AC- 29/06/2021
Item No.- 6.10

UNIVERSITY OF MUMBAI

Bachelor of Engineering

in

Automobile Engineering

Third Year with Effect from AY 2021-22

(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)

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	**Third Year B.E. in Automobile Engineering**
2	Eligibility for Admission	**After Passing Second Year Engineering as per the Ordinance 0.6243**
3	Passing Marks	**40%**
4	Ordinances / Regulations (if any)	**Ordinance 0.6243**
5	No. of Years / Semesters	**8 semesters**
6	Level	~~P.G.~~ **/ U.G./** ~~Diploma / Certificate~~ (Strike out which is not applicable)
7	Pattern	~~Yearly~~ **/ Semester** (Strike out which is not applicable)
8	Status	~~New~~ **/ Revised** (Strike out which is not applicable)
9	To be implemented from Academic Year	**2021-2022**

Date

Dr. S. K. Ukarande
Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

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 171, 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	Dr Anuradha Muzumdar
Associate Dean	Dean
Faculty of Science and Technology	Faculty of Science and Technology
University of Mumbai	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.

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Associate Dean
Faculty of Science and Technology
University of Mumbai

Dr Anuradha Muzumdar
Dean
Faculty of Science and Technology
University of Mumbai

Preface

Engineering education in India, in general, is being revamped so as to impart the theoretical knowledge along with industrial exposure. It is our attempt, when we are introducing a new curriculum; to bridge the industry-academia gap. To enable this, we have introduced components such as skill-based laboratories and project-based learning. We trust that this will allow the learner to apply knowledge gained in previous and current semesters to solve problems for gaining better understanding. What once were pure mechanical systems have now been transformed into multidisciplinary systems of mechatronics, electronics and computer science. Interdisciplinary knowledge is gaining importance as we are moving towards automated world as technology advances. Keeping this in mind the curriculum has been designed in a way so that learner shall be acquainted with many Interdisciplinary subjects.

Automobile Engineering is one of the fastest growing sectors, with lots of inventions and innovations happening. The graduating Automobile Engineers can contribute in the areas such as engines, transmission, safety and stability, energy and alternate energy etc. The challenges for our budding engineers would be manifold, when electric vehicles are already gaining popularity and driverless cars becoming a reality.

Engineers develop new technological solutions. During the engineering design process, the responsibilities of the engineer may include defining problems, conducting and narrowing research, analyzing criteria, finding and analyzing solutions, and making decisions. The Program Educational Objectives proposed for the undergraduate program in Automobile Engineering are listed below;

1. To prepare the stake holder to exhibit leadership qualities with demonstrable attributes in lifelong learning to contribute to the societal needs.
2. To make ready the stake holder to pursue higher education for professional development
3. To help the stake holder to acquire the analytical and technical skills, knowledge, analytical ability attitude and behavior through the program
4. To prepare the stakeholders with a sound foundation in the mathematical, scientific and engineering fundamentals
5. To motivate the learner in the art of self-learning and to use modern tools for solving real life problems and also inculcate a professional and ethical attitude and good leadership qualities
6. To Prepare the stake holder to able to Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

We trust this revised version of syllabus come up to the expectations of all stakeholders. We wish to place on record our sincere thanks and appreciations to the various contributors from the academia and industry for their most learned inputs in framing this syllabus.

Board of Studies in Mechanical Engineering

Dr. Vivek K. Sunnapwar : Chairman
Dr. S. M. Khot : Member
Dr. V. M. Phalle : Member
Dr. Siddappa Bhusnoor : Member
Dr. S.S. Pawar : Member
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Program Structure for Third Year Engineering
Semester V & VI
UNIVERSITY OF MUMBAI
(With Effect from 2021-2022)

Semester V

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract.	Theory	Pract.	Total
AEC501	Mechanical Measurements & Controls #	3	--	3	--	3
AEC502	Internal Combustion Engines	3	--	3		3
AEC503	Machine Design	3	--	3	--	3
AEC504	Finite Element Analysis #	3	--	3	--	3
AEDLO501X	Department Level Optional Course – 1#	3	--	3	--	3
AEL501	Measurement and Engine Testing Lab	--	2	--	1	1
AEL502	Machine Design	--	2	--	1	1
AEL503	Finite Element Analysis#	--	2	--	1	1
AESBL501	Professional Communication and Ethics - II #	--	2*+2	--	2	2
AEPBL501	Mini Project – 2 A	--	4$	--	2	2
Total		**15**	**14**	**15**	**07**	**22**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Prac/oral	Total
		Internal Assessment			End Sem Exam	Exam. Duration (in Hrs)			
		Test1	Test2	Avg					
AEC501	Mechanical Measurements & Controls #	20	20	20	80	3	--	--	100
AEC502	Internal Combustion Engines	20	20	20	80	3	--	--	100
AEC503	Machine Design	20	20	20	80	3	--	--	100
AEC504	Finite Element Analysis #	20	20	20	80	3	--	--	100
AEDLO501X	Department Level Optional Course – 1#	20	20	20	80	3	--	--	100
AEL501	Measurement and Engine Testing Lab	--	--	--	--	--	25	25	50

AEL502	Machine Design	--	--	--	--	--	25	--	50
AEL503	Finite Element Analysis#	--	--	--	--	--	25	25	50
AESBL501	Professional Communication and Ethics - II #	--	--	--	--	--	25	25	50
AEPBL501	Mini Project – 2 A	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	--	**125**	**100**	**725**

Department Level Optional Course – 1

Course Code	**Department Level Optional Course – 1**
AEDLO5011	Optimization Techniques#
AEDLO5012	Design of Experiments#
AEDLO5013	Computational Methods#

*** Theory class to be conducted for full class**
$ indicates work load of Learner (Not Faculty), for Mini Project
 # indicates common with Mechanical Engineering

Note: Students are required to undergo Internship (Garage Training) of minimum 4 weeks in vacation of Semester V.

Semester VI

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract. Tut.	Theory	Pract.	Total
AEC601	Automotive System Design	4	--	4	--	4
AEC602	Mechanical Vibrations	3	--	3		3
AEC603	Vehicle Body Engineering and Safety	3	--	3	--	3
AEC604	Automation and Artificial Intelligence #	3	--	3	--	3
AEDLO602X	Department Optional Course – 2#	3	--	3	--	3
AEL601	Automotive System Design	--	2	--	1	1
AEL602	Mechanical Vibrations	--	2	--	1	1
AEL603	Vehicle Body Engineering and Safety	--	2	--	1	1
AESBL601	Measurements & Automation #	--	4	--	2	2
AEPBL601	Mini Project – 2 B	--	4$	--	2	2
Total		**16**	**14**	**16**	**07**	**23**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Prac/oral	Total
		Internal Assessment			End Sem Exam	Exam. Duration (in Hrs)			
		Test 1	Test 2	Avg					
AEC601	Automotive System Design	20	20	20	80	3	--	--	100
AEC602	Mechanical Vibrations	20	20	20	80	3	--	--	100
AEC603	Vehicle Body Engineering and Safety	20	20	20	80	3	--	--	100
AEC604	Automation and Artificial Intelligence #	20	20	20	80	3	--	--	100
AEDLO602X	Department Level Optional Course – 2#	20	20	20	80	3	--	--	100
AEL601	Automotive System Design	--	--	--	--	--	25	25	50

AEL602	Mechanical Vibrations	--	--	--	--	--	25	--	25
AEL603	Vehicle Body Engineering and Safety	--	--	--	--	--	25	25	50
AESBL601	Measurements & Automation #	--	--	--	--	--	25	25	50
AEPBL601	Mini Project – 2 B	--	--	--	--	--	25	25	50
Total		**--**	**--**	**100**	**400**	--	**125**	**100**	**725**

Department Level Optional Course – 2

Course Code	**Department Level Optional Course – 2**
AEDLO6021	Press Tool Design#
AEDLO6022	Tool Engineering#
AEDLO6023	Metal Forming Technology#

$ indicates work load of Learner (Not Faculty), for Mini Project
 # indicates common with Mechanical Engineering

Note: Students are required to undergo Internship (Garage Training) of minimum 4 weeks in vacation of Semester VI.

Course Code	Course Name	Credits
AEC501	**Mechanical Measurements and Controls**	**03**

Objectives:

1. To study the principles of precision measuring instruments & their significance.
2. To familiarize with the handling & use of precision measuring instruments/ equipment's.
3. To impart knowledge of architecture of the measurement system.
4. To deliver working principle of mechanical measurement system.
5. To study concept of mathematical modelling of the control system.
6. To acquaint with control system under different time domain.

Outcomes: Learner will be able to…

1. Handle, operate and apply the precision measuring instruments / equipment's.
2. Analyze simple machined components for dimensional stability & functionality.
3. Classify various types of static characteristics and types of errors occurring in the system.
4. Classify and select proper measuring instrument for displacement, pressure, flow and temperature measurements.
5. Design mathematical model of system/process for standard input responses and analyse error and differentiate various types of control systems and time domain specifications
6. Analyse the problems associated with stability.

Module	Details	Hrs.
1	**1.1** Introduction to Metrology, Need for inspection, Fundamental principles and definition, Standards of measurement, Errors in measurements, International standardization. **1.2** Limits, fits and tolerances of interchangeable manufacture, Elements of interchangeable system, Hole based and shaft based systems, Tolerance grades, Types of fits, General requirements of Go & No go gauging, Taylor's principle, Design of Go & No go gauges.	**06**
2	**2.1** Principles of interference, Concept of flatness, Flatness testing, Optical flats, Optical Interferometer and Laser interferometer. **2.2** Surface texture measurement: importance of surface conditions, roughness and waviness, surface roughness standards specifying surface roughness parameters - Ra, Ry, Rz, RMS value etc., Surface roughness measuring instruments. **2.3** Screw Thread measurement: Two wire and three wire methods, Floating carriage micrometer. **2.4** Gear measurement: Gear tooth comparator, Master gears, Measurement using rollers and Parkinson's Tester.	**08**
3	**3.1** Significance of Mechanical Measurements, Classification of measuring instruments, generalized measurement system, types of inputs: Desired, interfering and modifying inputs. **3.2** Static characteristics: Static calibration, Linearity, Static Sensitivity, Accuracy, Static error, Precision, Reproducibility, Threshold, Resolution, Hysteresis, Drift, Span & Range etc.	**06**

4	**4.1** Displacement Measurement: Transducers for displacement, displacement measurement, potentiometer, LVDT, Capacitance Types, Digital Transducers (optical encoder), Nozzle Flapper Transducer **4.2** Strain Measurement: Theory of Strain Gauges, gauge factor, temperature Compensation, Bridge circuit, orientation of strain gauges for force and torque, Strain gauge based load cells and torque sensors **4.3** Pressure Measurement: Elastic pressure transducers viz. Bourdon tubes, diaphragm, bellows and piezoelectric pressure sensors, High Pressure Measurements, Bridge man gauge. Vacuum measurement: Vacuum gauges viz. McLeod gauge, Ionization and Thermal Conductivity gauges **4.4** Flow Measurement: Bernoulli flowmeters, Ultrasonic Flowmeter, Magnetic flow meter, rotameter **4.5** Temperature Measurement: Electrical methods of temperature measurement Resistance thermometers, Thermistors and thermocouples, Pyrometers	**08**
5	**5.1** Introduction to control systems, Classification of control system. Open loop and closed loop systems. **5.2** Mathematical modelling of control systems, concept of transfer function, Block diagram algebra **5.3** Transient and steady state analysis of first and second order system. Time Domain specifications. Step response of second order system. Steady-state error, error coefficients, steady state analysis of different type of systems using step, ramp and parabolic inputs	**06**
6	**6.1** Stability analysis: Introduction to concepts of stability, The Routh criteria for stability **6.2** Experimental determination of frequency response, Stability analysis using Root locus, Bode plot	**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)

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/Reference Books:

1. Engineering. Metrology, I.C. GUPTA, Dhanpat Rai Publications.
2. Engineering. Metrology, R. K. Jain, Khanna Publisher.
3. Measurement Systems: Applications and Design, by EO Doebelin,5th Edition, McGraw Hill
4. Mechanical Engineering Measurements, A. K. Sawhney, Dhanpat Rai & Sons, New Delhi
5. Instrumentation & Mechanical Measurements, A. K. Thayal
6. Control System Engineering by Nagrath I.J. and Gopal M, Wiley EasternLtd.
7. Modem Control engineering: by K. Ogata, Prentice Hall
8. Control systems by Dhanesh Manik, Cengage Learning
9. Engineering Metrology and Measurements by N V Raghavendra and L Krishnamurthy, Oxford University Press.
10. Instrumentation and Control System, W. Bolton, Elsevier
11. Experimental Methods for Engineers by J P Holman, McGraw Hills Int. Edition
12. Engineering Experimentation by EO Doebelin, McGraw Hills Int. Edition
13. Mechanical Measurements by S P Venkateshan, John Wiley & Sons

NPTEL Courses

https://nptel.ac.in/courses/112/103/112103261/ - Principles of Mechanical Measurement, IIT Guwahati

https://nptel.ac.in/courses/112/107/112107242/ - Mechanical Measurement System, IIT Roorkee

https://nptel.ac.in/courses/112/106/112106138/ - Mechanical Measurements and Metrology, IIT Madras

Course Code	Course Name	Credits
AEC502	**Internal Combustion Engines**	**03**

Objectives:

1. To provide fundamental idea on Spark Ignition & Compression Ignition Engines.
2. To familiarise with the complexity in combustion processes.
3. To give clear concept of power generation and engine performance.
4. To gather clear knowledge on effects of emission and its control.
5. To acquaint with recent trends in Engine Technology.

Outcomes: Learner will be able to…

1. Explain the actual engine operation.
2. Analyse the combustion process in IC engines.
3. Illustrate different power boosting methods in IC Engines
4. Analyse operating parameters & performance of IC Engines.
5. Illustrate emission norms and emission control techniques.
6. Comprehend the recent trends in fuels and engines

Module	Details	Hrs
1	**Introduction** Classification of I.C. Engines, Parts of I.C. Engine and their materials, Atkinson Cycle and Miller Cycle, Fuel Air and Actual working cycles analysis, Valve Timing Diagram, LHR & VCR Engines, Homogeneous charge compression Ignition, Rotary Engine-Six stroke engine concept (No Numerical from this module)	04
2	**Spark Ignition Engines** **Fuel Supply System:** Automotive engine air-fuel mixture requirements, principle of carburetion & working (only introduction – No Numerical) Fuel Injection: Single-point and Multipoint injection, Gasoline Direct Injection **Ignition System:** Schematic details and working of different types of Ignition systems in SI Engines **Combustion:** Combustion phenomenon in SI Engines, Ignition delay, Flame propagation, Pressure-Crank angle diagram, Detonation and Knocking, Factors affecting combustion and detonation, Introduction to combustion chamber design, Types of combustion chambers	08

3	**Compression Ignition Engines** **Fuel Injection Systems:** Air injection systems, Airless/solid injection systems, Common rail, individual pump, distributor and unit systems. Injection pumps, Fuel injector, Types of nozzles, Electronically controlled CRDI system **Combustion:** Combustion phenomenon in C I engines, Stages of combustion, Delay period, Knocking, Pressure-Crank angle diagram, Factors affecting combustion and knocking, Types of combustion chambers	08
4	**Engine lubrication:** Types of Lubricants, their properties, SAE rating of Lubricants, Types of Lubrication systems. **Engine Cooling:** Necessity of engine cooling, disadvantages of overcooling, Cooling systems and their comparison: Air cooling, Liquid cooling **Supercharging/Turbo-charging:** Objectives, Limitations, Methods and Types, Different arrangements of Turbochargers. Latest Trends in power boosting methods.	06
5	**Engine Testing and Performance:** Measurement of Brake Power, Indicated Power, Frictional Power, Fuel Consumption, Air flow, BMEP, Performance characteristics of SI and CI Engines, Effects of load and speed on Mechanical, Indicated Thermal, Brake Thermal and Volumetric Efficiencies, Heat Balance Sheet. **Engine Exhaust Emission and its control:** Constituents of exhaust emission and its harmful effects on environment and human health, Formation of NOx, HC, CO and particulate emissions, Methods of controlling emissions; Catalytic convertors, particulate traps, Exhaust Gas Recirculation, EURO and BHARAT norms.	08
6	**I C Engine Fuels:** Gasoline - Alcohol - Hydrogen - Natural Gas and Liquefied Petroleum Gas - Biodiesel- Biogas - Producer Gas: Properties - Suitability - Engine Modifications - Merits and Demerits as fuels. **Basics of Electronic Engine Controls:** Electronic Control Module (ECM): Components, requirement & working. Sensors: Throttle Position, Crankshaft Position, Camshaft Position, Inlet Air Temperature, Coolant Temperature, Mass Air flow and Exhaust Gas Oxygen sensors (their construction and importance in ECM) Electronic Spark control, Air Management system, Idle speed control	05

Text Books:

1. A Course in Internal Combustion Engine, Mathur and Sharma, Dhanpat Rai & Sons, New Delhi, 2001
2. Internal Combustion Engine, V Ganesan, McGraw-Hill, 1995
3. Internal Combustion Engines, Domkundwar & Domkundwar, Dhanpat Rai & Co., 2013

Reference Books:

1. Internal Combustion Engines Fundamentals, Heywood, McGraw Hill, 1988
2. High Speed Combustion Engines, Heldt, Oxford IBH Publishing Co., Calcutta, 1985
3. Internal Combustion Engines, V.L. Maleeve, McGraw-Hill Inc.,US; International 2 Revised ed edition, 1964
4. Fundamental of Internal Combustion Engines, Gill and Smith, 4/E,. Oxford & IBH Publishing Company Pvt. Limited, 2007
5. Fundamentals of Internal Combustion Engines, Gupta, Prentice-Hall of India Pvt.Ltd (June 1, 2006) 2nd ed,
6. Internal Combustion Engine, S.L. Beohar

Assessment:

Internal Assessment for 20 marks:

Consisting of **Two Compulsory Class Tests**

First test based on approximately 40% of content and second test based on remaining contents (approx.40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the syllabus.

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 syllabus**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions to be solved.**

Links for online NPTEL/SWAYAM courses:

1. https://nptel.ac.in/courses/112/103/112103262/
2. https://nptel.ac.in/courses/112/104/112104033/
3. https://onlinecourses.nptel.ac.in/noc20_me42/preview
4. https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-me42/

Course Code	Course Name	Credits
AEC503	**Machine Design**	**03**

Objectives:

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

Outcomes: Learner will be able to…

1. Demonstrate understanding of various design considerations
2. Illustrate basic principles of machine design
3. Design machine elements for static as well as dynamic loading
4. Design machine elements based on strength/ rigidity concepts
5. Use design data books in designing various components
6. Acquire skill in preparing production drawings of various designs

Module	Details	Hrs
1	**Introduction** Mechanical Engineering Design, Design methods; Material properties and their uses in design; Different considerations in design: Design consideration of casting, forging, Manufacturing, Aesthetic & Ergonomics; Basic principle of Machine Design; Modes of failures; Theories of failures; Different Standards & Codes and Preferred Series and Numbers.	**05**
2	**Design against static loads** Cotter joint (Socket & Spigot type); Knuckle joint; Turnbuckle; Eccentrically loaded Bolted Joints (considering initial tightening); Eccentrically loaded Welded joints; Power Screw - screw presses, C-clamps along with the Frame.	**10**
3	**Design of Shaft** Including power transmission and power distribution shafts, under static & fatigue criteria and using ASME code. **Keys** Types of Keys and their selection based on shafting condition **Couplings** Classification of coupling; Design of Flange couplings and Bush pin type flexible couplings.	**10**
4	**Design of Gears** Design of Spur & Helical Gears: Selection of Material; Gear Blank Design; Number of Teeth; Face Width; Beam Strength of Gear Tooth; Permissible Bending Stress; Effective Load on Gear Tooth; Estimation of Module Based on Beam Strength and Wear Strength.	**06**

5	**Design against fluctuating loads** Fluctuating, reversed and repeated stresses; Fatigue failure: static and fatigue stress concentration factors; Endurance limit- estimation of endurance limit; Design for finite and infinite life: using Soderberg, Gerber and Goodman design criteria.	**06**
6	**Design of Springs** Helical compression spring under Static and Variable loads; Design of Leaf springs	**05**

Assessment:
Internal Assessment for 20 marks:
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents and the second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

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

1. The question paper will comprise of total **six questions**, **each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover the maximum contents of the curriculum**
3. **The 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. Design of Machine Elements - V.B. Banadari, Tata McGraw Hill Publication
2. Design of Machine Elements - Sharma, Purohit. Prentice Hall India Publication
3. Machine Design by Pandya & Shah, Charotar Publishing

References:

1. Machine Design -An Integrated Approach - Robert L. Norton, Pearson Education
2. Mechanical Engineering Design by J.E.Shigley, McGraw Hill
3. Machine Design by Reshetov, Mir Publication
4. Machine Design by Black Adams, McGraw Hill
5. Fundamentals of Machine Elements by Hawrock, Jacobson McGraw Hill
6. Machine Design by R.C.Patel, Pandya, Sikh, Vol-I & II C. Jamnadas & Co
7. Design of Machine Elements by V.M.Faires
8. Design of Machine Elements by Spotts
9. Recommended Data Books – PSG and Mahadevan & Reddy

Links for online NPTEL/SWAYAM courses:

1. Design of Machine Elements | NPTEL Online Videos, Courses - IIT Video Lectures (nptelvideos.in)

Course Code	Course Name	Credits
AEC504	**Finite Element Analysis**	**03**

Prerequisite:

Knowledge of:

- Differential equations (Formulation and solution, Types-Ordinary, Partial, Order and degree of the DE and the boundary conditions)
- Matrix algebra (Matrix operations, gauss elimination method to get inverse the inverse of matrix)
- Basics of the core field (Governing laws, relationship between the various variables and constants –like in structural field stress-strain,Thermal field-temp, heat transfer rate etc

Objectives:

1. To understand the concepts of FEA and its applicability to different engineering field problems.
2. To understand the representation of the physical model into an equivalent FEA model and steps to solve it.
3. To acquaint with application of numerical techniques for solving problems.

Outcomes: Learner will be able to…

1. Solve differential equations using weighted residual methods.
2. Develop the finite element equations to model engineering problems governed by second order differential equations.
3. Apply the basic finite element formulation techniques to solve engineering problems by using one dimensional elements.
4. Apply the basic finite element formulation techniques to solve engineering problems by using two dimensional elements.
5. Apply the basic finite element formulation techniques to find natural frequency of single degree of vibration system.
6. Use commercial FEA software, to solve problems related to mechanical engineering.

Module	Details	Hrs
1	**Introduction:** 1.1 Introductory Concepts: Introduction to FEM, Historical Background, General FEM procedure, Applications of FEM in various fields Advantages and disadvantages of FEM 1.2 Mathematical Modelling of field problems in engineering, Governing Differential equations, primary/secondary variables, boundary conditions-types-essential/natural etc. 1.3Approximate solution of differential equations, Weighted residual techniques (Galerkin , Subdomain method).	**5**
2	**FEA Procedure:(Pre-processing, Processing, Post-processing)** 2.1 Discrete and Continuous Models, Weighted Residual Methods - Ritz Technique- Basic Concepts of the Finite Element Method. 2.2 Definitions of various terms used in FEM like element, order of the element, internal and external node/s, degree of freedom.	**8**

	2.3 Minimization of a functional, Principle of minimum total potential, Piecewise Rayleigh-Ritz method, Formulation of 'stiffness matrix', assembly concepts to develop system equation.	
3	**One Dimensional Problems:** 3.1 One dimensional second order equations - discretization-element types - linear and higher order elements -derivation of shape functions and stiffness matrices and force vectors. 3.2 Assembly of Matrices- solution of problems in one dimensional structural analysis, heat transfer and fluid flow (stepped and taper bars, fluid network, spring-Cart Systems) 3.3 Analysis of Plane trusses, Analysis of Beams	**10**
4	**Two Dimensional Finite Element Formulations:** 4.1 Introduction, three node triangular element, four node rectangular element 4.2 Natural coordinates and coordinates transformations: serendipity and Lagrange's methods for deriving shape functions for triangular element. 4.3 Convergence criterion, sources of errors	**5**
5	**Two Dimensional Vector Variable Problems:** 5.1 Equations of elasticity - Plane stress, plane strain and axi-symmetric problems 5.2 Jacobian matrix, stress analysis of CST.	**6**
6	**Finite Element Formulation of Dynamics and Numerical Techniques:** 6.1 Applications to free vibration problems of rod and beam, Lumped and consistent mass matrices. 6.2 Solutions techniques to Dynamic problems, longitudinal vibration frequencies and mode shapes, Fourth order beam equation, transverse deflections and natural frequencies of beams.	**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)

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 3Only **Four questions need to be solved**

Text/Reference Books:

1. Textbook of Finite Element Analysis by Seshu P, Prentice Hall of India
2. Finite Element Method by J N Reddy, TMH
3. 'Introduction to Finite Elements in Engineering, Chandrupatla and Belegundu, Pearson Education
4. Finite Element Methods by R Dhanraj and K Prabhakaran Nair, Oxford University Press
5. A first course in Finite Element Method by Logan D L, Thomson Asia PvtLtd

6. 'Concepts and Applications of Finite Element Analysis by Cook R D, Malkus D S, Plesha ME, John- Wiley Sons
7. The Finite Element Method in Engineering by S. S. Rao, Butter Worth Heinemann
8. Fundamental Finite Element Analysis and Application with Mathematica and MATLAB Computations by M. Asghar Bhatti, Wiley India Pvt. Ltd.

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/104/112104193/
https://nptel.ac.in/courses/105/106/105106051/
https://nptel.ac.in/courses/112/104/112104115/
https://nptel.ac.in/courses/112/103/112103295/
https://nptel.ac.in/courses/112/106/112106135/
https://nptel.ac.in/courses/112/106/112106130/
https://nptel.ac.in/courses/105/105/105105041/
https://nptel.ac.in/courses/112/104/112104116/

Course Code	Course Name	Credits
AEDLO5011	**Optimization Techniques**	**03**

Objectives:

1. To Understand the need and origin of the optimization methods.
2. To understand various linear, nonlinear and other optimization techniques.
3. To understand various multi criterion and multi-objective decision making methods.
4. To understand recent tools in optimization

Outcomes: Learner will be able to…

1. Identify the types of optimization problems and apply the calculus method to single variable problems.
2. Formulate the problem as Linear Programming problem and analyse the sensitivity of a decision variable.
3. Apply various linear and non-linear techniques for problem solving in various domain.
4. Apply multi-objective decision making methods for problem in manufacturing environment and other domain.
5. Apply multi criterion decision making methods for problem in manufacturing environment and other domain.
6. Apply Design of Experiments method for Optimization

Module	Details	Hrs
1	Basic Concepts: Statement of the Optimization Problem, Basic Definitions, Optimality Criteria for Unconstrained Optimization, Optimality Criteria for Constrained Optimization, Engineering Application of Optimization, Classification of Optimization Problems. Classical Optimization Techniques: Single variable optimization	**6**
2	Linear Programming Problem: Formulation, Simplex method, Big M Method, Two Phase, Primal to Dual, Dual Simplex method, Sensitivity Analysis and applications of LP Transportation and Assignment Models.	**8**
3	Integer Programming Model: Gomory's cutting plane method, Branch & Bound Technique. Non L.P. Model: Lagrangian method & Kuhn tucker Method, Newton's method. Discrete Event Simulation: Generation of Random Variable, Simulation Processes, Monte-Carlo Technique.	**8**

4	Multi Objective Decision making (MODM) Methods: Introduction to Multi objective optimization, Traditional Techniques such as, quadratic programming, geometric programming, Numerical on goal programming and dynamic programming. Introduction to Non-traditional optimization Techniques such as Genetic Algorithm, particle swarm, genetic algorithms, simulated annealing and Techniques based on Neural network & Fuzziness **(Only concepts)**	**8**
5	Multi Criterion Decision-making (MCDM) Methods: Introduction to multi criterion optimization Simple Additive Weighting (SAW) Method Weighted Product Method (WPM) Analytic Network Process (ANP) Analytic Hierarchy Process (AHP) Method TOPSIS Method PROMETHEE	**6**
6	Robust Design Methods: DOE and Taguchi techniques Full Factorial Design: The basics of "full factorials", ANOVA, Factorial effects and plots, and Model evaluation Fractional Factorial Design: The one-half fraction and one-quarter of the 2^k design, The general 2^{k-p} fractional factorial design Application of related software (Minitab, Design Expert or MATLAB)	**8**

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)

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/Reference Books:

1. S.S. Rao, "Engineering Optimization - Theory and Practice", John Wiley and Sons Inc.
2. Ranjan Ganguli, "Engineering Optimization - A Modern Approach" Universities Press
3. Pablo Pedregal, "Introduction to Optimization", Springer
4. L.C. Jhamb, "Quantitative Techniques Vol. 1 and 2", Everest Pub. House
5. Pierre D.A., "Optimization, Theory with Application", John Wiley & sons.

6. R V Rao, “Decision Making in the Manufacturing Environment Using Graph Theory and Fuzzy Multiple Attribute Decision Making” (Springer Publication).
7. Ritter, H., Martinetz, T., &Schulten, K., Addison,“Neural Computation and Self-Organizing Maps”-Wesley Publishing Company
8. Douglas C.Montgomery,“Design and analysis of experiments”(John Wiley & Sons Inc.)
9. Saravanan R,“Manufacturing Optimization through Intelligent Techniques”, Taylor & Francis (CRC Press)-2006.

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/101/112101298/ - Optimization from Fundamentals, IIT Bombay

Course Code	Course Name	Credits
AEDLO5012	**Design of Experiments**	**03**

Objectives:

1. To obtain clear understanding of use of statistics in experimentation
2. To obtain clear understanding of scheme of experimentation and its effect on accuracy of experimentation
3. To obtain knowledge of how to analyze results from such investigations to obtain conclusions
4. To become familiar with methodologies that can be used in conjunction with experimental designs for robustness and optimization

Outcomes: Learner will be able to…

1. Plan, design, and conduct experimental investigations efficiently and effectively;
2. Understand strategy in planning and conducting experiments;
3. Choose an appropriate experimentation scheme to evaluate a new product design or process improvement through experimentation strategy, data analysis, and interpretation of experimental results.

Module	Details	Hrs
1	**Introduction, Background and Overview:** A brief history of DOE-When to use DOE- Basic principles of DOE & Some typical applications. Overview of basic statistical concepts, Simple Comparative Experiments, Single Factor experiments, Randomized Blocks, Latin Square Designs and extensions. Testing of Hypothesis ('T'&'F' test), Introduction to Factorial Designs, 2^k Designs.	**06**
2	**Full Factorial Design:** The basics of "full factorials", ANOVA,Factorial effects including interaction effects and plots	**06**
3	**Two & Three Level Fractional Factorial Design:** Objective, The one-half fraction and one-quarter of the 2^k design, 2^{k-p} fractional factorial design, 3-level & Mixed-level Factorials & Fractional Factorials.	**08**
4	**The Robust Design:**Basics of robust designs, Loss Function, Taguchi designs, Orthogonal Arrays, Linear Graphs and Interaction effects, Signal to Noise Ratio, Parameter Design, Tolerance Design,Robust design example.	**08**
5	**Response Surface Methodology:** First & second order experiments, Analysis of second-order response surfaces, Central composite designs, Plackett-Burman designs, process optimization & reliability improving experiments	**06**
6	Experiment Design According to Shainin, Multi-variate charts, components search, paired comparisons	**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)

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

5. Question paper will comprise of total **six questions**, **each carrying 20 marks**
6. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
7. **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)
8. Only **Four questions need to be solved**.

Text/Reference Books:

1. Statistics for Experimenters,Box, GEP, Hunter, WG, and Hunter, JS, 1978, Wiley.
2. Empirical Model-Building and Response Surfaces,Box, GEP and Draper, NR 1987, Wiley.
3. Experimental Designs, Cochran, WG and Cox, GM, 1957, Wiley.
4. The Design of Experiments, 8th Ed., Fisher, RA, 1966, Hafner.
5. Design and Analysis of Experiments (Vol I), Hinkelmann, K and Kempthorne, O, 1994, Wiley.
6. Optimal Design of Experiments,Pukelsheim, F, 1993, Wiley.
7. Statistical Principles in Experimental Design,2nd Ed., Winer, BJ, 1962, McGraw-Hill.
8. Engineering Methods for Robust Product Design: Using Taguchi Methods in Technology and Product Development, Fowlkes WY, Creveling CM, 1995, Addison-Wesley Publishing Company
9. Design and Analysis of Experiments, 5th edition, by D.C. Montgomery, John Wiley & Sons, New York, 2001
10. Total Quality Management, 4th Ed,Besterfield D.H., Carol BesterfieldM ,MaryBesterfileld Sacre, Besterfield G.H.,Urdhwareshe H, Urdhwareshe R,2015, Pearson

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/110/105/110105087/ - Design and Analysis of Experiments, IIT Kharagpur
https://nptel.ac.in/courses/111/104/111104075/ - Analysis of Variance and Design of Experiments-I, IIT Kanpur
https://nptel.ac.in/courses/111/104/111104078/ - Analysis of Variance and Design of Experiments-II, IIT Kanpur

Course Code	Course Name	Credits
AEDLO5013	**Computational Methods**	**03**

Objectives:

1. Introduction to analytical and numerical techniques.
2. Application of mathematical modelling to mechanical systems.
3. Learn the significance of statistical techniques and data interpolation.

Outcomes: Learner will be able to…

1. Understand and develop mathematical models of physical systems.
2. Identify an appropriate mathematical formulation to linear algebraic equations.
3. Build an appropriate mathematical formulation to non-linear algebraic equations.
4. Evaluate and interpret the data regression, curve fitting and statistics.
5. Apply the numerical techniques and numerical schemes.
6. Formulate the concept of numerical methods in realistic applications.

Module	Details	Hrs
1	**Introduction to Computational Methods** Motivation and applications of Computational Methods. Computation and Error Analysis:Accuracy and precision; Truncation andround-off errors (Numericals); Binary Number System; Error propagation.	6
2	**Linear Systems and Equations** Matrix representation: Cramer's rule; Gauss Elimination. Matrix Inversion: LUDecomposition; Iterative Methods;Relaxation Methods; Eigen Values and Eigen Vectors.	6
3	**Non Linear Algebraic Equations:** Bracketing methods: Bisection, Regula-Falsi. Crouts Method: LU Decomposition. Open methods: Secant, Fixed pointiteration, Newton-Raphson; MultivariateNewton's method.	6
4	**Regression and Curve Fitting** Interpolation function; Cubic Splines; Multi regression analysis, polynomial regression. **Statistical methods:** Statistical representation of data, modeling and analysis of data, test of hypotheses. **Fuzzy Logic:** Introduction to fuzzy logic, Fuzzy Logic Systems Architecture, Case study of Mechanical system.	8
5	**Integration and Integral Equations** Newton Cotes Quadrature **ODEs: Initial Value Problems** Euler's methods; Predictor-corrector method (Adam's Moulton, Milne's Method)	7

	ODEs: Boundary Value Problems Finite difference Method; Finite Element Method, Finite Volume Method	
6	**Application of Numerical Methods** Predict vibration response of components to intricate profile generated by different machine tools, Design next generation Formula One cars to working at the cutting edge of robotics, Predict behaviour of flows to estimation of heat transfer in complex scenarios; Crank Nicolson method – Solution of 1-D Wave equation.	**6**

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)

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

Question paper will comprise of total **six questions**, **each carrying 20 marks**
Question 1 will be **compulsory** and should **cover maximum contents of the curriculum**
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)
Only **Four questions need to be solved**.

Text/Reference Books:

1. S. P. Venkateshan& Prasanna Swaminathan, "Computational Methods in Engineering", Ane Books Pvt. Ltd., 1st Edition, (2014) ISBN: 978-0-12-416702-5.
2. Steven C. Chapra& Raymond P.Canale, "Numerical Methods for Engineers", Mc-Graw Hill Education, 8TH Edition, (2020), ISBN: 1260571386
3. Joe D Hoffman, "Numerical Methods for Engineers and Scientists", Second Edition, Marcel Dekker (2001) ISBN: 0-8247-0443-6.
4. M.K. Jain, S.R. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 7th Edition, New Age International Publishers, 2019.
5. S.S. Sastry, Introductory Methods of Numerical Analysis, PHI, Fifth Edition, 2012.
6. Rajesh Kumar Gupta, Numerical Methods – Fundamentals and Applications, Cambridge University Press, First Edition, 2019.
7. Gupta and Santosh K., "Numerical Methods for Engineers", 4th Edition, New Age International Publishers, 2019, ISBN: 9789387788794
8. FerzigerJ.and M. Peric, "Computational Methods for Fluid Dynamics" 3rd Edition, Springer, (2001) ISBN: 9783540420743.
9. Versteeg H., and W. Malalasekra,"An Introduction to Computational Fluid Dynamics: The Finite Volume Method" 2nd Edition, PHI(2007) ISBN: 9780131274983.

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/127/106/127106019/ - Numerical Methods for Engineers, IIT Madras
https://nptel.ac.in/courses/111/107/111107105/ - Numerical Methods, IIT Roorkee
https://nptel.ac.in/courses/111/106/111106101/ - Numerical Analysis, IIT Madras
https://nptel.ac.in/courses/111/107/111107107/ - Numerical Methods: Finite Difference Approach, IIT Roorkee

Course Code	Course Name	Credits
AEL501	**Measurement and Engine Testing Lab**	**01**

Objectives:

1. To acquaint with the various methods for measurement of engine performance.
2. To analyse engine emissions.
3. To familiarise with latest developments in engine Technology

Outcomes: Learner will be able to…

1. Overhaul and Assemble engine components.
2. Perform load test/speed test on engine setup.
3. Calculate performance of multi cylinder engine.
4. Analyse engine performance and draw heat balance sheet.
5. Perform exhaust gas analysis.
6. Get acquainted with Calibration of sensors.

Term work:

Term work shall consist of minimum 8 exercises, from the list as per following details:

a) 2 must be actual experiments from Part A. From Part A exercise 1 is compulsory.
b) 4 must be actual experiments from Part B
c) 2 must be actual experiments from Part C

PART A: Dismantle and assemble the following:

1. 2-Stroke/4-Stroke Engines
2. Carburettor
3. Ignition system
4. Fuel injection system

PART B: Actual Test experiments:

1. Morse Test on Multi-cylinder S.I. engine
2. Speed Test on Spark Ignition or/and Compression Ignition engine
3. Load Test on Diesel engine.
4. Heat Balance Sheet on S.I. or C.I. engine.
5. Determination of Air fuel ratio and volumetric efficiency of the engine
6. Exhaust Gas/Smoke analysis of S.I./ C.I. engines

PART C: Measurement Experiments:

1. Calibration of Tachometers.
2. Study of Pressure, Torque, Temperature, Flow Measurement Sensors in IC engine.
3. System Identification of any one of the sensors.

PART D: Topics for Case study of various models:

I. Variable Valve Timing
II. Twin and Triple Turbo charging
III. Variable Compression Ratio Engine
IV. Electronic MPFI with various modes
V. Single overhead camshaft and double overhead camshaft
VI. Engine Downsizing
VII. Eco-boost Engine
VIII. Turbocharging for S.I. Engine

Term Work:

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

1. Laboratory work (8 Exercises): **15 marks**
2. Case study: **05 marks**
3. Attendance: **05 marks**

Practical and Oral Examination:

A. Pair of Internal and External Examiner should conduct practical/Oral exam.

B. Distribution of marks for practical and oral examination shall be as follows:

i. Practical performance 15 marks
ii. Oral 10 marks

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

D. Student's work along with evaluation report to be preserved till the next exam.

Course Code	Name of the Course	Credit
AEL502	**Machine Design**	**01**

Objectives:

1. To study basic principles of machine design
2. To familiarize with the use of design data books & various codes of practice
3. To identify potential failures associated with a machine component by using DFMEA.

Outcomes: Learner will be able to…

1. Design Knuckle Joint and cotter joint
2. Design shaft under various conditions.
3. Design rigid and flexible flange couplings.
4. Design helical compression spring and leaf spring.
5. Use design data books in designing various components.
6. Report uncertainties associated with potential failure modes inherited from the component design.

Term Work: (Comprises part A, B & C)
A) Term work - Shall consist of (minimum 3) design exercises from the list which may include computer-aided drawing on **A3 size sheets**.

1) Knuckle Joint/cotter joint
2) Rigid/ Flexible flange couplings
3) Leaf springs
4) C-clamps along with the Frame

B) Assignment: Design exercises in the form of design calculations with sketches and/ or drawings on the following machine elements.

1) Bolted and welded joints
2) Combined stresses problem using the theories of failure.
3) Shaft design with/ without the use of ASME Code.
4) Design against fluctuating loads (For finite and infinite life)
5) Design of Gears

C) Case Study: A case study should be given to either individual or a group of two students to report uncertainties associated with potential failure modes inherited from a component design using the DFMEA approach.

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

- Part A: 10 marks.
- Part B: 05 marks.
- Part C: 05 marks
- Attendance: 05 Marks.

Course Code	Course Name	Credits
AEL503	**Finite Element Analysis**	**01**

Objectives:

1. To familiarise FEA concept for practical implementation
2. To acquaint with FEA application software

Outcomes: Learner will be able to…

1. Select appropriate element for given problem
2. Select suitable meshing and perform convergence test
3. Select appropriate solver for given problem
4. Interpret the result
5. Apply basic aspects of FEA to solve engineering problems
6. Validate FEA solution

Term Work: (Comprises a and b)

a. List of Experiments: Students should use the commercial software or open source application programs, to verify the results obtained by manual calculations. The input data and output results of the problem solved using the computer programs (Minimum 6) should be included in the Journal. The proposed list is given below:

1. Any two problems using bar element
2. Any two problems using truss element
3. Any two problems using CST element
4. Any two problem using axisymmetric element
5. Any one problem of free vibration analysis using bar element
6. Any one problem on steady state heat conduction
7. Any one problem for analysis of Beams.

While performing the analysis the students should understand the concepts of selection of element type, meshing and convergence of solution.(using approach of refining mesh and or order of the element)

b. Course Project: (Any one task out of the following proposed list **)**

A group of not more than four students, shall do

1) Finite Element Analysis of any mechanical engineering element /system, which involves element selection, assigning properties, meshing, assigning loads, and boundary conditions, analysis and result interpretation.
2) Develop the program to verify the results obtained by manual calculations for simple 1D/2D problems using Python, MATLAB programming platform etc.
3) Simulate a problem and validate the results with experimental results (the test rigs from Strength of material /Heat transfer/Dynamics of machine/fluid lab etc may be used for obtaining the experimental results)

The 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

1. Pair of Internal and External Examiner should conduct practical/viva based on contents
2. Duration of practical examination is 2 hour
3. Distribution of marks for practical/viva examination shall be as follows:
   a. Practical performance ……**15** marks
   b. Oral……... **10** marks

Evaluation of practical examination to be done based on the experiment performed andthe output of the experiments during practical examination.
Students work along with evaluation report to be preserved till the next examination.

Text/Reference Books:

1. Programming the Finite Element Method, I M Smith,D V Griffiths and Margetts WILEY Publications.
2. The Finite Element Method: Theory, Implementation, and Applications, Larson, Mats G., Bengzon, Fredrik,Springer
3. Introduction to Finite Element Analysis and Design by N. H. Kim, B. V. Sankar, and A. V. Kumar by Wiley publication
4. Finite Element analysis using ANSYS by PaletiSrinivas,Krishna Chaitanya, Rajesh Kumar Detti, PHI Publication.
5. Finite Element Analysis Theory and Application With ANSYS by Saeed Moaveni, Pearson Publication.
6. Introduction to Finite Element Analysis Using MATLAB and Abaqus By Amar Khennane, CRC Press publication

Course Code	Course Name	Credits
AESBL501	**Professional Communication and Ethics - II**	**02**

Objectives:

Learners should be able to:

1. Discern and develop an effective style of writing important technical/business documents.
2. Investigate possible resources and plan a successful job campaign.
3. Understand the dynamics of professional communication in the form of group discussions, meetings, etc. required for career enhancement.
4. Develop creative and impactful presentation skills.
5. Analyse personal traits, interests, values, aptitudes and skills.
6. Understand the importance of integrity and develop a personal code of ethics.

Outcomes: Learners will be able to…

1. Plan and prepare effective business/ technical documents which will in turn provide solid foundation for their future managerial roles.
2. Strategize their personal and professional skills to build a professional image and meet the demands of the industry.
3. Emerge successful in group discussions, meetings and result-oriented agreeable solutions in group communication situations.
4. Deliver persuasive and professional presentations.
5. Develop creative thinking and interpersonal skills required for effective professional communication.
6. Apply codes of ethical conduct, personal integrity and norms of organizationalbehaviour.

MODULE	DETAILS	HRS
MODULE 1 - ADVANCED TECHNICAL WRITING :PROJECT/PROBLEM BASED LEARNING (PBL)		
1.1. Purpose and Classification of Reports	**Classification on the basis of:** ● Subject Matter (Technology, Accounting, Finance, Marketing, etc.) ● Time Interval (Periodic, One-time, Special) ● Function (Informational, Analytical, etc.) ● Physical Factors (Memorandum, Letter, Short & Long)	**06**
1.2. Parts of a	● Prefatory Parts (Front Matter)	

Long Formal Report	• Report Proper (Main Body) • Appended Parts (Back Matter)	
1.3. Language and Style of Reports	• Tense, Person & Voice of Reports • Numbering Style of Chapters, Sections, Figures, Tables and Equations • Referencing Styles in APA & MLA Format • Proofreading through Plagiarism Checkers	
1.4. Definition, Purpose & Types of Proposals	• Solicited (in conformance with RFP) & Unsolicited Proposals • Types (Short and Long proposals)	
1.5. Parts of a Proposal	• Elements • Scope and Limitations • Conclusion	
1.6. Technical Paper Writing	• Parts of a Technical Paper (Abstract, Introduction, Research Methods, Findings and Analysis, Discussion, Limitations, Future Scope and References) • Language and Formatting • Referencing in IEEE Format	
MODULE 2 - EMPLOYMENT SKILLS		
2.1. Cover Letter & Resume	• Parts and Content of a Cover Letter • Difference between Bio-data, Resume & CV • Essential Parts of a Resume • Types of Resume (Chronological, Functional & Combination)	**06**
2.2 Statement of Purpose	• Importance of SOP • Tips for Writing an Effective SOP	
2.3 Verbal Aptitude Test	• Modelled on CAT, GRE, GMAT exams	
2.4. Group Discussions	• Purpose of a GD • Parameters of Evaluating a GD • Types of GDs (Normal, Case-based & Role Plays) • GD Etiquettes	

2.5. Personal Interviews	• Planning and Preparation • Types of Questions • Types of Interviews (Structured, Stress, Behavioural, Problem Solving & Case-based) • Modes of Interviews: Face-to-face (One-to one and Panel) Telephonic, Virtual	
MODULE 3 - BUSINESS MEETINGS		
3.1. Conducting Business Meetings	• Types of Meetings • Roles and Responsibilities of Chairperson, Secretary and Members • Meeting Etiquette	**02**
3.2. Documentation	• Notice • Agenda • Minutes	
MODULE 4 -TECHNICAL/ BUSINESS PRESENTATIONS		
4.1. Effective Presentation Strategies	• Defining Purpose • Analysing Audience, Location and Event • Gathering, Selecting &Arranging Material • Structuring a Presentation • Making Effective Slides • Types of Presentations Aids • Closing a Presentation • Platform Skills	**02**
4.2 Group Presentations	• Sharing Responsibility in a Team • Building the contents and visuals together • Transition Phases	
MODULE 5 - INTERPERSONAL SKILLS		
5.1. Interpersonal Skills	• Emotional Intelligence • Leadership & Motivation • Conflict Management & Negotiation • Time Management • Assertiveness • Decision Making	**08**
5.2 Start-up Skills	• Financial Literacy • Risk Assessment	

	• Data Analysis (e.g. Consumer Behaviour, Market Trends, etc.)	
MODULE 6 - CORPORATE ETHICS		
6.1. Intellectual Property Rights	• Copyrights • Trademarks • Patents • Industrial Designs • Geographical Indications • Integrated Circuits • Trade Secrets (Undisclosed Information)	**02**
6.2. Case Studies	• Cases related to Business/ Corporate Ethics	

List of Assignments for Termwork

(In the form of Short Notes, Questionnaire/ MCQ Test, Role Play, Case Study, Quiz, etc.)

1. Cover Letter and Resume
2. Short Proposal
3. Meeting Documentation
4. Writing a Technical Paper/ Analysing a Published Technical Paper
5. Writing a SOP
7. IPR
8. Interpersonal Skills
9. Aptitude test (Verbal Ability)

Note:

1. The Main Body of the project/book report should contain minimum 25 pages (excluding Front and Back matter).
2. The group size for the final report presentation should not be less than 5 students or exceed 7 students.
3. There will be an end–semester presentation based on the book report.

Guidelines for Internal Assessment

Term Work 25 Marks
Assignments 10 Marks
Attendance 05 Marks
Presentation slides 05 Marks
Book Report (hard copy) 05 Marks
Internal Oral - 25 Marks
Oral Examination will be based on a GD & the Project/Book Report presentation.
Group Discussion 10 Marks
Project presentation (Individual Presentation) 10 Marks
Group Dynamics 05 Marks

SUGGESTED READING

1. Arms, V. M. (2005). Humanities for the engineering curriculum: With selected chapters from Olsen/Huckin: Technical writing and professional communication, second edition. Boston, MA: McGraw-Hill.
2. Bovée, C. L., &Thill, J. V. (2021). Business communication today. Upper Saddle River, NJ: Pearson.
3. Butterfield, J. (2017). Verbal communication: Soft skills for a digital workplace. Boston, MA: Cengage Learning.
4. Masters, L. A., Wallace, H. R., & Harwood, L. (2011).Personal development for life and work. Mason: South-Western Cengage Learning.
5. Robbins, S. P., Judge, T. A., & Campbell, T. T. (2017). Organizational Behaviour. Harlow, England: Pearson.
6. Meenakshi Raman, Sangeeta Sharma (2004) Technical Communication, Principles and Practice. Oxford University Press
7. Archana Ram (2018) Place Mentor, Tests of Aptitude For Placement Readiness. Oxford University Press
8. Sanjay Kumar &PushpLata (2018). Communication Skills a workbook, New Delhi: Oxford University Press.

Virtual Labs

https://ve-iitg.vlabs.ac.in/- Virtual English and Communication Virtual Lab, IIT Guwahati

http://vlabs.iitb.ac.in/vlabs-dev/labs/communication/- Professional Communication Virtual Lab, IIT Bombay

Course code	Course Name	Credits
AEPBL501	**Mini Project - 2A**	**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 fundamentals to 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
AEC 601	**Automotive Systems & Design**	**04**

Objectives:

1. To study the basics of automotive systems and subsystems.
2. To study working of different automotive systems and subsystems.
3. To study different types of vehicle layout.
4. To have a basic idea about how automotive systems are designed.

Outcomes: Learner will be able to…

1. Identify different Automotive systems and components.
2. Compare different types of Automotive systems and components.
3. Understand the working of different types of Automotive systems and components
4. Apply knowledge of Engineering Mechanics and Strength of materials to design different Automotive systems and components.
5. Select materials for different Automotive systems and components for designing.
6. Design the different Automotive systems and components by using a data book.

Module	Details	Hours
1.	**Frame-**Different types of Layouts **Design of Engine Components-**Types of Piston and Cylinder Liners,Types of Connecting Rod(Only Barrel Type) and Types of Crankshaft(Only Centered type)	**08**
2.	**Automotive Clutches and Transmission-** Necessity of clutch in a automobile, Working and Construction of Single plate,Multi-plate,Centrifugal,Semi Centrifugal, Electromagnetic clutches, Fluid Flywheel,Torque Converter Purpose and Elements of Gear Box, Characteristic Curves, Types-Sliding mesh, Constant Mesh, Synchromesh, Wear and thermal consideration. **Epicyclic Gearboxes used in automatic transmissions-** Principle of Planetary gear trains, Continuously Variable Transmission-Types and Operation of typical CVT **Design of Gearbox-**Constant Mesh	**12**

3.	**Drive Line**: UV joint, CV joint, Propeller Shaft construction and arrangement, Elements of drive line, 2WD, 4WD, Part time and Full time 2WD and 4WD.Driving thrust and its effects, Torque reaction and Side thrust, Hotchkiss drive, Torque tube drive, Radius rods, Stabilizers **Final Drive** –Types of Final drive,Loads acting on Front and Rear axles,Types of Front Axles and Stub axles. **Differential** –Principle, Constructional details of Differential unit,Housing,Non slip differential and differential locks types- **Design of Drive Line-**Design of propeller shaft and Axles	**08**
4.	**Steering**-Introduction to steering systems, Manual Steering, Ackerman and Davis Steering Mechanisms, Steering Linkages Different types of Steering gear boxes,Power steering systems, Front End Wheel Geometry.	**04**
5.	**Brakes**- Introduction to Brake System, Components of Brake System,Mechanical Brakes, Hydraulic Brake, Air Brake, Anti Lock Brake System, Braking Analysis,Materials for Brake Lining. **Design of Brakes-**Stopping Distance,Energy Absorbed by a Brake, Heat to be dissipated during Braking.	**08**
6.	**Suspension**- Introduction to Suspension System, Components of Suspension System, Dependent and Independent Suspension and Types,Types of Suspension Springs-Single leaf, Multi Leaf spring, Coil, Torsion Bar, Rubber, Pneumatic and Hydro elastic suspension spring systems. **Wheels and Tyres**- Tire requirement, tire characteristics, Constructional detail, tire dimensions and specifications, Types of wheels and Hubs.	**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 covered in Theory and Laboratory.

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) covering contents of the curriculum covered in Theory and Laboratory.

4. Only Four questions need to be solved.

Text Books:

1. Newton, Steed & Garrett, Motor Vehicles, Butterworth Heinemann.

2. N. K. Giri, Automotive Mechanics, Khanna Publishers.

3. D. Crolla, D. E. Foster, T. Kobayashi and N. Vaughan (Editors-in-Chief), Encyclopedia of Automotive Engineering, Parts 1-6, Wiley, 2015.

4. Design of machine elements - V. B. Bhandari Tata McGraw Hill Pub.

5. Recommended Data Books – PSG , K. Mahadevan,Kale Khandare

6. Gear Design Handbook - GitinMaitra

Reference Books:

1. Crouse. W. H, Automotive Chassis and Body, McGraw Hill New York.

2. Jack Erjavec, Automotive Technology – A systems approach, Cengage Learning.

3. M. J. Nunny, Automotive Technology, SAE Publication.

NOTE:

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

Links for Online NPTEL/SWAYAM Courses:

1.https://onlinecourses.nptel.ac.in/noc20_me18/preview

2.https://nptel.ac.in/courses/112/105/112105124/

3.https://nptel.ac.in/courses/112/105/112105219/

Course Code	Course Name	Credits
AEC602	**Mechanical Vibrations**	**03**

Objectives:

1. To study the basic concepts of vibration analysis.

2. To estimate the natural frequency/frequencies of vibration systems in free vibration, using both exact and numerical methods.

3. To estimate the response of 1 degree of freedom under forced vibration.

4. To acquaint with the basic principles of vibration measuring instruments.

5. To study the balancing of rotating and reciprocating mass systems.

Outcomes: Learner will be able to...

1. Develop mathematical models to represent dynamic system.

2. Estimate natural frequency of mechanical system using various methods.

3. Analyze vibratory response of mechanical system under forced vibration.

4. To estimate the natural frequencies and mode shapes of multi-degree of freedom system, using both exact and numerical methods.

5. Balance an existing unbalanced system partially/completely.

Module	Details	Hours
01	**1.1 Basic Concepts of Vibrations:** Vibration and oscillation, causes and effects of vibrations, vibration parameters—spring, mass and damper, minimum number of parameters required for vibration to occur, vibration terminology, classification of vibrations, steps involved in vibration analysis. **1.2 Free Undamped Single Degree of Freedom Vibration Systems:** Methods to formulate differential equation—Newton's method or D'Alembert's principle, and Energy methods—Based on conservation of total energy, Rayleigh's energy method, Lagrange's energy method, equivalent system method. Springs in series and parallel combination, inclined spring, effect of spring's own mass to	**07**

	calculate natural frequency of system. Application of these methods in longitudinal, transverse and torsional single degree of freedom vibration systems, or a combination of these.	
02	**2.1 Free Damped Single Degree of Freedom Vibration Systems:** Need of damping in vibration systems, introduction to damper models—viscous, Coulomb (dry friction), slip/interfacial, solid/structural/hysteresis damping (Note: only basic introduction to slip and solid dampings, no calculations expected). Viscous damping—Derivation of differential equation of motion, derivation of solution (response) equations, damping ratio or damping factor, critical damping coefficient, underdamped, critically damped and over damped systems. Logarithmic decrement, Work done by viscous damper, inclined damper, dampers in series and parallel combinations. Coulomb/dry-friction damping—derivation of differential equation, number of cycles covered by the mass to stop once disturbed (disturbance in the form of initial displacement only), comparison of viscous and Coulomb dampings.	**08**
03	**3.1 Free Undamped Multi Degree of Freedom Vibration Systems:** Exact methods for derivation of differential equations of motion for multi degree of freedom systems—Newton method and Lagrangian energy method, matrix analysis to estimate eigenvalues and eigenvectors & hence natural frequencies and mode shapes for multi-mass undamped vibration systems (limited to 2 degree of freedom only), Holzer's method for longitudinal and torsional unbranched vibration systems, Dunkerley's and Rayleigh's methods for estimating fundamental frequency of tranverse vibration of simply supported and cantilever beams (up to a maximum of 4 point loads only), influence coefficients and Maxwell's reciprocal theorem.	**07**
04	**4.1 Forced Single Degree of Freedom Vibration Systems:** Analysis of linear and torsional systems subjected to harmonic excitation in terms of force and motion (viscous damping only), force isolation and transmissibility, isolators and mounts. **4.2 Vibration Measuring Instruments:** Principle of seismic instruments, vibrometer, accelerometer, velometer—with and without measurement errors. Principle of frequency-measuring instruments, Fullarton's tachometer and Frahm's reed tachometer.	**07**
05	**5.1 Balancing of Rotating Masses:**	**07**

	Static and dynamic balancing of multi-rotor system. **5.2 Balancing of Reciprocating Masses:** Approximate analytical method for finding acceleration of reciprocating piston (mass of connecting rod and crank neglected), primary and secondary unbalanced forces, inline engine, direct and reverse crank method.	
06	**6.1 Whirling of Shafts / Rotor Dynamics / Critical Speed:** Critical speed of a single rotor—undamped and damped.	**03**

Theory Examination:

Internal Assessment (20 marks):

Consisting of **2 compulsory class tests.**

First test based on initial 40% of the content, and second test based on remaining content (but excluding contents covered in Test-1).

End Semester Examination (80 marks):

Weigtage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the syllabus.

i. Question paper will comprise of total six questions.

ii. All questions carry equal marks.

Iii. Questions will be mixed in nature (for example Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

iv. Only four questions need to be solved.

Term Work (25 marks):

This shall consist of a file submission that includes **laboratory work (10 marks)**, **assignments (10 marks),** and **attendance in theory and practicals (rounded off to 5 marks)**.

Viva -voce (Orals) and Practical Examination (25 marks):

Viva-voce (Orals) and Practical Examination shall be conducted in the presence of one Internal Examiner (from parent college) and one External Examiner (from other college/industy expert), and marks should be allotted as per the following scheme:

(i) Viva-voce (Orals): 10 marks

(ii) Practical : 15 marks

Links for online NPTEL/SWAYAM courses:

1. https://nptel.ac.in/courses/112/107/112107212/

2. https://nptel.ac.in/courses/112/103/112103112/

3. https://nptel.ac.in/courses/112/103/112103111/

4. https://nptel.ac.in/courses/112/107/112107087/

Text/Reference Books:

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

Course Code	Course Name	Credits
AEC603	**Vehicle Body Engineering and Safety**	**03**

Objectives:

1. To Understand fundamentals of Vehicle Body design.
2. To Study different vehicle structural design and their requirements.
3. To Study various static and dynamics load acting on the vehicle.
4. To familiarize with basic concepts of vehicle safety.
5. To study safety features and safety regulations.

Outcomes: Learner will be able to…

1. Illustrate different types of Vehicle structures.
2. Comprehend various loads acting on vehicle body.
3. Classify different materials related to vehicle body.
4. Discuss Aerodynamic concept related to vehicle body.
5. Comprehend Vehicle design from safety point of view.
6. Enumerate interrelation ship among occupant, restraint systems and vehicles in accidents.

Module	Details	Hrs.
01	**1.1 Vehicle Chassis:** Introduction, functions and design considerations, Chassis frame components, Sections used, types of frames. Location of different chassis components, exterior and interior trims, Location of power plant. structure types: Open, Semi integral and Integral bus structure **1.2 Vehicle Body:** Introduction, Classification of vehicle based on body types, Requirements of body, Loads on the vehicle body. **1.3 Vehicle body materials** Introduction to materials used in vehicle body building (Steel sheet, timber, plastics, aluminium alloy, glass, Ultralight Steel Auto Body (ULSAB), FRP, GRP etc., properties of materials-Corrosion anticorrosion methods, selection of paint and painting process)	**08**

02	**2.1 Visibility:** Regulations, driver's visibility, Methods of improving visibility. Bus Floor height, engine location, entrance and exit location, seating dimensions. Driver cabin design. **2.2 Structural surface:** Terminology and overview of structural surface types, Vehicle structure analysis by simple structural surface (SSS) Method. Thin Walled Structures-General Principle, Torsion, Torsion centre, Forces in End Load Carrying Members. **2.3 Overall Criteria for Vehicle Comparison:** Design, Running costs, Overall Design Efficiency. **2.4 Aerodynamics:** Objectives, Various types of forces and moments, body optimization techniques for minimum drag.	**08**
03	**3.1 Preliminary design:** Drawing of the preliminary design, Vehicle Body Weight Analysis, Calculation of C.G for Vehicle, Master Model. **3.2 Body Loads:** Bending, Torsion, Lateral and Braking and Acceleration Load Cases. Idealized structure, Structural surface, Shear panel method, Symmetric and asymmetric vertical loads in a car, Longitudinal load, Different loading situations.	**07**
04	**4.1 Vehicle safety** : Introduction, energy equation, types of vehicle collision, Types of safety (Active and Passive). **4.2 Basic concepts of vehicle safety** Fail-safe, Alternative design, Redundancy and derating, Fault tolerance, Universal design. **4.3 Design of seat:** Design and requirement of Driver, Passenger and child seat**,** Occupant Protection, Biomechanics and Occupant Simulation. Role of seat and seat belt in vehicle crash.	**07**
05	**5.1 Crash Testing:** Introduction, Crash testing methods, vehicle body testing, Dynamic Vehicle Simulation, Pedestrian Protection. **5.2 Body repair techniques:** Introduction, tools, repairs procedure.	**06**

06	**6.1 Passive Safety Features** Air bags, Crumple zone, bumper design for safety**.** **6.2 Active Safety Features** Anti-lock braking system, Electronic Stability Control (ESP), Collision warning system, adaptive cruise control. **6.3 Overview of Vehicle Scrapping Policy in India, Scrapping Methodology.** **6.4 Introduction to automotive standards (AIS, FMVSS, CMVR/CMVSS).**	**05**

Theory Examinations:

Internal Assessment for 20 marks:

Consisting **two compulsory class tests**

First test based on initial 40% of the content and second test based on remaining content (but excluding contents covered in Test I).

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the syllabus.

i. Question paper will comprise of total six questions.

ii. All questions carry equal marks.

iii. Questions will be mixed in nature (for example Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

iv. Only four questions need to be solved.

Text/Reference Books:

1. John Fenton, “Vehicle Body Layout & Analysis”, Hutchinson, London.
2. J Powloski, “Vehicle Body Engineering”, Business Books Ltd., London.
3. J.G. Giles, “Body Construction and Design”, Vol. 6. llefe Books/Butterworth & Co. London
4. P. L. Kohli, “Automotive Chassis & Body”, Papyrus Publishing House, New Delhi.
5. John Fenton, “Handbook of Automotive Body Construction and Design Analysis” Professional Engineering Publishing.
6. Automotive vehicle safety by George Peters and Barbara Peters, CRC Press, 2002.
7. Role of the seat in rear crash safety by David C. Viano, SAE International, 2002.
8. Automotive Safety Handbook by Ulrich W. Seiffert and LotharWech, SAE International, 2007.
9. Public Safety Standards of the Republic of India

Links for online NPTEL/SWAYAM courses:

1. https://nptel.ac.in/courses/107/103/107103084/
2. https://nptel.ac.in/courses/107/106/107106080/

Course Code	Course Name	Credits
AEC604	**Automation and Artificial Intelligence**	**03**

Objectives:

1. To understand the need and justification of automation.
2. To study design of pneumatic and hydraulic circuits.
3. To study and understand electropneumatic circuits and PLC Design
4. To familiarize with robotic systems in automated manufacturing processes.
5. To study and understand AI and machine learning technologies for automation.

Outcomes: Learner will be able to…

1. Demonstrate understanding of fundamentals of industrial automation and AI.
2. Design & develop pneumatic / hydraulic circuits.
3. Design and develop electropneumatic circuits and PLC ladder logics.
4. Demonstrate understanding of robotic control systems and their applications.
5. Demonstrate understanding of various AI and machine learning technologies.

Module	Details	Hrs
1	**1.1 Introduction to Automation** Definition and fundamentals of automation, Elements of Automated system, Automation principles and strategies, Levels of automation, types of automation, Advanced automation functions **1.2 Introduction to Artificial Intelligence** Introduction, Historical development, Intelligent Systems, Types of Intelligent Agents, Components of AI, Foundations of AI, Scope of AI, Current trends in AI, Relevance to Mechanical Engineering	**04**
2	**2.1 Design of Pneumatic Circuits** Design of Pneumatic sequencing circuits using Cascade method and Shift register method (up to 2 cylinders) **2.2 Design of Hydraulic Circuits** Basic Hydraulic Circuits: Meter in, meter out and Bleed off circuits; Intensifier circuits, Regenerative Circuit, Counter balance valve circuit and sequencing circuits.	**08**
3	**3.1 Electro-pneumatic Circuits** Design of Electro-Pneumatic Circuits using single solenoid and double solenoid valves; with and without grouping; **3.2 PLC Discrete Control Systems** Design of Pneumatic circuits using PLC Control (ladder programming only) up to 2 cylinders, with applications of Timers and Counters and concept of Flag and latching.	**08**
4	**Robots and their applications**: Introduction to Robots, Types,	**07**

	Classifications, Selection of Robots, Robot Degrees of freedom, Robot configuration, Accuracy and repeatability, Specification of a Robot, Robot feedback controls: Point to point control and Continuous path control, Control system for Robot joint, Adaptive control, Drives and transmission systems, End effectors, Industrial robot applications, Nex-gen robots.	
5	**(Concept and Algorithms, No programming or numericals)** **5.1 Problem Solving:** Tree and Graph Search, Uninformed v/s informed search, uninformed methods: depth first search, breadth first search, Informed search: heuristic search, Best first search, branch and bound **5.2 Machine Learning:** Introduction, types of machine learning: supervised, unsupervised, reinforcement learning **5.3 Learning with Decision Trees:** Introduction to Decision Trees, Classification and Regression Trees, K means clustering algorithm, K nearest neighbours algorithm, hierarchical clustering, Concept of ensemble methods: bagging, boosting, random forests	**06**
6	**(Concept and Algorithms, No programming or numericals)** **6.1 Learning with regression:** Linear regression, Logistic regression **6.2 Artificial Neural Networks** Concept of ANN, Basic Models of Artificial Neural Networks Important Terminologies of ANNs McCulloch-Pitts Neuron, NN architecture, perceptron, delta learning rule, backpropagation algorithm, Gradient Descent algorithm, feed forward networks, activation functions **6.3 Introduction to AI Technologies in the realm of Automation** Concept of Natural Language Processing, Machine Vision, Deep learning, Expert systems, Genetic Algorithms, Industry 4.0	**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)

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/Reference Books:

1. Applied Mechatronics- A. Smaili and F. Mrad, OXFORD university press
2. Mechatronics System Design , Shetty and Kolk, Cengage Learning, India Edition
3. Mechatronics - Electronic Control Systems in Mechanical Engineering , Bolton Pearson eduaction
4. Introduction to Mechatronics, AppuKuttan K.K., OXFORD Higher Education
5. Pneumatic Circuits and Low Cost Automation by Fawcett JR
6. Electromechanical Design Handbook , Walsh, McGraw-Hill
7. Electro-mechanical Engineering - An Integrated Approach , Fraser and Milne
8. Industrial Hydraulics: Pippenger
9. Vickers Manual on Hydraulics
10. Hydraulic Valves and Controls: Pippenger
11. Fundamentals of pneumatics: Festo series
12. Mechatronics, NitaigourMahalik, Tata McGraw-Hill
13. Mechatronics, HMT
14. M.P.Groover "Automation, Production Systems and Computer Integrated Manufacturing", Pearson Education,New Delhi
15. M.P. Groover, M. Weiss, R.N. Nagel, and N.G. Odrey, "Industrial Robotics Technology programming and Applications", McGraw-Hill,
16. Yoram Korean, "Robotics for engineers", McGrew Hill Co
17. John W Webb and Reis, Ronald A., "Programmable Logic Controllers: Principles & Applications", Prentice Hall.
18. Frank Petruzella," Programmable Logic Controllers", McGraw-Hill Education; 4 edition
19. Artificial Intelligence: A Modern Approach by Peter and Norvig ISBN-0-13103805-2,
20. Artificial Intelligence by Elaine Rich, Kevin Knight and Nair ISBN-978-0-07008770-5, TMH,
21. Artificial Intelligence by Saroj KausikISBN:- 978-81-315-1099-5, Cengage Learning
22. Artificial Intelligence and Intelligent Systems by Padhy, Oxforfd University Press,
23. Artificial Intelligence & Machine Learning by Vinod Chandra .S.S. Anand Harindran. S. (PHI)
24. A first course in Artificial Intelligence – By Deepak Khemani. Mc GrawHill

Links for online NPTEL/SWAYAM courses:
https://nptel.ac.in/courses/112/103/112103174/
https://nptel.ac.in/courses/112/103/112103293/
https://nptel.ac.in/courses/112/102/112102011/
https://nptel.ac.in/courses/112/101/112101098/
https://nptel.ac.in/courses/112/103/112103280/
https://nptel.ac.in/courses/106/106/106106139/

Course Code	Course Name	Credit
AEDLO6021	**Press Tool Design**	**03**

Objectives:

1. To acquaint with various press working operations for mass production of sheet metal components
2. To familiarise with sheet metal working techniques for design of press tools
3. To inculcate knowledge about scrap minimization, safety aspects and automation in press working

Outcomes: Learner will be able to…

1. Demonstrate various press working operations for mass production of sheet metal parts
2. Identify press tool requirements to build concepts pertaining to design of press tools
3. Prepare working drawings and setup for economic production of sheet metal components
4. Select suitable materials for different elements of press tools
5. Illustrate the principles and blank development in bent & drawn components
6. understand safety aspects and automation in press working

Module	Details	Hrs
1	**Introduction to Press Working** 1.1 Classification of common Press working operations, Benefits and limitations of using Press tools. Applications of pressed parts/components. 1.2 Theory of Shearing in Press Working. Optimum Cutting clearance & its effect on tolerances of pressed components. Press working terminology, Functions of different elements of a press tool. material handling equipment, Methods of feeding the strip/coil material.	**06**
2	**Design Progressive die** 2.1 Calculations for Economic Strip Layout, Calculations of Cutting force and Stripping force, recommending minimum tonnage of a press, Methods of reducing cutting loads on press tools 2.2 Design aspects of Press tool elements viz. Punches & methods of mounting punches, types of Die block, Stripper, Pilot, stock guides, stock stops, Selection and arrangement of Hardware used in Press tools. Selection of steels and its hardness for different elements of Press tools. 2.3 Centre of pressure, Different types Die sets and its selection, shut height of die, Problems based design of progressive die	**10**
3	**Bending and Drawing-** 3.1 Theory of Bending, Spring back and measures to control it, Calculations for Blank development of Simple Bent components, Minimum bend radius, Types of Bending dies, roller bending, bending force problems on bend length calculation and bending force, 3.2 Theory of Drawing, Metal flow in Drawing & forming operations; reduction ratio and redrawing limits, draw clearance, drawing and blank holding forces for cylindrical draws only. Blank development of Cup, problems on drawing 3.3 Defects in drawn parts	**08**

	3.4 Basic construction and working of Bending and Drawing dies	
4	**Miscellaneous Dies-** Basic construction & working of Shaving dies, Trimming dies, Compound dies, Combination dies, Coining dies, Embossing dies, Simple Progressive & Compound Progressive dies, drop through and inverted die, curling die, transfer die	**04**
5	**Selection of Presses and its setting** Classification of presses, Selection of Press and Press setting, calculation of shut press shut height and die shut height, Overloading of presses (load, energy considerations)	**04**
6	**Introduction to Automation & Safety in Press shop** Types of CNC Press, Types of CNC press controller, Basic hydraulic and pneumatic circuit used in press for stock feeding and ram movement, different types sensors used for hand protection, stock feeding etc., other safety equipment like break, clutch, face shield etc.	**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)
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/Reference Books:

1. Die Design Fundamentals by J. R. Paquin, Industrial Press
2. Techniques of Press Working Sheet Metal by D F Eary and E A Reed
3. Press Tools Design and Construction by P H Joshi, S Chand Publishing
4. Tool Design by C. Donaldson and V C Goold, TMH
5. Production Engineering by P. C. Sharma, S Chand Publishing
6. Metal working ASM Handbook

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/105/112105233/ - Metal Cutting and Machine Tools, IIT Kharagpur

Course Code	Course Name	Credit
AEDLO6022	**Tool Engineering**	**03**

Objectives:

1. To familiarize with the basic concepts of machining science like mechanics of machining, tool wear, tool life, surface roughness and tool materials.
2. To familiarize with various single and multipoint cutting tools designing processes
3. To study the economics of machining process

Outcomes: Learner will be able to…

1. Calculate the values of various forces involved in the machining operations
2. Design various single and multipoint cutting tools
3. Analyze heat generation in machining operation and coolant operations
4. Illustrate the properties of various cutting tool materials and hence select an appropriate tool material for particular machining application
5. Demonstrate the inter-relationship between cutting parameters and machining performance measures like power requirement, cutting time, tool life and surface finish
6. Analyze economics of machining operations

Module	Details	Hrs
1	1.1 **Metal Cutting Theory:** Orthogonal and oblique cutting, various types of chips, Mechanics of orthogonal steady state metal cutting, shear plane and shear plane angle, Merchant's force circle, stresses, shear strain, velocity relations, rate of strain, energy considerations, Concept of specific power consumption in machining, Ernst and Merchant's model & modified model for orthogonal cutting, problems on above topic. 1.2 **Dynamometry:** Dynamometer requirements, force measurement, electric transducers, strain gauge lathe dynamometer, strain rings, milling dynamometer, drilling dynamometer, piezoelectric dynamometry	**08**
2	2.1 **Temperatures in metal cutting and cutting fluids**: Heat generation in metal cutting, heat transfer in a moving material, temperature distribution in metal cutting, effect of cutting speed on temperature, prediction of temperature distribution in machining, measurement of cutting temperature, work tool thermocouple, direct thermocouple measurement, radiation methods, hardness changes in steel tools, Cutting fluid types, the action of coolants, the action of lubricants, characteristics of an efficient lubricant in metal cutting, application methods of cutting fluid, dry cutting and minimum quantity lubrication, cryogenic cooling, cutting fluid maintenance and environmental considerations, disposal of cutting fluids	**05**
3	**Cutting tool materials and machining induced surface integrity** 3.1 Properties of cutting tool materials, Major tool material types, Plain carbon steel, high speed steel, cast alloys, cemented tungsten carbide, titanium carbides, ceramic and cermet tools, synthetic diamond,	**04**

	polycrystalline diamond (PCD), cubic boron nitride (CBN), coated tools, Techniques for manufacturing coated tools 3.2 Measurement and specification of surface finish, primary cutting edge finish, fracture roughness, BUE formation and its influence on finish, secondary cutting edge finish,	
4	**Tool life and Machining Economics**: 4.1 Definition, tool wear, criteria for tool failure, effect of cutting parameters and tool geometry on tool life, Taylor's tool life equation, machinability of material, factors affecting machinability, 4.2 Components of product cost, Optimum cutting velocity for minimum cost of production and maximum production rate, problems on above topic.	**06**
5	**Design of single point cutting tools**: Different systems of tool nomenclature like MRS and ORS, Constructional features of solid tool, tipped tools, mechanically held regrindable insert type tools and throw away tip type tools, Design of shanks, cutting tip and chip breakers for HSS and Carbide tools, ISO coding system for tipped tools and tool holders, Tool design for EDM and USM.	**05**
6	**Design of multi point cutting tools**: Introduction to various form tools, Broach nomenclature, design steps for circular pull type, key way and spline broaches, Design of face and peripheral milling cutters, Drill, Reamer and Tap design using standard procedure.	**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)

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. Fundamentals of Metal Machining and Machine Tools, Third Edition by Winston A. Knight, Geoffrey Boothroyd, CRC press Taylor and Francis group
2. Metal Cutting Principles by Milton Clayton Shaw,2nd Edition, Oxford University Press
3. Cutting Tools by P H Joshi, A H Wheeler Publishing Co Ltd
4. ASM Handbook, Vol. 16: Machining by Joseph R. Davis,9th Edition, ASM International

5. Fundamentals of Metal Cutting and Machine Tools by B. L. Juneja, G. S. Sekhon and Nitin Seth,2nd Edition, New Age International
6. Metal Cutting Theory and Cutting Tool Design, by V. Arshinov and G. Alekseev, Mir publishers, Moscow
7. Typical Examples and Problems in Metal Cutting and Tool Design, by N. Nefedov and K. Osipov, Mir publishers, Moscow
8. Production Technology – HMT handbook

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/105/112105233/ - Metal Cutting and Machine Tools, IIT Kharagpur

Course Code	Course Name	Credits
AEDLO6023	**Metal FormingTechnology**	**03**

Objectives:

1. To conversant with the basic knowledge on fundamentals of metal formingprocesses
2. To study various metal formingprocesses
3. Understanding plastic deformation and technical analysis of forming processes

Outcomes: Learner will be able to

1. Understand the concept of different metal formingprocess.
2. Approach metal forming processes both analytically andnumerically
3. Design metal formingprocesses
4. Develop approaches and solutions to analyze metal forming processes and the associated problems andflaws.

Module	Details	Hrs
1.	**Introduction to Metal Forming:** Metallurgical aspects of metal forming, slip, twinning mechanics of plastic deformation, effects of temperature, strain rate, microstructure and friction in metal forming-yield criteria and their significance, Classification of Metal Forming Processes, Advantages and Limitations, Stress strain relations in elastic and plastic deformation, concept of flow stresses, deformation mechanisms, Hot and Cold Working Processes and Its Effect on MechanicalProperties.	**08**
2.	**Rolling:** Introduction and Classification, Types of Rolling Mills, Forces andGeometrical Relationships in Rolling, Calculation of Rolling Load, Roll Pass Design, and Defects in Rolled Products.	**07**
3.	**Forging:** Introduction and Classification, operation and principle of Forging Processes and Equipment, Methods of forging, Open and Close Die Forging Processes, Defects, Structure and Properties of Forged Products. Force Analysis inforging.	**07**
4.	**Extrusion:** Introduction and Classification, Extrusion Equipment, Forces inextrusion, Analysis of Extrusion Process, Extrusion of components including Seamless Pipes and Tubes. Extrusion of pipes by cold working,	**06**
5.	**Drawing:** Introduction and Classification, Wire Drawing, Rod Drawing, Tube	**06**

	Drawing, Deep Drawing, Analysis of Wire Drawing Process and Load Calculations.	
6.	**Sheet Metal Forming:** Principle, process parameters, equipment and application of the following processes: spinning, stretch forming, plate, V and edge bending, Curling, Ironing, Roll Bending, Metal Spinning. Press brake forming, explosive forming, Hydro forming, electro hydraulic forming, and magnetic pulse forming.High Velocity forming of metals and High energy Rate forming	**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)

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/Reference Books: -

1. Lin D Balint M Pietrzyk, Microstructure Evolution in Metal Forming Processes 1st Edition
2. Amitabha Ghosh and Asok Kumar Mallick, Manufacturing Science, Affiliated East-West Press
3. Christian Brecher and Ozdemir , Advances in Production Technology, Springer Publications
4. P.C.Sharma , A Text Book on Production Engineering, S.Chand Publications
5. P. N. Rao, “Manufacturing Technology”, Tata McGraw Hill
6. Aviter, “Fundamental of Metal Working”, McGraw Hill Publisher
7. Dieter, “Mechanical Metallurgy”

Links for online NPTEL/SWAYAM courses:

https://nptel.ac.in/courses/112/107/112107250/ - Principles of Metal Forming Technology, IIT Roorkee
https://nptel.ac.in/courses/112/106/112106153/ - Forming, IIT Madras

Course Code	Course Name	Credits
AEL601	**Automotive System Design**	**01**

Objectives:

1. To help students better understand Automotive systems and subsystems through Dismantling and assembling of various subsystems components.
2. To give hands on experience to students on designing different automotive components.
3. To Understand and apply concepts in designing automotive components.

Outcomes: Learner will be able to…

1. Identify Automobile systems and subsystems.
2. Dismantle and assemble Clutch and gearbox
3. Dismantle and assemble Propeller shaft
4. Dismantle and assemble Steering Gearbox
5. Dismantle and assemble Differential
6. Demonstrate design calculations for various automotive components.

Term Work :(Comprises both A & B)

A.List of Experiments

1. Dismantling and reassembling of Clutch.

2. Dismantling and reassembling of Gear box.

3. Dismantling and reassembling of Propeller Shaft.

4. Dismantling and reassembling of Differential.

5. Dismantling and reassembling of Steering gear linkages and steering gear box.

6. Dismantling and reassembling of any one type of braking systems.

B.Design Calculations

a.Exercises on the following in the form of design calculations(Any Three)

A. Design of any one Engine Component

B.Design of clutches (Single,Multi and Centrifugal)

C. Design of Gearbox

D. Design of Brakes

E.Design of Propeller Shaft/Axles

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

1) Part A: 10 marks

2) Part B: 10 marks

3) Attendance (Theory and Practical): 05 marks

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

End Semester Practical/Oral Examination:

1. Pair of Internal and External Examiner should conduct practical/Oral based on contents Distribution of marks for practical/Oral examination shall be as follows:

Practical performance:15 marks

Oral: 10 marks

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

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

Course Code	Course Name	Credits
AEL602	**Mechanical Vibrations**	**01**

Objectives:

1. Study some single undamped degree of freedom systems theoretically and experimentally, and validate the time period of small vibrations/oscillations.
2. Obtain displacement vs. time graphs experimentally, and plot the same through response equations by the use of graphing and programming software viz., MS Excel etc.
3. Plot dimensionless steady-state amplitude vs. frequency ratio curves for various values of damping ratio for the case of forced vibrations, by the use of some programming software.
4. Balance a rotating system statically and dynamically.
5. Perform virtual experiments using Sakshat Virtual Laboratory.

Outcomes: Learner will be able to…

1. Derive the differential equation of motion, frequency & time-period, for the given single degree of freedom vibration system, for small oscillations.
2. Perform experiments on physical vibration systems and compare the theoretical and experimental results, for validation and verification.
3. Program using scientific mathematical software or using basic programming software, to obtain the necessary plots in time and frequency domains, and interpret the results thus obtained.
4. Balance a rotating unbalanced system completely, by making use of analytical and/or graphical methods.
5. Perform simulation of experiments through Sakshat Virtual Laboratory interface.

List of Experiments: At least 6 experiments based on the **serial numbers 01 – 07** as follows:

Sr. No.	Title of the Experiment	Lab. Sessions (Hours)
01	Determining the undamped natural frequency / time period of free undamped vibrations/oscillations of the following systems, theoretically and experimentally: (**any 4**) 1. Simple spring-mass system 2. Simple pendulum 3. Compound pendulum 4. Single rotor-shaft system 5. Bifilar suspension system	**08**

02	Free damped torsional oscillations.	**02**
03	Forced vibration of one degree of freedom system, subjected to frequency-squared excitations (rotating unbalance).	**02**
04	Computer program on frequency-domain plots of dimensionless steady-state amplitudes for various values of damping ratio.	**02**
05	Dunkerley's / Rayleigh's experiment on transverse vibration of beam for finding fundamental frequency.	**02**
06	Balancing of rotating masses.	**02**
07	Virtual Laboratory Experiments using Sakshat VLab portal.	**04**

Text/Reference Books:

1. Vibration Monitoring, Testing, and Instrumentation (Mechanical Engineering Series) - Clarence W. deSilva - CRC Press.

2. Vibration Testing: Theory and Practice - Kenneth G. McConnell, Wiley.

3. Modal Testing: A Practitioner's Guide - Peter Avitabile - Wiley.

Course Code	Course Name	Credits
AEL603	**Vehicle Body Engineering and Safety**	**01**

Objectives:

1. To help student understand and model various cross-sections used in chassis frame.
2. To help student to understand different vehicle body styles.
3. To give hands on experience to students on Designing and analysis of Chassis Frame.
4. To study vehicle comparison criteria.

Outcome: Learner will be able to

1. Model various cross sections used in Chassis frame.
2. Calculate various loads acting on chassis frame.
3. Compare to vehicles of same class.
4. Illustrate different vehicle body styles.
5. Compute tractive force and centre of gravity of the vehicle.

Term Work: (Comprises of parts A, B & C)

A. List of Experiments

1. Structural analysis of Chassis Frame using any FEA Software's for different sections (C-section, I- section, L-section, O-section, Hat section, Tubular section).

2. Case study on crash test dummy.

3. Comparison of two vehicles under same class based on overall design criteria and safety features.

4. Case study on tractive force analysis.

5. Case study on Centre of gravity calculation.

6. Case study on automotive standards (AIS, FMVSS, CMVR/CMVSS).

(Perform any four experiments from the list)

B. Mini Project

Analysis of Chassis frame containing a 3D Model of any existing Automobile Chassis or Body or combination of both (Min 2 Max 4 Students per Group)

C. Drawing sheet

Three A2 size sheets based on

1. Car body style
2. Bus body style
3. Commercial Vehicle body style

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

1) Laboratory work (Experiments) : **05 marks**

2) Mini project : **10 marks**

3) Drawing sheets : **05 marks**

4) Attendance (Theory and Practical) : **05 marks**

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

End Semester Practical/Oral Examination:

1. Pair of Internal and External Examiner should conduct practical/Oral based on contents
   Distribution of marks for practical/Oral examination shall be as follows:
   Practical performance 15 marks
   Oral 10 marks
2. Evaluation of practical examination to be done based on the experiment performed and the output of the experiment during practical examination

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

Course Code	Course Name	Credits
AESBL601	**Measurements and Automation**	**02**

Objectives:

1. To study fundamentals of inspection methods and systems.
2. To study working of mechanical measurement system.
3. To familiarise with different types of control systems.
4. To study different hydraulic and pneumatic systems.
5. To study various design principles of robotics through kinematic analysis, workspace analysis and trajectory planning.

Outcomes: Learner will be able to…

1. Apply inspection gauge to check or measure surface parameters.
2. Measure surface parameters using precision measurement tools and equipment.
3. Measure different mechanical parameters by using sensors.
4. Analyse the response of a control systems.
5. Demonstrate use of automated controls using pneumatic and hydraulic systems.
6. Implement program on PLC system and demonstrate its application

The laboratory experiments should be based on the following:

Group A (Metrology):

1. Experiments on linear and angular measurement using Vernier calliper, micrometer and Bevel protractor.
2. Experiments on surface measurement by using Surface roughness tester.
3. Experiments on measurement of gear parameters using Gear tooth Vernier calliper / Parkinson gear tester.
4. Experiments on screw thread measurement using screw thread micrometer, Floating carriage micrometer / bench micrometer.
5. Experiments on linear / angular measurements of screw / gear /single point tool using Optical profile projector or Tool maker's microscope.
6. Experiment using Mechanical / Pneumatic type Comparator.
7. Experiments on flatness measurement by Autocollimator / Interferometry method

Group B (Mechanical Measurement):

1. Experiments on measurement of displacement by sensors like LVDT, Potentiometers etc.
2. Experiments on measurement of pressure by gauges or sensors like vacuum Gauges, pressure gauge, piezoelectric sensors, strain gauge sensors etc.
3. Experiments on measurement of vibration by accelerometers or NI.
4. Experiments on feedback control systems and servomechanisms
5. Experiment on frequency response system identification / transient state response of a control system.
6. Experiment on design of PID controller for a system or simulate and tune a PID controller using lab view.

Group C (Automation):

1. Experiment on trainer kit (Any one)

a) Designing sequential operation for two cylinders using electro-hydraulic circuits.

or

b) Designing sequential operation for two cylinders using electro- pneumatic circuits.

2. Experiment on simulation using software like Festo, AutoSim etc.

a) Simulation of basic pneumatic and electro-pneumatic circuits.

or

b) Simulation of hydraulic and electro-hydraulic circuits.

3. Experiments on Ladder programming

a) Experiments on Ladder programming on PLC for simple ON OFF control, timers, counter, two motor system, simple control applications with logic/ timers/counters.

or

b) Experiments on Ladder programming for Mechatronics system (e.g. bottle filling plant, control of electro-pneumatic or electro-hydraulic systems).

4. Experiments on Robotics

a) Demonstration and study of functions of components of robotics arm.

or

b) Visualization of DH (Denavit–Hartenberg) parameters in Roboanalyzer (*Roboanalyzer is free software developed by IIT Delhi, available on www.roboanalyzer.com).

Term Work

Term work shall consist of minimum Nine Experiments. Three from each group mentioned above. There will be no theoretical assignment for the lab course. The distribution of marks for term work shall be as follows:

Laboratory work (Experiments) : 20 marks

Attendance: : 05 marks

End Semester Practical/Oral Examination:

1. Pair of Internal and External Examiner should conduct practical and viva based on contents.
2. Practical examination (in a group of not more than 4 students) duration is 2 hours
3. Distribution of marks for practical/viva examination shall be as follows:

Practical performance: 15 marks

Oral: 10 marks

4. Evaluation of practical examination to be done based on the experiment performed and the output of the experiment during practical examination.
5. Students work along with evaluation report to be preserved till the next examination.

Virtual Labs

http://ial-coep.vlabs.ac.in/ - Industrial Automation Laboratory, COEP

Course code	Course Name	Credits
AEPBL601	**Mini Project - 2B**	**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 fundamentals to 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