	**03**

Objectives:

1. To acquaint with basic concept of kinematics and kinetics of machine elements
2. To familiarize with basic and special mechanisms
3. To study functioning of motion and power transmission machine elements

Outcomes: Learner will be able to…

1. Identify various components of mechanisms
2. Develop mechanisms to provide specific motion
3. Draw velocity and acceleration diagrams of various mechanisms
4. Choose a cam profile for the specific follower motion
5. Predict condition for maximum power transmission in the case of a belt drive
6. Illustrate requirements for an interference-free gear pair

Module	Content	Hours
1	**1.1 Kinetics of Rigid Bodies** Concept of mass moment of inertia and its application to standard objects. 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** Structure, Machine, Mechanism, Kinematic link & its types, Kinematic pairs, Types of constrained motions, Types of Kinematic pairs, Kinematic chains, Types of joints, Degree of freedom (mobility), Kutzbach mobility criterion, Grűbler's criterion & its limitations Four bar chain and its inversions, Grashoff's law, Slider crank chain and its inversions, Double slider crank chain and its inversions	**07**
2	**Special Mechanisms** (No problems on this module) **2.1 Straight line generating mechanisms:** Introduction to Exact straight line generating mechanisms - Peaucillier's and Hart's Mechanisms, Introduction to Approximate Straight line generating mechanisms- Watt's, Grasshopper mechanism, Tchebicheff's mechanisms **2.2 Offset slider crank mechanisms** - Pantograph, Hook-joint (single and double). **2.3 Steering Gear Mechanism** - Ackerman, Davis steering gears	**04**
3	**3.1 Velocity Analysis of Mechanisms (mechanisms up to 6 links)** Velocity analysis by instantaneous centre of rotation method (Graphical approach), Velocity analysis by relative velocity method (Graphical approach) **3.2 Acceleration Analysis of Mechanisms (mechanisms up to 6 links)** Acceleration analysis by relative method including pairs involving Coriolis acceleration (Graphical approach)	**10**
4	**Cam and Follower Mechanism** 4.1 Cam and its Classification based on shape, follower movement, and manner of constraint of follower; Followers and its Classification based on shape, movement, and location of line of movement; Cam and follower terminology; 4.2 Motions of the follower: SHM, Constant acceleration and deceleration (parabolic), Constant velocity, Cycloidal; Introduction to cam profiles (No problems on this point)	**04**

5	**Belts, Chains and Brakes:** **5.1 Belts**: Introduction, Types and all other fundamentals of belting, Dynamic analysis –belt tensions, condition of maximum power transmission **5.2 Chains** (No problems)**:** types of chains, chordal action, variation in velocity ratio, length of chain (No problems) **5.3 Brakes** (No problems)**:** Introduction, types and working principles, Introduction to braking of vehicles	**04**
6	**Gears and Gear Trains:** **6.1 Gears**- Introduction, Types, Law of gearing, Forms of teeth, Details of gear terminology, Path of contact, Arc of contact, Contact ratio, Interference in involutes gears, Minimum number of teeth for interference free motion, Methods to control interference in involutes gears, Static force analysis in gears - spur, helical, bevel, worm & worm wheel (No problems on this point) **6.2 Gear Trains:** Kinematics and dynamic analysis of simple and compound gear trains, reverted gear trains, epi-cycle gear trains with spur or bevel gear combination	**10**

Assessment:

Internal Assessment for 20 marks: Consisting Two Compulsory Class Tests First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I). Duration of each test shall be one hour.

End Semester Examination: Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
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 any module other than module 3)
4. Only Four questions need to be solved.

Text Books:

1. S.S. Ratan, “Theory of Machines”, Tata McGraw Hill
2. Ghosh and A.K. Mallik, “Theory of Mechanisms and Machines”, East-West Press

References:

1. J.J. Uicker, G.R. Pennock, and J.E. Shigley, “Theory of Machines and Mechanism”, Oxford Higher Education
2. P.L. Ballaney, “Theory of Machines”, Khanna Publishers
3. M.A. Mostafa, “Mechanics of Machinery”, CRC Press
4. R.L. Norton, “Kinematics and Dynamics of Machinery”, McGraw Hill
5. A.G. Erdman, G.N. Sander, and S. Kota, “Mechanism Design: Analysis and Synthesis Vol I”, Pearson

Course Code	Course Name	Credits
MEC404	**CAD/CAM**	**03**

Objectives:

1. To familiarize with basic concepts of computer graphics.
2. To acquaint with the process of using biomedical data for 3D modelling.
3. To study programming aspects of subtractive manufacturing process.
4. To familiarize with basic process of additive manufacturing in particularly 3D printing.

Outcomes: Learner will be able to…

1. Identify suitable computer graphics techniques for 3D modelling.
2. Transform, manipulate objects & store and manage data.
3. Develop 3D model using various types of available biomedical data.
4. Create the CAM Toolpath for specific given operations.
5. Build and create data for 3D printing of any given object using rapid prototyping and tooling processes.
6. Illustrate understanding of various cost effective alternatives for manufacturing products.

Module	Details	Hours
1.	**Computer Graphics** 1.1 Introduction: Scope of CAD/CAM in product life cycle, CAD/CAM hardware and software, 2D and 3D computer graphics representation, Mapping of Geometric Models. 1.2 Parametric representation of curves and surfaces: Synthetic Curves - Bezier curves, Hermite Curves, B-spline curves. Surface representation. 1.3 Solid Modeling: Constructive solid geometry (CSG), Boundary Representation (B-Rep), Wire Frame Modeling, Solid Modeling, Surface Modeling, Parametric Modeling, Feature based modeling, Constraint Based Modeling.	**06**
2.	**Geometric Transformation** 2.1 Homogeneous Coordinate system, Matrix representation, Concatenations, 2D and 3D geometric transformation (Translation, Reflection, Scaling, Rotation)	**07**
3.	**Modeling based on Biomedical data** 3.1 Introduction to medical imaging: Computed tomography (CT), Cone beam CT (CBCT), Magnetic resonance (MR), Noncontact surface scanning, Medical scan data , Point cloud data 3.2 Working with medical scan data: Pixel data operations, Using CT data: a worked example, Point cloud data operations, Two-dimensional formats, Pseudo 3D formats, True 3D formats, File management and exchange	**06**
4.	**Subtractive Manufacturing** 4.1 Introduction: NC/CNC/DNC machines, Machining Centers, Coordinate system 4.2 CNC machining practices and programming: setup, and operation of two- and three-axis CNC machines programming using manual part programming method, Canned Cycles.	**07**

5.	**Additive Manufacturing** 5.1 Rapid Prototyping: Introduction, Classification of RP Processes, Advantages & disadvantages. RP Applications; in Design, Concept Models, Form & fit checking, Functional testing, CAD data verification, Rapid Tooling, and bio fabrication. 5.2 Working Principle, Application, Advantages & disadvantages: of Stereolithography Apparatus (SLA) Selective Laser Sintering (SLS), 3D Printing, Fused Deposition Modeling (FDM), and Laminated Object Manufacturing (LOM)	**06**
6.	**Virtual Manufacturing** 6.1 Virtual Manufacturing: Introduction, Scope, Socio-economic Aspects and Future Trends	**04**

Assessment:

Internal Assessment for 20 marks: Consisting Two Compulsory Class Tests First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I). Duration of each test shall be one hour.

End Semester Examination: Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
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 any module other than module 3)
4. Only Four questions need to be solved.

References:

1. CAD/ CAM, Theory & Practice, Ibrahim Zeid, R. Sivasubramanian, Tata McGraw Hill Publications
2. CAD/CAM Principles and Applications, P. N. Rao, Tata McGraw Hill Publications
3. CAD/CAM Computer Aided and Manufacturing, Mikell P. Groover and Emory W. Zimmers, Jr., Eastern Economy Edition
4. CNC Technology and Programming, Krar, S., and Gill, A., McGraw Hill Publishers.
5. Medical Modelling The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd.
6. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, I. Gibson l D. W. Rosen l B. Stucker, Springer Publication.
7. Rapid Prototyping and Manufacturing, P. F. Jacobs, Society of Manufacturing Engineers
8. Advanced Machining and Manufacturing Processes, Kaushik Kumar DivyaZindani, J. Paulo Davim, Springer International Publishing

Course Code	Course Name	Credits
MEC404	**Industrial Electronics**	**03**

Objectives:

1. To study power electronic switches and circuits and their applications.
2. To acquaint with basics of analog and digital circuits for the design of mechanical processes control.
3. To study structure, working and characteristics of different types of industrial electric motors and their selection for a particular application.

Outcomes: Learner will be able to…

1. Illustrate construction, working principles and applications of power electronic switches.
2. Identify rectifiers and inverters for dc and ac motor speed control.
3. Develop circuits using OPAMP and Timer IC 555.
4. Identify digital circuits for industrial applications.
5. Demonstrate the knowledge of basic functioning of microcontrollers.
6. Analyze speed-torque characteristics of electrical machines for speed control.

Module	Detailed Contents	Hours
1.	**Semiconductor Devices:** Review of diodes, V-I characteristics and Applications of: rectifier diode, zener diode, LED, photodiode; SCR V-I characteristics, UJT triggering circuit, 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 of Power BJT, power MOSFET, IGBT; Comparison of SCR, Triac, Power BJT, power MOSFET, IGBT	**8**
2.	**Phase controlled rectifiers and Bridge inverters:** Full wave controlled rectifier using SCR's(semi controlled, fully controlled) with R load only, Block diagram of closed loop speed control of DC motors, 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)	**7**
3.	**Operational amplifiers and 555 Timer:** Operational amplifier circuits, Ideal OPAMP behaviour, common OPAMP ICs; Basic OPAMP circuits- Inverting amplifier, Non-inverting amplifier, Voltage follower (Buffer), Comparator, Instrumentation Amplifier, Active first order filter: Low pass and high pass filter; Power Op Amps, IC-555 timer-Operating modes: monostable, astablemultivibrator	**4**
4.	**Digital logic and logic families:** Boolean algebra and logic gates. logic families: Logic Levels, Noise Immunity, Fan Out, Propagation Delay, TTL and CMOS logic families, Flip flops: Set Reset(SR), Trigger(T), clocked F/Fs; Registers, Multiplexer and Demultiplexer applications	**4**

5.	**Microprocessor and Microcontrollers:** Overview of generic microprocessor, architecture and functional block diagram, Comparison of microprocessor and microcontroller MSP430 architecture, assembly language programming, C compiler programming, basics of interfacing with external input / output devices (like reading external analog voltages, digital input output) Applications of microcontroller: Temperature measurement, Speed Measurement using Proximity Sensor, Piezoelectric Actuator Drive	**8**
6.	**Motors**: Review and comparison of DC motors and AC induction motors, Basic principles of speed control of AC induction motor, Basics of BLDC motor, Linear Actuator motor, Servo Motor; Motor Specifications, suitability of each motor for various industrial applications, Selection and sizing of motors for different applications. Applications for pumps, conveyors, machine tools, Microcontroller based speed control for Induction Motor.	**5**

Assessment:

Internal Assessment for 20 marks: Consisting Two Compulsory Class Tests First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I). Duration of each test shall be one hour.

End Semester Examination: Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total six questions, each carrying 20 marks
2. Question 1 will be compulsory and should cover maximum contents of the curriculum
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 any module other than module 3)
4. Only Four questions need to be solved.

References:

1. Power Electronics M.H. Rashid, Prentice-Hall of India
2. Power Electronics, P S Bhimbra
3. Power Electronics, VedamSubramanyam, New Age International
4. Power Electronics, Ned Mohan, Undeland, Robbins, John Wiley Publication
5. Electronic Devices and Circuits, Robert Boylestad and Louis Nashelsky, Prentice-Hall
6. Industrial Electronics and Control by S K Bhattacharya, S Chatterjee, TTTI Chandigarh
7. Modern Digitals Electronic, Jain R P, Tata McGraw Hill, 1984
8. Digital principal and Application, Malvino and Leach, Tata McGraw Hill, 1991
9. Fundamentals of Microcontrollers and Embedded System, Ramesh Gaonkar, PENRAM
10. MSP430 Microcontroller Basics, John H. Davies, Newnes; 1 edition 2008

Course Code	Course Name	Credits
MEL401	**Industrial Electronics**	**01**

Objectives:

1. To study operational characteristics of various analog and digital circuits.
2. To study microcontroller-based applications and its programming
3. To study operational characteristics of electrical motors.

Outcomes: Learner will be able to…

1. Demonstrate characteristics of various electrical and electronics components
2. Develop simple applications built around these components
3. Identify use of different logic gates and their industrial applications
4. Built and demonstrate parameter measurements using microcontroller
5. Test and Analyze speed-torque characteristics of electrical machines for speed control.

List of Experiment: Minimum ten experiments need to be performed, six from 1-9 and four from 10-15.

List of experiments:

Sr.No.	**List of Experiments**
1.	MOSFET / IGBT as a switch
2.	V-I characteristics of SCR
3	Triggering circuit of SCR (UJT)
4.	Light dimmer circuit using Diac-Triac
5.	Full wave Rectifier using SCR with R /R-L load
6.	Single phase Bridge inverter with rectifier load
7.	OPAMP as Inverting and Non inverting amplifier.
8.	OPAMP as a Comparator
9.	555 timer as AstableMultivibrator
10.	Study of logic gates and Logic Operations like, NOT, AND, OR
11.	Realization of basic gates using universal gates
12.	Speed control of DC motor
13.	Speed control of induction motor
14.	Simple programs using microcontroller
15.	Simple microcontroller based application like Temp Measurement/ Speed Measurement using Proximity Sensor/ Piezoelectric Actuator Drive
16.	Microcontroller based speed control for Induction Motor

Assessment:

Distribution of marks for term work

Laboratory work	20 Marks
Attendance	05 Marks

End Semester Practical/Oral Examination:

1. Pair of Internal and External Examiner should conduct practical/viva based on contents
2. Distribution of marks for practical/viva examination shall be as follows:
    a. Practical performance 15 marks
    b. Viva 10 marks
3. Evaluation of practical examination to be done based on the experiment performed and the output of theexperiment during practical examination
4. Students work along with evaluation report to be preserved till the next examination

Course Code	Course Name	Credits
MEL402	**Kinematics of Machinery**	**01**

Objectives:

1. To familiarize with various mechanisms and inversions
2. To acquaint with basics of power transmission systems

Outcomes: Learner will be able to…

1. Draw velocity diagram usingInstantaneous Centre method
2. Find velocity and acceleration of a point on a four-bar mechanism by using Relative method.
3. Analyze velocity and acceleration of a specific link of a slider crank mechanism using graphical approach by Relative method.
4. Plot displacement-time, velocity-time, and acceleration-time diagrams of follower motion.
5. Draw cam profile for the specific follower motion.
6. Develop and build mechanisms to provide specific motion.

Term Work: Comprises of (a) and (b)

(a) Laboratory Work

Sr. No.	Details	Hours
1.	Analysis of velocity of mechanisms by Instantaneous Centre of Rotation method – 3 to 5 problems	**04**
2.	Analysis of velocity of mechanisms by Relative Velocity method – 3 to 5 problems	**04**
3.	Analysis of acceleration of mechanism by Relative method including pairs involving Coriolis acceleration – 3 to 5 problems	**04**
4.	Motion analysis and plotting of displacement–time, velocity-time and acceleration-time, jerk-time, and layout of cam profiles - 2 to 3 problems	**06**
5.	Mini project on design and fabrication of any one mechanism for a group of maximum 4 students	**08**

(b) Assignments: Minimum two problems on each of the following topics

Sr. No.	Topic
1.	Belts and Chains
2.	Brakes
3.	Gears and Gear trains

Assessment:

Distribution of marks for Term Work shall be as follows:

1. Laboratory Work : 15marks.
2. Assignments : 05 Marks
3. Attendance : 05 marks.

Course Code	Course Name	Credits
MEL403	**Python Programming**	**01**

Objectives:

1. To introduce basic concepts of Python programming language as well as common packages and libraries.
2. To generate an ability to design, analyze and perform experiments on real life problems in mechanical engineering using python.

Outcomes: Learner will be able to….

1. Demonstrate understand of basic concepts of python programming.
2. Identify, install and utilize python packages
3. Develop and execute python programs for specific applications.
4. Develop and build python program to solve real-world engineering problems
5. Prepare a report on case studies selected.

Module	Details	Hours
1.	Introduction to python and its applications. Installation of Python and setting up a programming environment such as Anaconda and Spyder Python Basics: Variable and variable types, Booleans, Numbers (integers, floats, fractions, complex numbers), strings, lists, tuples, sets, dictionaries. bytes and byte arrays, Manipulating variables, indexing, slicing, basic operators (arithmetic, relational, logical, membership, identity). String methods, list methods, list slicing, set methods, in built python functions, input and output functions.	**4**
2.	Basic Coding in Python: If, else, elif statements, for loops, range function, while loops, List comprehensions, functions in python. Introduction to OOP, Classes, Objects, Reading and writing files.	**2**
3.	Python libraries: Installing of different libraries, packages or modules. Basic concepts of the following libraries: NumPy, Matplotlib, Pandas, SciPy Optional libraries based on case studies in Module 4: Pillow, Scikit, OpenCV, Python in Raspberry Pi	**4**
4.	Case Studies using Python (Select any 3): 1. Solving a linear differential equation using SciKit and plotting the result in matplotlib. Students can use differential equations from any previous topic studied in the programme such as mechanics, materials science, fluid mechanics, kinematics of machines, thermodynamics, production etc. 2. Image processing and manipulation and auto detection of any object. Applications in self-driving cars may be discussed. 3. Python programming of a Raspberry PI: Students can sense using a sensor, process the reading and then control some physical output (like motor or LED) 4. Project involving basic machine learning (Students should understand the basic concepts of machine learning and apply to specific situation)	**6**

	5. Any other case study that uses Python to solve Mechanical Engineering problems. 6. Customizing applications by writing API programs using python like to create joints, get physical properties, get circle and arc data from edge.	

Note: In module 4: Advanced learners may opt to do multiple case studies beyond minimum required. Student with laptops or personal computers should be encourages to install Python on it and independently work on these projects.
Students should prepare a short report for each case study and submit their findings. They should also give a presentation on their case study as well as a live demonstration of their projects.

Assessment:

Internal:
Distribution of term work marks as below;

1. Laboratory Work: 5 Marks
2. Case Study Reports and Presentation: 5 marks each: 15 marks
3. Attendance: 5 Marks

External Practical/Oral:

1. Practical examination of 2 hours duration followed by Oral to be conducted by Pair of Internal and External Examiner based on contents
2. Evaluation of practical examination to be done by examiner based on the printout of students work
3. Distribution of marks
    a. Practical examination: 20 marks
    b. Oral based on practical examination: 05 marks

Note: Students work along with evaluation report to be preserved till the next examination

References:

1. Core Python Programming, Dr. R. NageswaraRao, Dreamtech Press
2. Programming through Python, M.T.Savaliya and R.K.Maurya, StarEdu Solutions
3. Beginning Python: Using Python 2.6 and Python 3.1. James Payne, Wrox publication2.
4. Any digital resources and online guides for python or its packages. Such as "The Python Tutorial", http://docs.python.org/release/3.0.1/tutorial/

Course Code	Course Name	Credits
MESBL401	**Skill based Lab: CNC and 3-D Printing**	**02**

Objectives:

1. To familiarize with subtractive manufacturing process in particular CNC systems.
2. To acquaint with basic part programing process for specific operations.
3. To familiarize with additive manufacturing process in particularly 3D printing.
4. To acquaint with basic process of 3D modeling using biomedical data.

Outcomes: Learner will be able to….

1. Develop and execute part programing for any given specific operation.
2. Build any given object using various CNC operations.
3. Demonstrate CAM Tool path and prepare NC- G code.
4. Develop 3D model using available biomedical data.
5. Build any given real life object using 3D printing process.
6. Convert 2D images into 3D model

Sr. No.	List of Exercises	Hours
1	Part programming and part fabrication on CNC Turning trainer (Involving processes like Step turning, facing, Taper turning, threading, etc.) (One job in a group of 4-5 students)	**24**
2	Part programming and part fabrication on CNC Milling trainer (Involving processes like contouring, drilling, facing, pocketing etc.) (One job in a group of 4-5 students)	
3	Part Programming Simulation for any Unconventional Machining Process (Electric Discharge Machining, laser cutting Machining, Plasma Cutting Machining etc.)	
4	Tool-path generation by translation of part geometry from computer aided design (CAD) to computer aided manufacturing (CAM) systems.	
5	Post processing of Code generated via CAM system	
6	Case Study: Report on a visit conducted to any Commercial CNC Machining Centre explaining the Design features, pre processing in CAM software and its capabilities.	
7	Development of physical 3D mechanical structure using any one of the rapid prototyping processes.	**24**
8	Check the constraints of any two RP systems for features like layer thickness, orientation of geometry, support generation, post processing etc.	

9	Design an object with free form surface & printing it using any RP process.	
10	Segmentation in Slicer's Segment Editor module for the purpose of 3D printing (3D Slicer open source) (Application: Any Bone part as per available Dicom files)	
11	Creation of 3D model from 2D images using any image processing software and printing it. (3D Slicer open source) (Application: Any body organ like Heart, Gallbladder etc. as per available Dicom files)	
12	Case Study: Usability of rapid tooling integrated investment casting process, with their advantages and limitations in any one of emerging areas of dentistry, jewelry, surgical implants, turbine blades, etc.	

Assessment:

Term work shall consist of

- Any **4 exercises from 1 to 6 and 3 exercises from 7 to 11 of the above list**
- Exercise 12 is mandatory.

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

1. Part A Exercises: 10 Marks
2. Part B Exercises: 10 Marks
3. Attendance: 05 Marks

Practical/Oral examination

1. Each student will be given a practical assignment on the basis of the above exerciseswhich will be completed within a given time and assessed by examiners during the oral examination.
2. The distribution of marks for oral-practical examination shall be as follows:
   a. Practical Assignment : 15 marks
   b. Oral : 10 marks
3. Evaluation of practical/oral examination to be done based on the performance of practical assignment.
4. Students work along with evaluation report to be preserved till the next examination

References:

1. CAD/CAM Principles and Applications, P. N. Rao, Tata McGraw Hill Publications
2. CNC Technology and Programming, Krar, S., and Gill, A., McGraw Hill Publishers.
3. CNC Programming for Machining, Kaushik Kumar, ChikeshRanjan, J. Paulo Davim, Springer Publication.
4. Medical Modelling The Application of Advanced Design and Rapid Prototyping Techniques in Medicine, Richard Bibb, Dominic Eggbeer and Abby Paterson, Woodhead Publishing Series in Biomaterials: Number 91, Elsevier Ltd.

5. Biomaterials, artificial organs and tissue engineering, Edited by Larry L. Hench and Julian R. Jones, Woodhead Publishing and Maney Publishing, CRC Press 2005
6. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, I. Gibson l D. W. Rosen l B. Stucker, Springer Publication.
7. Rapid Prototyping and Manufacturing, P. F. Jacobs, Society of Manufacturing Engineers

Course code	Course Name	Credits
MEPBL 401	**Mini Project - 1B**	**02**

Objectives

1. To acquaint with the process of identifying the needs and converting it into the problem.
2. To familiarize the process of solving the problem in a group.
3. To acquaint with the process of applying basic engineering fundamentalsto attempt solutions to the problems.
4. To inculcate the process of self-learning and research.

Outcome: Learner will be able to…

5. Identify problems based on societal /research needs.
6. Apply Knowledge and skill to solve societal problems in a group.
7. Develop interpersonal skills to work as member of a group or leader.
8. Draw the proper inferences from available results through theoretical/ experimental/simulations.
9. Analyse the impact of solutions in societal and environmental context for sustainable development.
10. Use standard norms of engineering practices
11. Excel in written and oral communication.
12. Demonstrate capabilities of self-learning in a group, which leads to life long learning.
13. Demonstrate project management principles during project work.

Guidelines for Mini Project

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students hall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty supervisor may give inputs to students during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert the best solution into working model using various components of their domain areas and demonstrate.

- The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.
- With the focus on the self-learning, innovation, addressing societal problems and entrepreneurship quality development within the students through the Mini Projects, it is preferable that a single project of appropriate level and quality to be carried out in two semesters by all the groups of the students. i.e. Mini Project 1 in semester III and IV. Similarly, Mini Project 2 in semesters V and VI.
- However, based on the individual students or group capability, with the mentor's recommendations, if the proposed Mini Project adhering to the qualitative aspects mentioned above gets completed in odd semester, then that group can be allowed to work on the extension of the Mini Project with suitable improvements/modifications or a completely new project idea in even semester. This policy can be adopted on case by case basis.

Guidelines for Assessment of Mini Project:

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work marks for both semesters shall be as below;
    - Marks awarded by guide/supervisor based on log book : 10
    - Marks awarded by review committee : 10
    - Quality of Project report : 05

Review/progress monitoring committee may consider following points for assessment based on either one year or half year project as mentioned in general guidelines.

One-year project:

- In first semester entire theoretical solution shall be ready, including components/system selection and cost analysis. Two reviews will be conducted based on presentation given by students group.
    - First shall be for finalisation of problem
    - Second shall be on finalisation of proposed solution of problem.
- In second semester expected work shall be procurement of components/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.
    - First review is based on readiness of building working prototype to be conducted.
    - Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.

Half-year project:

- In this case in one semester students' group shall complete project in all aspects including,
    - Identification of need/problem
    - Proposed final solution
    - Procurement of components/systems
    - Building prototype and testing
- Two reviews will be conducted for continuous assessment,
    - First shall be for finalisation of problem and proposed solution
    - Second shall be for implementation and testing of solution.

Assessment criteria of Mini Project.

Mini Project shall be assessed based on following criteria;

1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact
7. Innovativeness
8. Cost effectiveness and Societal impact
9. Full functioning of working model as per stated requirements
10. Effective use of skill sets
11. Effective use of standard engineering norms
12. Contribution of an individual's as member or leader
13. Clarity in written and oral communication

- In **one year, project**, first semester evaluation may be based on first six criteria's and remaining may be used for second semester evaluation of performance of students in mini project.
- In case of **half year project** all criteria's in generic may be considered for evaluation of performance of students in mini project.

Guidelines for Assessment of Mini Project Practical/Oral Examination:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organisations having experience of more than five years approved by head of Institution.
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Mini Project shall be assessed based on following points;

1. Quality of problem and Clarity
2. Innovativeness in solutions
3. Cost effectiveness and Societal impact
4. Full functioning of working model as per stated requirements
5. Effective use of skill sets
6. Effective use of standard engineering norms
7. Contribution of an individual's as member or leader
8. Clarity in written and oral communication