UNIVERSITY OF MUMBAI

Revised syllabus (Rev- 2016) from Academic Year 2016 -17
Under

FACULTY OF TECHNOLOGY

Automobile Engineering

Second Year with Effect from AY 2017-18
Third Year with Effect from AY 2018-19
Final Year with Effect from AY 2019-20

As per **Choice Based Credit and Grading System**
with effect from the AY 2016–17

Co-ordinator, Faculty of Technology's Preamble:

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

Faculty of Technology, University of Mumbai, in one of its meeting unanimously resolved that, each Board of Studies shall prepare some Program Educational Objectives (PEOs) and give freedom to affiliated Institutes to add few (PEOs). It is also 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. It was also resolved that, maximum senior faculty from colleges and experts from industry to be involved while revising the curriculum. I am happy to state that, each Board of studies has adhered to the resolutions passed by Faculty of Technology, and developed curriculum accordingly. In addition to outcome based education, semester based credit and grading system is also introduced to ensure quality of engineering education.

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

Choice based Credit and grading system is implemented from the academic year 2016-17 through optional courses at department and institute level

Dr. S. K. Ukarande
Co-ordinator,
Faculty of Technology,
Member - Academic Council
University of Mumbai, Mumbai

Chairman's Preamble:

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

As the Chairman, Board of Studies in Mechanical Engineering of the University of Mumbai, I am happy to state here that, the Program Educational Objectives for Undergraduate Program were finalized in a brain storming sessions, which was attended by more than 40 members from different affiliated Institutes of the University. They are either Heads of Departments or their senior representatives from the Department of Mechanical Engineering. The Program Educational Objectives finalized for the undergraduate program in Mechanical Engineering are listed below;

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

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

Dr. S. M. Khot

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

Semester V

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract	Theory	Pract	Total
AEC501	Internal Combustion Engines*	04	--	04	--	04
AEC502	Mechanical Measurements and Control*	04	--	04	--	04
AEC503	Heat Transfer*	04	--	04	--	04
AEC504	Automotive Systems	03	--	03	--	03
AEDLO 501X	Department Level Optional Course I	04	--	04	--	04
AEL501	Internal Combustion Engines*	--	02	--	01	01
AEL502	Mechanical Measurements and Control*	--	02	--	01	01
AEL503	Heat Transfer*	--	02	--	01	01
AEL504	Automotive Systems	--	02	--	01	01
AEL505	Manufacturing Sciences Lab*	--	02	--	01	01
AEL506	Business Communication and Ethics*	--	$2^{\$}+2$	--	02	02
Total		**19**	**14**	**19**	**07**	**26**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (Hrs)			
		Test1	Test 2	Avg					
AEC501	Internal Combustion Engines*	20	20	20	80	03	--	--	100
AEC502	Mechanical Measurements and Control*	20	20	20	80	03	--	--	100
AEC503	Heat Transfer*	20	20	20	80	03	--	--	100
AEC504	Automotive Systems	20	20	20	80	03	--	--	100
AEDLO 501X	Department Level Optional Course I*	20	20	20	80	03	--	--	100
AEL501	Internal Combustion Engines*	--	--	--	--	--	25	25	50
AEL502	Mechanical Measurements and Control*	--	--	--	--	--	25	25	50
AEL503	Heat Transfer*	--	--	--	--	--	25	25	50
AEL504	Automotive Systems	--	--	--	--	--	25	25	50
AEL505	Manufacturing Sciences Lab*	--	--	--	--	--	25	--	25
AEL506	Business Communication and Ethics*	--	--	--	--	--	50	--	50
Total				**100**	**400**		**175**	**100**	**775**

Course Code	Department Level Elective Course I
AEDLO5011	Press Tool Design*
AEDLO5012	Machining Sciences and Tool Design*
AEDLO5013	Design of Jigs and Fixtures*

***Common with Mechanical Engineering**

$ Theory for entire class to be conducted

Semester VI

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract	Theory	Pract	Total
AEC601	Chassis and Body Engineering	04	--	04	--	04
AEC602	Machine Design I*	04	--	04	--	04
AEC603	Finite Element Analysis*	04	--	04	--	04
AEC604	Mechanical Vibrations	04	--	04	--	04
AEDLO 602X	Department Level Optional Course II	04	--	04	--	04
AEL601	Chassis and Body Engineering	--	02	--	01	01
AEL602	Machine Design I*	--	02	--	01	01
AEL603	Finite Element Analysis*	--	02	--	01	01
AEL604	Mechanical Vibrations	--	02	--	01	01
AEL605	Mechatronics Lab	--	02	--	01	01
Total		**20**	**10**	**20**	**05**	**25**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract/ Oral	Total
		Internal Assessment			End Sem Exam	Exam Duration (Hrs)			
		Test1	Test 2	Avg					
AEC601	Chassis and Body Engineering	20	20	20	80	03	--	--	100
AEC602	Machine Design I*	20	20	20	80	03	--	--	100
AEC603	Finite Element Analysis*	20	20	20	80	03	--	--	100
AEC604	Mechanical Vibrations	20	20	20	80	03	--	--	100
AEDLO 602X	Department Level Optional Course II	20	20	20	80	03	--	--	100
AEL601	Chassis and Body Engineering	--	--	--	--	--	25	25	50
AEL602	Machine Design I*	--	--	--	--	--	25	--	25
AEL603	Finite Element Analysis*	--	--	--	--	--	25	25	50
AEL604	Mechanical Vibrations	--	--	--	--	--	25	25	50
AEL605	Mechatronics Lab	--	--	--	--	--	25	25	50
Total				**100**	**400**		**125**	**100**	**725**

Course Code	Department Level Optional Course II
AEDLO6021	Mechatronics
AEDLO6022	Robotics
AEDLO6023	Automotive Materials

***Common with Mechanical Engineering**

Course Code	Course Name	Credits
AEC501	Internal Combustion Engines*	4

Objectives

1. To familiarize with the working of S.I. and C.I. engines and its important systems
2. To acquaint with the various methods for measurement of engine performance
3. To provide insight into the harmful effects of engine pollutants and its control
4. To familiarise with the latest technological developments in engine technology

Outcomes: Learner will be able to…

1. Demonstrate the working of different systems and processes of S.I. engines
2. Demonstrate the working of different systems and processes of C.I. engines
3. Illustrate the working of lubrication, cooling and supercharging systems.
4. Analyse engine performance
5. Illustrate emission norms and emission control
6. Comprehend the different technological advances in engines and alternate fuels

Module	Detailed Contents	Hrs.
01	**Introduction** Classification of I.C. Engines; Parts of I.C. Engine and their materials, Cycle of operation in Four stroke and Two-stroke IC engines and their comparative study; Fuel air cycles and their analysis, Actual working cycle, Valve Timing Diagram. LHR Engines, Homogeneous charge compression Ignition,Rotary engine-Six stroke engine concept	06
02	**S.I. Engines** **Fuel Supply System:** Spark ignition Engine mixture requirements, Fuel-Air ratio, Simple carburettor and auxiliary circuits (excluding mathematical analysis of carburettors) Injection systems: Single-point and Multipoint injection, Gasoline Direct Injection **Ignition System:** Battery Ignition System, Magneto Ignition System, Functions and working of ignition coil, spark plug, contact breaker point, Requirements and working of Ignition advance mechanisms; mechanical and vacuum, Electronic Ignition Systems; Capacitor Discharge Ignition System, Transistorized Coil Assisted Ignition System, Transistor Ignition system with contactless breaker **Combustion :** Combustion phenomenon in SI Engines, Ignition delay, Flame propagation, Pressure-Crank angle diagram, Abnormal combustion, Auto ignition, Detonation and Knocking, Factors affecting combustion and detonation, Types of combustion chambers	12
03	**Compression Ignition Engines** **Fuel Injection Systems:** Air injection systems, Airless/solid injection systems, Common rail, individual pump, distributor and unit systems. Injection pumps, Fuel injector, Types of nozzle, Electronically controlled unit fuel injection 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	10
04	**Engine lubrication:** Types of lubricants and their properties, SAE rating of lubricants, Types of lubrication systems **Engine Cooling:** Necessity of engine cooling, disadvantages of overcooling, Cooling systems and their comparison: Air cooling, Liquid cooling **Supercharging/Turbo-charging:** Objectives, Limitations, Methods and Types,Different arrangements of turbochargers and superchargers	06

05	**Engine Testing and Performance** Measurement of Brake Power, Indicated Power, Frictional Power, Fuel Consumption, Air flow, BMEP, Performance characteristic of SI and CI Engine Effect 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 at its harmful effect 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.	10
06	**Alternative Fuels** 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), Inputs required and output signals from ECM, Sensors: Throttle Position, Inlet Air Temperature, Coolant Temperature, Crankshaft Position, Camshaft Position, Mass Air flow and Exhaust Gas Oxygen sensors, their construction and importance in ECM. Electronic Spark control, Air Management system, Idle speed control	04

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of content 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 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 need to be solved**

References:

1. Internal Combustion Engines, Willard W.Pulkrabek, Pearson Education.
2. Internal Combustion Engines, Shyam Agrawal, New Age International
3. Internal Combustion Engine, Mathur and Sharma
4. Internal Combustion Engines, Mohanty, Standard Book House
5. Internal Combustion Engine, Gills and Smith
6. Internal Combustion Engines Fundamentals, John B. Heywood , TMH
7. Internal Combustion Engines, Gupta H N, 2nd ed, PHI
8. Internal Combustion Engine, V Ganesan, TMH
9. Introduction to Internal Combustion Engines, Richard Stone, Palgrave Publication, 4th Edition
10. Internal Combustion Engine, S.L. Beohar
11. Internal Combustion Engine, P.M Heldt.
12. Internal Combustion Engines, V.L. Maleeve
13. Internal Combustion Engine, E.F. Oberi.
14. Internal Combustion Engine, Domkundwar

Course Code	Course Name	Credits
AEC502	Mechanical Measurement and Control*	4

Objectives

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

Outcomes: Learner will be able to…

1. Classify various types of static characteristics and types of errors occurring in the system.
2. Classify and select proper measuring instrument for linear and angular displacement
3. Classify and select proper measuring instrument for pressure and temperature measurement
4. Design mathematical model of system/process for standard input responses
5. Analyse error and differentiate various types of control systems and time domain specifications
6. Analyse the problems associated with stability

Module	Contents	Hours
01	1.1 Significance of Mechanical Measurements, Classification of measuring instruments, generalized measurement system, types of inputs: Desired, interfering and modifying inputs. 1.2 Static characteristics: Static calibration, Linearity, Static Sensitivity, Accuracy, Static error, Precision, Reproducibility, Threshold, Resolution, Hysteresis, Drift, Span & Range etc. 1.3 Errors in measurement: Types of errors, Effect of component errors, Probable errors.	08
02	2.1 **Displacement Measurement**: Transducers for displacement, displacement measurement, potentiometer, LVDT, Capacitance Types, Digital Transducers (optical encoder) , Nozzle Flapper Transducer 2.2 **Strain Measurement**: Theory of Strain Gauges, gauge factor, temperature Compensation, Bridge circuit, orientation of strain gauges for force and torque, Strain gauge based load cells and torque sensors 2.3 **Measurement of Angular Velocity**: Tachometers, Tachogenerators, Digital tachometers and Stroboscopic Methods. 2.4 **Acceleration Measurement:** theory of accelerometer and vibrometers, practical accelerometers, strain gauge based and piezoelectric accelerometers	08
03	**3.1 Pressure Measurement:** Elastic pressure transducers viz. Bourdon tubes, diaphragm, bellows and piezoelectric pressure sensors, High Pressure Measurements, Bridge man gauge. Vacuum measurement: Vacuum gauges viz. McLeod gauge, Ionization and Thermal Conductivity gauges **3.2 Flow Measurement**: Bernoulli flowmeters, Ultrasonic Flowmeter, Magnetic flow meter, rotameter **3.3 Temperature Measurement**: Electrical methods of temperature measurement Resistance thermometers, Thermistors and thermocouples, Pyrometers **3.4 Sensitivity analysis of sensor**-influence of component variation **3.5 Signal conditioning**: Amplifier, Conversion, Filtering, Impedance Buffering, Modulation / Demodulation, Linearization, Grounding and Isolation	08
04	**4.1** Introduction to control systems, Classification of control system. Open loop and closed loop systems. **4.2** Mathematical modelling of control systems, concept of transfer function, Block diagram algebra	06

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

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of content 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 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 need to be solved**

References

1. Measurement Systems: Applications and Design, by EO Doebelin,5th Edition,*McGraw Hill*
2. Mechanical Engineering Measurements, A K Sawhney, *Dhanpat Rai& Sons, New Delhi*
3. Instrumentation & Mechanical Measurements, A KThayal
4. Control System Engineering by NagrathIJ and Gopal M, *Wiley EasternLtd.*
5. Modem Control engineering: by KOgata, *Prentice Hall*
6. Control systems by DhaneshManik, Cengage Learning
7. Engineering Metrology and Measurementsby N V Raghavendra and L Krishnamurthy, Oxford University Press
8. Instrumentation and Control System, W. Bolton, Elsevier
9. Experimental Methods for Engineers by J P Holman, McGraw Hills Int. Edition
10. Engineering Experimentation by EO Doebelin, McGraw Hills Int. Edition
11. Mechanical Measurements by S P Venkateshan, Ane books, India

Course Code	Course Name	Credits
AEC 503	Heat Transfer*	04

Objectives

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

Outcomes: Learner will be able to…

1. Identify the three modes of heat transfer (conduction, convection and radiation).
2. Illustrate basic modes of heat transfer
3. Develop mathematical model for each mode of heat transfer
4. Develop mathematical model for transient heat transfer
5. Demonstrate and explain mechanism of boiling and condensation
6. Analyse different heat exchangers and quantify their performance

Module	Detailed Contents	Hrs.
01	**Basic concepts of heat transfer:**Define heat transfer and its importance in engineering applications, Difference between heat transfer and Thermodynamics, Physical Mechanism of modes of heat transfer, Governing laws of heat transfer, Conduction mode: Thermal conductivity, Thermal diffusivity, Convection mode: Free and Forced convection, Heat transfer Coefficient, Radiation mode: Emissivity, transmissivity, reflectivity, absorptivity, Black body, Grey body, Opaque body, Steady and unsteady heat transfer, One dimensional, two dimensional and three dimensional heat transfer, Thermal resistance concept in heat transfer, Thermal contact resistance	04
02	**Conduction:**Assumptions in heat conduction, Generalized heat conduction equation in rectangular, cylindrical coordinates, Initial and boundary conditions, Steady state heat conduction through plane wall, Composite wall, cylinder, composite cylinder wall, sphere, Internal Heat generation concept, Heat conduction with heat generation in plane wall, solid cylinder and solid sphere, Critical radius of insulation in cylinder and sphere	08
03	**Heat transfer from Extended Surface:**Types of extended surface and its significance, Governing differential equation for fin and its solution, Fin performance: Fin effectiveness and Fin efficiency, Thermo Well **Unsteady state heat transfer:**Applications of unsteady state heat transfer, Lumped system Analysis, Criteria for lumped system analysis: characteristic length, Biot Number, Thermal time constant and Response of a thermocouple, Heisler Charts **Numerical methods in heat transfer:**Significance of numerical methods in heat transfer, Finite difference formulation of differential equations, One-dimensional heat conduction.	08
04	**Convection:**Determination of heat transfer coefficient, Dimensional Analysis, Dimensionless numbers in free and forced convection and their significance **External Flow:**Velocity Boundary layer and Thermal Boundary layer, Laminar and turbulent flow over a flat plate, Flow across cylinder and sphere, Flow across bank of tubes **Internal Flow:**Velocity Boundary layer and Thermal Boundary layer, Laminar and Turbulent flow in tubes, General thermal analysis: Constant heat flux and constant surface temperature	10
05	**Radiation:**Basic laws of radiation, Black body radiation, Planck's law, Kirchhoff's law, Wein displacement law, Lambert cosine law, Radiation intensity, Radiation heat exchange between black bodies, Shape factor algebra, Radiation heat exchange between nonblack bodies, Electrical network approach for radiation heat exchange: Radiosity and irradiation, Radiation shield	08
06	**Boiling and Condensation:**Boiling heat transfer, Pool boiling: different regimes and pool boiling curve, Flow boiling: Different Regimes and Boiling curve, Condensation heat transfer, Film condensation, Dropwise Condensation **Heat Exchangers:**Types of heat exchangers, Overall heat transfer coefficient, Fouling factor, Analysis of heat exchangers, LMTD, Effectiveness –NTU method, Correction factor, Effectiveness of heat exchangers **Heat Pipe:** Introduction and application	10

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of content 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 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 need to be solved**

ReferenceBooks:

1. Introduction to thermodynamics and Heat transfer by Yunus A Cengel2nd Edition, McGraw Hill International
2. Fundamentals of Heat and Mass Transfer by FPIncropera and D P deWitt, Wiley India
3. Heat Transfer by P S Ghoshdastidar, 2nd Edition, Oxford University Press
4. Heat and Mass Transfer, by R Rudramoorthy and LMalaysamy,2nd Edition, PEARSON
5. Heat Transfer by J P Holman, Mcgraw Hill
6. Heat Transfer by S P Sukhatme, University Press
7. Heat and Mass Transfer by PK Nag, TMH
8. Heat and Mass Transfer by Mahesh Rathod, Laxmi Publications
9. Heat and Mass Transfer byR K Rajput, S Chand and company

Course Code	Course Name	Credits
AEC 504	Automotive Systems	3

Objectives

1. To study basic and advance automotive systems.
2. To study working of different automotive systems and subsystems.
3. To study different vehicle layouts.
4. To have basic idea about how automotive systems are developed.

Outcomes: Learner will be able to…

1. Identify different automotive systems and subsystems.
2. Identify different automotive components.
3. Illustrate working and functions of various automotive components
4. Illustrate working and function of electric drive lines.
5. Comprehend working of Special vehicles through case study.
6. Identify and Demonstrate different vehicle layouts.

Module	Detailed Contents	Hrs.
01	**1. CLUTCHES** 1.1 Function requirements of Flywheel and clutch 1.2 Types of Single plate clutch 1.4 Clutch control systems 1.5 Clutch center plate construction 1.6 Direct release clutch 1.7 Centrifugally operated clutches 1.8 Multi-plate clutches 1.9 Angle spring clutch 1.10 Wet clutch 1.11 Fluid Coupling	08
02	**2.TRANSMISSION** 2.1 Purpose and Necessity of gear box 2.2 Constant mesh gear box 2.3 Sliding mesh gear box 2.4 Synchromesh gear box 2.5 Gear selector mechanism 2.6 Heavy vehicle gear boxes **2.7 Torque convertors** **2.8 Epicyclic gear box operation** **2.9 Semi – Automatic and Automatic transmission** 2.9.1 Hydraulic control systems 2.9.2 Electro hydraulic control systems 2.9.3 Automatic lay shaft gear boxes 2.9.4 Dual mode transmission with sequential gear change 2.9.5 Direct shift gear boxes 2.9.6 Over drive gears 2.9.7 Continuously variable transmissions **2.10 Electric drives** 2.10.1 General arrangement and description of electric transmissions 2.10.2 Working principle and control 2.10.3 Advantages and limitations of electric drives	08

03	**3. DRIVE LINES** 3.1 Drive Lines 3.1.1 Universal joints 3.1.2 Constant velocity joints 3.1.3 Propeller shaft construction 3.1.4 Drive line arrangement 3.1.5 Rear-wheel drive and front-wheel drive layouts 3.1.6 Front-wheel drive shafts 3.1.7 Tandem axle drive for heavy vehicles 3.1.8 Drive lines for public service vehicles	04
04	**4. FINAL DRIVE AND REAR AXLES** 4.1 Final drive gears and bearings 4.2 Differential gears 4.3 Differential- All types 4.4 Rear axle construction 4.5 Heavy vehicle rear axle 4.6 Four wheel drive systems 4.6.1 Basic consideration of four wheel drive 4.6.2 Part time four wheel drive 4.6.3 Full time four wheel drive	04
05	**5. BRAKING AND SUSPENSION SYSTEMS** 5.1 Braking System 5.1.1 Requirement and Types-Block Brakes, Band Brakes, Hydraulic brake, Air Brake, Endurance Brake 5.2 Suspension System 5.2.1 Basic ride considerations 5.2.2 Types of suspension systems 5.2.3 Types of suspension spring 5.2.4 Tandem axle suspension 5.2.5 Shock dampers 5.2.6 Adaptive suspension systems 5.2.7 Active roll control systems	06
06	**6. STEERING , TYRES, ROAD WHEELS AND HUBS** 6.1 Steering systems 6.1.1 Steering principles and layout 6.1.2 Front end geometry and wheel alignment 6.1.3 Steering and suspension ball joints 6.1.4 Manual steering gears 6.1.5 Steering axles for heavy vehicles 6.1.6 Hydraulic power-assisted steering 6.1.7 Speed-sensitive hydraulic power-assisted steering 6.1.8 Electro-hydraulic power-assisted steering 6.1.9 Electrical power-assisted steering 6.1.10 Types of four-wheel steering 6.2 Tires, Road wheels and Hubs 6.2.1 Introduction to Tire characteristics 6.2.2 Tire construction 6.2.3 Road wheels and hubs	06

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.

ReferenceBooks:

1. Light and Heavy Vehicle Technology, M.J. Nunney, Elsevier, Fourth Edition.
2. Automotive Technology, Jack Erjavec, Cengage Learning, Fifth Edition.
3. Automotive Braking, Thomas W. Birch, Cengage Learning, Third Edition.
4. Motor Automotive technology, Anthony E. Schwaller, Delmar, Third Edition.
5. Automotive suspension and steering systems, Thomas W. Birch, Delmar Cengage Learning, Third Edition.

Course Code	Course Name	Credits
AEDLO5011	Press Tool Design*	4

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. Elaborate failure mechanisms of pressed components, safety aspects and automation in press working

Module	Contents	Hours
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. Construction of Basic shearing die. Functions of different elements of a press tool. Methods of feeding the strip/coil material.	08
2	**Design and Calculations** of Piercing & Blanking Die– 2.1 Calculations for Economic Strip Layout, Calculations of Cutting force and Stripping force, Recommending minimum tonnage of a press. Centre of Pressure (its importance and calculation) 2.2 Design aspects of Press tool elements viz. Punches & methods of retaining punches, Die block, Stripper, Pilot, etc. Methods of reducing cutting loads on press tools 2.3 Different types Die sets and its selection	14
3	3.1 **Selection of Material & Hardware –**Selection and arrangement of Hardware used in Press tools. Selection of steels and its hardness for different elements of Press tools.	03
4	**Bending and Drawing-** 1.1 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 1.2 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 1.3 Defects in drawn as well as bent parts, Presses selection for drawing/forming operations 1.4 Basic construction and working of Bending and Drawing dies	12
5	5.1 **Miscellaneous Dies-** Basic construction & working of Shaving dies, Trimming dies,Compound dies, Combination dies, Coining dies, Embossing dies, Simple Progressive & Compound Progressive dies	05
6	**Selection of Presses and its setting –** 6.1 Selection of Press and Press setting for Shearing, Bending, Progressive and Drawing dies, Equipment for Sheet metal operations (Basics only), Overloading of presses (load, energy considerations) 6.2 Introduction to Automation & Safety in Press shop	06

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based onapproximately 40% of contents and second test based on remainingcontents (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. Die Design Fundamentals by J. R. Paquin, Industrial Press
2. Techniques of Press Working Sheet Metal by D F Earyand 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

Course Code	Course Name	Credits
AEDLO5012	Machining Sciences And Tool Design*	4

Objectives

1. To familiarise with the basic concepts of machining science like mechanics of machining, tool wear, tool life and surface roughness.
2. To familiarise 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. Analyse 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. Analyse economics of machining operations

Module	Details	Hrs.
01	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, Lee and Shaffer model, Analytical modelling of machining operations, mechanistic modelling of machining, slip line field analysis, finite element analysis, modelling of material properties 1.2 **Dynamometry:** Dynamometer requirements, force measurement, electric transducers, strain gage lathe dynamometer, strain rings, milling dynamometer, drilling dynamometer, surface grinding dynamometer, piezoelectric dynamometry	10
02	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, temperature in primary deformation zone, temperature in secondary deformation zone, 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 and microstructure 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, cutting fluid maintenance and environmental considerations, disposal of cutting fluids, dry cutting and minimum quantity lubrication, cryogenic cooling	06
03	**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, polycrystalline diamond (PCD), cubic boron nitride (CBN), 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,	06

	geometrical contribution to roughness, edge finishing, residual stress and micro hardness	
04	4.1 **Tool life and machining economics:** Definition, flank wear and crater wear, criteria for tool failure, effect of cutting parameters and tool geometry on tool life, Taylor's tool life equation, Experimental methods to find Taylor exponents, Components of product cost,Optimum cutting velocity for minimum cost of production and maximum production rate	**06**
05	5.1 **Design of single point cutting tools** : Different systems of tool nomenclature like MRS, ORS and NRS, Interrelationship among different systems of nomenclature for tool angles, Constructional features of solid tool, tipped tools, mechanically held regrind able 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	**08**
06	6.1 **Design of multi point cutting tools :** Various types such as flat form tool, tangential form tool, circular form tool, constructional details and fields of application, Profile design of flat and circular form tools,Broach nomenclature, design steps for circular pull type, key way and spline broaches, Design of face and peripheral milling cutters	**10**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based onapproximately 40% of contents and second test based on remainingcontents (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

Course Code	Course Name	Credits
AEDLO5013	Design of Jigs and Fixtures*	4

Objectives

1. To acquaint with the concepts of planning and writing sequence of operations
2. To acquaint basics of identification and selection of location and clamping points on work-piece
3. To familiarise design principles in designing simple productive and cost effective jigs and fixtures

Outcomes: Learner will be able to…

1. Write methodically, thesequence of operations of simple work-piece
2. Identify and select locating and clamping points on work-piece
3. Demonstrate construction of drill jig
4. Illustrate construction of milling fixture
5. Identify appropriate combination of tools, jigs and fixture, suitable for a particular machining operation
6. Design assembly of jigs and fixtures on simple work-piece

Module	Details	Hrs
01	1.1 **Introduction to Tool Design** Production Tooling's Jigs, Fixtures and their difference, their requirement(accuracy, machinability, quantity modifications so as toassist production, Interchange ability, Simplicity, Swarf disposal,Handling, Ease of operation, Skill reduction, Cost reduction), Analysis forOperation planning, sequencing of operations.	08
02	**Basic Construction of Jig & Fixture** 1.1 **Location & Locating Devices** Locating principles: Degrees of freedom, Redundant location, Fool-proofing, nesting, Locators: locators that control work piece on flat surfaces, location of cylindrical surfaces, conical locators, centralizers. 1.2 **Clamping & clamping Devices** Requirement of clamping system, Position of clamps, Types of clamps, Clamping devices; examples of typical clamps(multiple clamping and equalizing devices, quick acting clamping mechanisms such as link, toggle, cam, eccentric, pneumatic, hydraulic and electric devices), Component distortion under clamping and cutting forces, Material used for different clamping devices of jigs/fixture and recommended hardness	10
03	3.1 **Construction of Drill Jig** Introduction, Selection of location, supporting and clamping faces /points, cutting tools and means of guiding and supporting Jigs, varioustypes of Jig Bushes, Commonly used drill jigs, Case Study on Design of Drill Jig	10
04	4.1 **Construction of Milling fixture** Introduction, Selection of location, supporting and clamping faces /points choice, tool setting block and Tennon's, Case Study on Design of Milling Fixture	08
05	5.1 **Introduction to Commonly used Fixtures** Turning Fixture (Chucks, collets, Mandrels) Grinding Fixture, BroachingFixture, and Welding Fixture	08
06	6.1 **Indexing Jig & Fixture** Introduction, Application of indexing, Essential features of an indexing jig /fixture, Indexing Devices	04

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based onapproximately 40% of contents and second test based on remainingcontents (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. Jig and Fixture Design Manual, Erik K. Henrikson, Industrial Press
2. An introduction to jig and tool Design, MH A Kempster, 3rd Edition, ELBS
3. Jigs and Fixture, P. H. Joshi, TMH
4. Tool design, C. Donaldson, George H. Lecain, V.C. Goold, TMH
5. Jigs and Fixture Handbook, A.K. Goroshkin, Mir Publication
6. Jigs and Fixture, ASTME
7. Non- Standards Calming Devices, Hiran E. Grant TMH, New Delhi

Course Code	Course Name	Credits
AEL 501	Internal Combustion Engines Lab*	01

Objectives:

1. To familiarise concept of thermal conductivity, heat transfer coefficient through experiments
2. To familiarise experimental verification of the concepts of heat transfer

Outcomes: Learner will be able to ….

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

Part A: Dismantle, overhaul and assemble the following

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

Part B: Performing experiments on engine test rigs

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

Term Work

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

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

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

End Semester Practical/Oral Examination:

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

Course Code	Course/Subject Name	Credits
AEL 502	Mechanical Measurement and Control*	1

Objectives

1. To study calibration of different measuring instruments
2. To study working of mechanical measurement system
3. To familiarise with different types of control systems

Outcomes: Learner will be able to…

1. Calibrate displacement sensors
2. Calibrate pressure and vacuum gauges
3. Measure torque using strain gauges
4. Identify system/process characteristics for standard input responses
5. Identify various types of control systems and time domain specifications
6. Analyse the problems associated with stability

List of Experiments

Sr. No.	Topic
1	Calibration of Displacement sensors like LVDT, Potentiometers etc.
2	Calibration of Pressure Gauges
3	Calibration of Vacuum Gauges
4	Torque measurement using strain gauges
5	Calibration of tachometers
6	Vibration Measurement & Calibration of Accelerometers.
7	Experiments on feedback control systems and servomechanisms
8	System Identification of any one of the sensor
9	Experiment on frequency response system identification
10	Experiment on transient state response of a control system.
11	Experiment on design of PID controller for a system.

(a) Design based experiments shall be encouraged using standard National Instrument/ texas instrument/ dSPACEGmbh/ Arduino or any other platform),**Learners (in a group) may be encouraged for Project Based Learning. Appropriate weightage may be given in term work assessment**

Term Work

Term work shall consist of minimum 8experiments (04 from the measurement group and 4 from the control group),
The distribution of marks for term work shall be as follows:

- Laboratory work (Experiments) **:** **15 marks**
- Design based experiment: **05 marks**
- Attendance**:** **05 marks**

End Semester Practical/Oral Examination:

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

Subject Code	Subject Name	Credits
AEL 503	Heat Transfer Lab*	01

Objectives:

1. To familiarise concept of thermal conductivity, heat transfer coefficient through experiments
2. To familiarise experimental verification of the concepts of heat transfer

Outcomes: Learner will be able to ….

1. Estimate thermal conductivity of metals/non metals/liquids
2. Compute heat transfer coefficient in natural as well forced convection
3. Measure emissivity of grey body
4. Quantify fin effectiveness/efficiency
5. Analyse heat exchanger performance
6. Demonstrate energy balance for heat exchanger

The laboratory experiments should be based on the following:

Exp.No	Name of Experiments	Time
1	**Conduction: (Any Two)** 1. Measurement of thermal conductivity of metal rod 2. Measurement of thermal conductivity of insulating material 3. Measurement of thermal conductivity of liquid 4. Determination of contact resistance 5. Effect of area on heat transfer	2Hrs
2	**Convection: (Any One)** 1. Measurement of heat transfer coefficient in natural convection 2. Measurement of heat transfer coefficient in forced convection 3. Comparison of heat transfer coefficient of free and forced convection	2Hrs
3	**Radiation: (Any One)** 1. Verification of Stefan Boltzmann Law 2. Measurement of Emissivity of Grey surface	2Hrs
4	**Transient Conduction:** 1. Unsteady state heat transfer in cylinder/rod/wall	2Hrs
5	**Fins: (Any One)** 1. Determination of fin efficiency and fin effectiveness 2. Comparison of fin performance of Various type of fins	2Hrs
6.	**Boiling and Condensation: (Any One)** 1. Measurement of heat transfer coefficient in boiling process of water. 2. Measurement of heat transfer coefficient in condensation of saturated steam.	2Hrs
7	**Heat Exchangers: (Any One)** 1. Estimation of overall heat transfer coefficient and effectivenessof double pipe heat exchanger (parallel flow and Counter flow arrangement) 2. Estimation of overall heat transfer coefficient and effectivenessof shell and tube heat exchanger (parallel flow and Counter flow arrangement) 3. Estimation of overall heat transfer coefficient and effectiveness of plate type heat exchanger.	2Hrs

Assignments: Assignment consisting of at least 3 numerical on each of the following topics

1. Steady state conduction
2. Fins and unsteady state conduction
3. Convection and dimensional analysis

4. Radiation
5. Heat Exchangers

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

Assessment:

Term work Mark distribution will be as follows:

Laboratory work	15 marks
Assignments	05 marks
Attendance	05 marks

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

Course Code	Course Name	Credits
AEL504	Automotive Systems	1

Objectives:

1. To help student better understand Automotive systems and subsystems through cut section models and Case studies
2. To give hands on experience to students on different automotive systems through Dismantling and Assembly
3. To Understand latest developments in automotive systems technology.

Outcomes: Learner will be able to

1. Identify Automobile systems and subsystems.
2. Dismantle and assemble Clutch
3. Dismantle and assemble Gearbox
4. Dismantle and assemble Propeller shaft
5. Dismantle and assemble Steering Gearbox
6. Dismantle and assemble Differential

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.Case Studies

Assign case studies for each student on *any one* of the following topics:

1. **Four wheelers**: Light and Heavy vehicles (Passenger and Commercial)
2. **Three wheelers**: Case study of Indian models. Front mounted engine and rear mounted engine types. Auto rickshaws, Pick up van, Delivery van and Trailer, Bijli electric vehicle.
3. **Two wheelers**: Case study of major Indian models of major motor cycles, scooters and mopeds.
4. **Off Road Vehicles:** Case study regarding working principle and construction of each-Earth Moving Machines, Scrappers, Graders, Shovels and Ditchers, Farm Equipment's, Military and Combat Vehicles.

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

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Course Code	Course Name	Credits
AEL 505	Manufacturing Sciences Lab*	1

Objectives:

1. To study conventional machining operations
2. To familiarise with CNC machining operation
3. To acquaint with Non Traditional machining operations

Outcomes: Learner will be able to …

1. Estimate machining time forsimple and taper turning operations on lathe
2. Estimate machining time for threading/knurling operations on lathe
3. Estimate machining time for various machining operations on shaper
4. Perform NC, CNC and DNC machining operations
5. Write CNC program for different operations
6. Identify machining parameters for various Non Traditional machining operations

Sr No.	Details
1	Introduction to machining operations
2	Introduction to lathe machine (other than plain turning operation) and shaping machine
3	Machining and machining time estimation for taper turning
4	Machining and machining time estimation for thread cutting
5	Machining and machining time estimation for internal thread cutting
6	Machining and machining time estimation for knurling
7	Machining and machining time estimation for eccentric turning
8	Machining of hexagon and square in shaping machine
9	NC, CNC, DNC machining operations
10	CNC programming for Turning and Drilling operations
11	Different Non Traditional machining operations with process parameters

Term Work:

All the assignments mentioned above with relevant sketches.

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

All the above listed assignments: **20 marks**

Attendance: **05 marks**

Subject Code	Subject Name	Credits
MEL506	**Business Communication & Ethics**	**02**

Objectives:

1. To inculcate professional and ethical attitude at the workplace
2. To enhance effective communication and interpersonal skills
3. To build multidisciplinary approach towards all life tasks
4. To hone analytical and logical skills for problem-solving

Outcomes: Learner will be able to…

1. Design a technical document using precise language, suitable vocabulary and apt style.
2. Develop the life skills/ interpersonal skills to progress professionally by building stronger relationships.
3. Demonstrate awareness of contemporary issues knowledge of professional and ethical responsibilities.
4. Apply the traits of a suitable candidate for a job/higher education, upon being trained in the techniques of holding a group discussion, facing interviews and writing resume/SOP.
5. Deliver formal presentations effectively implementing the verbal and non-verbal skills

Module	Detailed Contents	Hrs.
01	**Report Writing**	**05**
1.1	Objectives of Report Writing	
1.2	Language and Style in a report	
1.3	Types : Informative and Interpretative (Analytical, Survey and Feasibility)and Formats of reports (Memo, Letter, Short and Long Report)	
02	**Technical Writing**	**03**
2.1	Technical Paper Writing (IEEE Format)	
2.2	Proposal Writing	
03	**Introduction to Interpersonal Skills**	**09**
3.1	Emotional Intelligence	
3.2	Leadership and Motivation	
3.3	Team Building	
3.4	Assertiveness	
3.5	Conflict Resolution and Negotiation Skills	
3.6	Time Management	
3.7	Decision Making	
04	**Meetings and Documentation**	**02**
4.1	Strategies for conducting effective meetings	
4.2	Notice, Agenda and Minutes of a meeting	
4.3	Business meeting etiquettes	
05	**Introduction to Corporate Ethics**	**02**
5.1	Professional and work ethics (responsible use of social media - Facebook, WA, Twitter etc.	
5.2	Introduction to Intellectual Property Rights	
5.4	Ethical codes of conduct in business and corporate activities (Personal ethics, conflicting values, choosing a moral response and making ethical decisions)	
06	**Employment Skills**	**07**
6.1	Group Discussion	
6.2	Resume Writing	
6.3	Interview Skills	

6.4	Presentation Skills	
6.5	Statement of Purpose	

Assessment:

List of Assignments

1. Report Writing (Theory)
2. Technical Proposal
3. Technical Paper Writing (Paraphrasing a published IEEE Technical Paper)
4. Interpersonal Skills (Group activities and Role plays)
5. Interpersonal Skills (Documentation in the form of soft copy or hard copy)
6. Meetings and Documentation (Notice, Agenda, Minutes of Mock Meetings)
7. Corporate ethics (Case studies, Role plays)
8. Writing Resume and Statement of Purpose

Term Work

Term work shall consist of all assignments from the list.

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

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

References:

1. Fred Luthans, "Organizational Behavior", Mc Graw Hill,
2. Lesiker and Petit, "Report Writing for Business*"*, Mc Graw Hill
3. R.Subramaniam, "Professional Ethics" Oxford University Press
4. Huckin and Olsen, "Technical Writing and Professional Communication", McGraw
5. Raman and Sharma, Fundamentals of Technical Communication, Oxford University Press
6. Hill Wallace and Masters, "Personal Development for Life and Work", Thomson Learning, 12th Edition
7. Heta Murphy, "*Effective Business Communication"* , Mc Graw Hill, edition
8. R.C Sharma and Krishna Mohan, "*Business Correspondence and Report Writing",*
9. Raman Sharma, *Communication Skills*, Oxford University Press
10. B N Ghosh, "*Managing Soft Skills for Personality Development*", Tata McGraw Hill Lehman,
11. Dufrene, Sinha, "*BCOM*", Cengage Learning, 2nd edition
12. Bell . Smith, "Management Communication" Wiley India Edition, 3rd edition
13. Dr. K. Alex ,"Soft Skills", S Chand and Company
14. Robbins Stephens P., "Organizational Behavior", Pearson Education
15. https://grad.ucla.edu/asis/agep/advsopstem.pdf

Course Code	Course Name	Credits
AEC 601	Chassis and Body Engineering	4

Objectives

1. To Understand fundamentals of Vehicle Body design
2. To Study different vehicle structural design and their requirements.
3. To Study Vehicle Aerodynamics.
4. To Study different vehicle body structures
5. To study various materials related to body structures

Outcomes: Learner will be able to…

1. Illustrate different types of Vehicle structures
2. Comprehend various loads acting on vehicle body.
3. Illustrate different vehicle body styles.
4. Classify different materials related to vehicle body.
5. Discuss Aerodynamic concept related to vehicle body
6. Illustrate importance of thin walled structures in vehicle body elements.

Module	Detailed Contents	Hrs.
01	**Fundamental aspects of Vehicle Bodies** 1.1Chassis and structure types: Open, Semi integral and Integral bus structure. Frames: functions and types of frames, Loads on frames, Load distribution of structure. 1.2 Classification of motor vehicle, Location of power plant, Location of different chassis components, 1.3 Terminology and overview of structural surface types, history and Overview of structural types. Basic concept of design. 1.4 Vehicle body materials and their selection: Introduction to materials used in vehicle body building (Steel sheet, timber, plastics, FRP, GRP etc, properties of materials-Corrosion anticorrosion methods, scalation of paint and painting process)	08
02	**Vehicle body styles** **2.1 Car Body Details:** Types: Saloon, Convertibles, Limousine, Estate van, racing and sports car. Visibility: regulations, driver's visibility, test for visibility, Methods of improving visibility and space in cars. Safety: safety design, safety equipments for car. Car body construction, Front assembly, Roof Assembly, Under floor, bonnet etc. **2.2 Bus Body Details:** Types, mini bus, single Decker, double Decker, two levels, split level and articulated bus. Bus Body Lay Out: Floor height, engine location, entrance and exit location, seating dimensions. Constructional details: Frame construction, Double skin construction-Types of metal section used-Regulations-Conventional and Integral type construction. **2.3Commercial Vehicle Body Details:** Types of bodies, flat platform, drop side, fixed side, tipper body, tanker body, light construction vehicle body types, Dimensions of driver seat in relation to control, Driver cabin design.	08
03	**Vehicle Aerodynamics:** Objectives, Vehicle drag and types, various types of forces and moments, Effects of forces and moments, side wind effects on forces and moments, various body optimization techniques for minimum drag .Calculation of drag.	08

04	**Ergonomics and Preliminary Design** **4.1 Design and requirement of Driver, Passenger and child seat.** 4.2 Drawing of the preliminary design-Vehicle Body Weight Analysis, Calculation of C.G for Vehicle, Vehicle Weight Distribution and Master Model. 4.3 Overall Criteria for Vehicle Comparison: Design, Running costs, Overall Design Efficiency.	08
05	**Body Loads** **5.1 Loads on Vehicles:** Bending, Torsion, Lateral and Braking and Acceleration Load Cases, Shear Panel Method **5.2 Calculation of loading cases** Static loading case, Asymmetric loading case, Longitudinal loads, Side Loads, Calculation of different cases.	08
06	**Strength of Vehicle Body Elements** 6.1 Thin Walled Structures-General Principle, Torsion, Torsion centre, Forces in End Load Carrying Members. Effect of Holes, Spot welded joints. 6.2 Latest Trends in Design, Manufacturing and Materials.ULSAB Design, Tailored blanks. Manufacturing Process: Hydro forming tubular, Sheet Stamping	08

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.

ReferenceBooks:

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.

Course Code	Course Name	Credits
AEC602	MACHINE DESIGN – I*	4

Objective:

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

Outcomes: Learner will be able to ….

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

Modules	Details	Hrs.
1	Mechanical Engineering Design, Design methods, Aesthetic and Ergonomics consideration in design, Material properties and their uses in design, Manufacturing consideration in design, Design consideration of casting and forging, Basic principle of Machine Design, Modes of failures, Factor of safety, Design stresses, Theories of failures (Selection in the process of designing), Standards, I.S. Codes, Preferred Series and Numbers	06
2	**Curved Beams:** Assumptions made in the analysis of curved beams, Design of curved beams: Bending stresses in curved beams, such as crane hook, C-frame, etc. **Thick Cylinders:** Design of thick cylinders subjected to an internal pressure using Lame's equation	06
3	**Design against static loads:**Cotter joint, Knuckle joint, Turn buckle, Bolted and welded joints under eccentric loading;Power Screw – screw presses, C-clamps along with the Frame, Screw Jack	12
4	**Design against fluctuating loads:** variables stresses, reversed, repeated, fluctuating stresses. Fatigue failure: static and fatigue stress concentration factors, Endurance limit- estimation of endurance limit, Design for finite and infinite life, Soderberg and Goodman design criteria, Fatigue design under combined stresses	06
5	**Design of Shaft:** power transmitting, power distribution shafts, Module (excluding crank shaft) under static and fatigue criteria **Keys**: Types of Keys and their selection based on shafting condition **Couplings:** Classification of coupling, Design of Flange couplings, Bush pin type flexible couplings	11
6	**Design of Springs:** Helical compression, Tension Springs under Static and Variable loads, Leaf springs	07

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based onapproximately 40% of contents and second test based on remainingcontents (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. Design of Machine Elements - V.B. Banadari, Tata McGraw Hill Publication
2. Design of Machine Elements - Sharma, Purohil. Prentice Hall India Publication
3. Machine Design -An Integrated Approach - Robert L. Norton, Pearson Education
4. Machine Design by Pandya & Shah, Charotar Publishing
5. Mechanical Engineering Design by J.E.Shigley, McGraw Hill
6. Recommended Data Books - PSG
7. Machine Design by Reshetov, Mir Publication
8. Machine Design by Black Adams, McGraw Hill
9. Fundamentals of Machine Elements by Hawrock, Jacobson McGraw Hill
10. Machine Design by R.C.Patel, Pandya, Sikh, Vol-I & II C. Jamnadas& Co
11. Design of Machine Elements by V.M.Faires
12. Design of Machine Elements by Spotts

Course Code	Course Name	Credits
AEC603	FINITE ELEMENT ANALYSIS*	4

Objectives:

1. To familiarise with concepts of FEM
2. To study the applicability of FEM to engineering problems
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.
01	**Introduction:** 1.1 Introductory Concepts: Introduction to FEM, Historical Background, General FEM procedure, Applications of FEM in various fields Advantages and disadvantages of FEM 1.2 Mathematical Modelling of field problems in engineering, Governing equations, Differential equations in different fields 1.3 Approximate solution of differential equations, Weighted residual techniques, Boundary value problems	08
02	**FEA Procedure:** 2.1 Discrete and Continuous Models, Weighted Residual Methods - Ritz Technique- Basic Concepts of the, Finite Element Method 2.2 Definitions of various terms used in FEM like element, order of the element, internal and external node/s, degree of freedom, primary and secondary variables, boundary conditions. 2.3 Minimization of a functional, Principle of minimum total potential, Piecewise Rayleigh-Ritz method, Formulation of 'stiffness matrix', transformation and assembly concepts	08
03	**One Dimensional Problems:** 3.1 One dimensional second order equations - discretization-element types - linear and higher order elements -derivation of shape functions and stiffness matrices and force vectors 3.2 Assembly of Matrices- solution of problems in one dimensional structural analysis, heat transfer and fluid flow (stepped and taper bars, fluid network, spring-Cart Systems) 3.3 Analysis of Plane trusses, Analysis of Beams 3.4 Solution of one dimensional structural and thermal problems using FE Software, Selection of suitable element type, modelling, meshing, boundary condition, convergence of solution, result analysis, case studies	10
04	**Two Dimensional Finite Element Formulations:** 4.1 Introduction, three node triangular element, four node rectangular element, four node quadrilateral element, eight node quadrilateral element 4.2 Natural coordinates and coordinates transformations: serendipity and Lagrange's methods for deriving shape functions for triangular and quadrilateral element 4.3 Sub parametric, Isoparametric, super parametric elements, Compatibility, Patch test, Convergence criterion, sources of errors	08

05	**Two Dimensional Vector Variable Problems:** 5.1 Equations of elasticity - Plane stress, plane strain and axisymmetric problems 5.2 Jacobian matrix, stress analysis of CST and four nodeQuadratic element	**08**
06	**Finite Element Formulation of Dynamics and Numerical Techniques:** 6.1 Applications to free vibration problems of rod and beam, Lumped and consistent mass matrices 6.2 Solutions techniques to Dynamic problems, longitudinal vibration frequencies and mode shapes, Fourth order beam equation,transverse deflections and natural frequencies of beams	**06**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based onapproximately 40% of contents and second test based on remainingcontents (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. Text book of Finite Element Analysis by Seshu P, Prentice Hall of India
2. Finite Element Method by JNReddy, 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 SSRao, Butter WorthHeinemann
8. Fundamental Finite Element Analysis and Application with Mathematica and MATLAB Computations by M. Asghar Bhatti, Wiley India Pvt. Ltd.

Course Code	Course Name	Credits
AEC 604	Mechanical Vibrations	4

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

Outcomes: Learner should be able to ….
1. Develop mathematical model to represent dynamic system.
2. Estimate natural frequency of mechanical system.
3. Analyze vibratory response of mechanical system.
4. Estimate the parameters of vibration isolation system.
5. Balance an existing unbalanced rotating and reciprocating system completely/partially.
6.Comprehend the application of condition monitoring and fault diagnosis on a live project/case study.

Module	Details	Hrs
01	**1.1 Basic Concepts of Vibration** Vibration and oscillation, causes and effects of vibrations, Vibration parameters – spring, mass, damper; Damper models, Vibration Terminology—periodic motion, non periodic motion, aperiodic motion, Simple harmonic motion (SHM), Degree of freedom, static equilibrium position, Vibration classification, Steps involved in vibration analysis. **1.2 Free Undamped Single Degree of Freedom Vibration Systems**Longitudinal, transverse, torsional vibration systems; Formulation of differential equations by Newton's method or D'Alembert's principle; Energy, Lagrangian and Rayleigh's Methods.	08
02	**2.1 Free Damped Single Degree of Freedom Vibration Systems** Viscous damped system – underdamped, critically-damped, overdamped; Logarithmic decrement; Coulomb's damping; Combined viscous and Coulomb's damping. **2.2 Equivalent Single Degree of Freedom Vibration Systems** Conversion of multi-springs, multi masses, multi–dampers into a single spring-mass-dampersystem with linear or rotational co-ordinates.	08
03	**3.1 Free Undamped Multi Degree of Freedom Vibration Systems** Eigen values and Eigen vectors for linear and torsional systems (limited to a maximum of three degrees of freedom); Holzer method for linear and torsional unbranched systems; Two rotor system, Three rotors and geared system; Transfer function approach;Dunkerley's and Rayleigh's method for transverse vibrations	08
04	**4.1 Forced Single Degree of Freedom Vibratory Systems** Analysis of linear and torsional systems subjected to harmonic force excitation and harmonic motion excitation (viscous damping only) **4.2 Vibration Isolation and Transmissibility** Force Transmissibility, Motion Transmissibility, Typical isolators& mounts **4.3Vibration Measuring Instruments** Principle of seismic instruments; Vibrometer, Accelerometer, Velometer– with and without measurement errors. Principle of frequency-measuring instruments; Fullartor's tachometer and Frahm's tachometer	08
05	**5.1 Balancing of Rotating Masses** 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, In-line engines, V - engines (excluding radial engines), Direct and Reverse Crank method.	08

06	**6.**1 Stability of four wheel vehicle taking a turn considering gyroscopic effect 6.2 **Rotor Dynamics:** Critical speed of a single rotor - undamped and damped. **6.3 Introduction to Conditioning Monitoring and Fault Diagnosis.** At least two case studies in detail based on Conditioning Monitoring and Fault Diagnosis.	**08**

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.

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

Course Code	Course Name	Credits
AEDLO6021	Mechatronics	4

Objectives

1. To study key elements of Mechatronics system and its integration
2. To familiarise concepts of sensors characterization and its interfacing with microcontrollers
3. To acquaint with concepts of actuators and its interfacing with microcontrollers
4. To study continuous control logics i.e. P, PI, PD and PID
5. To study discrete control logics in PLC systems and its industrial applications

Outcomes: Learner will be able to…

1. Identify the suitable sensor and actuator for a Mechatronics system
2. Select suitable logic controls
3. Analyse continuous control logics for standard input conditions
4. Develop ladder logic programming
5. Design hydraulic/pneumatic circuits
6. Design a Mechatronics system

Module	Detailed Contents	Hrs.
1	**Introduction of Mechatronics and its block diagram representation** Key elements of mechatronics, Applications of Mechatronics domestic, industrial etc. Representation of mechatronic system in block diagram and concept of transfer function for each element of mechatronic system, Reduction methods and its numerical treatment for represented block diagram	08
2	**Selection of Sensors & Actuators** Sensors:Criteria for selection of sensors based on requirements, principle of measurement,sensing method, performance chart etc. (Displacement,temperature, acceleration,force/pressure) based on static and dynamic characteristics. Actuators: Selection of actuators based on principle of operation, performancecharacteristics, maximum loading conditions, safety etc. Principle and selection of mechano-electrical actuators (1) DC motors (2) Stepper Motors (3) Solenoid Actuators (4) Servo Motors (5) BLDC	08
3	**Data Acquisition, Signal Conditioning & Microcontroller SystemTheory:** Concept of Bit accuracy/width and Sampling speed, sampling theorem, aliasing, Nyquist criteria, ADC (Analog to Digital Convertor) Successive approximation method and sample and hold circuitry, DAC (Digital to Analog Convertor) R-2R circuit and DAC resolution Signal Filters: Low pass, High Pass and Band Pass with circuit diagrams for simple cases	08
4	**Pneumatics and hydraulics:** Hydraulic and pneumatic devices:Different types of valves, Actuators and auxiliary elements in Pneumatics and hydraulics, their applications and use of their ISO symbols, Synthesis and design of circuits (up to 2 cylinders)–pneumatic, electro- pneumatics and hydraulics, electro-hydraulics	08
5	**Control System** Control system design and analysis by Root Locus Method, Control system Design by Frequency response method, stability margin, Nyquist diagram, Bode diagram P, I and D control actions, P, PI, PD and PID control systems, Transient response:- Percentage overshoot, Rise time, Delay time, Steady state error, PID tuning (manual), Zigler Method	08
6	**Discrete Control System PLC (Programming Logic Control)Theory:** Introduction to PLC, Architecture, Ladder Logic programming for different types of logic gates, Latching, Timers, Counter, Practical Examples of Ladder Programming	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. Mechatronics, Kenji Uchino and Jayne R. Giniewicz, publication: Marcel Dekker, Inc
2. Applied Mechatronics- A. Smaili and F. Mrad, OXFORD university press
3. Mechatronics System Design , Shetty and Kolk, Cengage Learning, India Edition
4. Introduction to Mechatronics and Measurement Systems, Alciatore and HistandTata McGraw-Hill
5. Mechatronics, Necsulescu, Pearson education
6. Mechatronics - Electromechanics and Control Mechanics , Mill Springer-Verlag
7. Mechatronics - Electronic Control Systems in Mechanical Engineering , Bolton Pearson eduaction
8. Mechatronics - Electronics in products and processes , Bradley, et al. Chapman and Hall
9. Mechatronics - Mechanical System Interfacing , Auslander and Kempf, Prentice Hall
10. Introduction to Mechatronics, AppuKuttan K.K., OXFORD Higher Education
11. Pneumatic Circuits and Low Cost Automation by Fawcett JR
12. The Art of Electronics, Horowitz and Hill Cambridge, University Press
13. Electromechanical Design Handbook , Walsh, McGraw-Hill
14. Electro-mechanical Engineering - An Integrated Approach , Fraser and Milne
15. Handbook of Electromechanical Product Design , Hurricks Longman, John Wiley, Addison Wesley
16. Principles and Applications of Electrical Engineering , Rizzoni, Irwin Publishing
17. Understanding Electro-Mechanical Engineering - An Introduction to Mechatronics , KammIEEE
18. Modeling and control of Dynamic Systems, Macia and Thaler, Cengage Learning, India Edition
19. Mechatronics, A. Smaili, F. Mrad, OXFORD Higher Education.
20. Pneumatic and Hydraulic Control Systems: Aizerman. M.A.
21. Industrial Hydraulics: Pippenger
22. Vickers Manual on Hydraulics
23. Computer Numerical Control of Machine Tools: Thyer. G.R.
24. Pneumatic Applications: Deppert Warner & Stoll Kurt
25. Mechanization by Pneumatic Control: Vol. 1 & 2 Deppert Warner & Stoll kurt
26. Hydraulics and Pneumatics for Production: Stewart
27. Hydraulic Valves and Controls: Pippenger
28. Fundamentals of pneumatics: Festo series
29. Automatic Control Engineering: Francis. H. Raven.
30. Mechatronics, NitaigourMahalik, Tata McGraw-Hill
31. Mechatronics, HMT
32. System Identification: Theory for the User (2nd Edition) , Lennart Ljung
33. Design with Microprocessors for Mechanical Engineers, StifflerMcGraw-Hill

Course Code	Course/Subject Name	Credits
AEDLO6022	Robotics	04

Objectives:

1. To study the basics of robotics and its control
2. To study various design principles of robotics through kinematic analysis, workspace analysis, and trajectory planning
3. To study applications of robots in industrial inspection and material handling
4. To study the role of a robot as a humanoid

Outcomes: Learner will be able to…

1. Demonstrate the basic functioning of a robot
2. Identify various components of robots
3. Carryout kinematic analysis, workspace analysis, and trajectory planning for a robot
4. Identify suitable sensors/actuators for robot
5. Select an appropriate robot for given industrial inspection and material handling systems.
6. Illustrate various aspects of a robot as a humanoid

Module	Details	Hrs.
01	**Introduction** Definition of robot, Evolution of robots, Laws of robots, International Robotic Standards, Types of robots, Selection of robots, Robot Classifications, 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, Actuators and sensors, Drives and transmission systems, End effectors, Applications of robots	08
02	**Kinematics of Robots** **Direct:** Link coordinates D-H Representation, The ARM equation, Direct kinematic analysis for Four axis, SCARA Robot and three, five, and six axis Articulated Robots. **Inverse:** The inverse kinematics problem, General properties of solutions, Tool configuration, Inverse kinematics of four axis SCARA robot and three and five axis Articulated robot. **Mobile Robot Kinematics** Introduction, Kinematic models and constraints, Representing robot position, Forward kinematic models, Wheel kinematic constraints, Robot kinematic constraints, Mobile robot maneuverability, Degree of mobility, Degree of steerability, Mobile robot workspace, Degree of freedom, Holonomic robots, Path and trajectory considerations, Motion control, Open loop control, Feedback control.	10
03	**Workspace Analysis and Trajectory Planning** Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations, Joint space technique - Continuous path motion, Interpolated motion, Straight line motion and Cartesian space technique in trajectory planning.	10
04	**Sensors & Actuators** Sensors: Selection of sensors (Displacement, temperature, acceleration ,force/pressure) based on static and dynamic charecterstics, Interfacing: Concept of interfacing, bit accuracy and sampling speed, amplifying electronics, and microcontroller Actuators: Principle and selection of mechano-electrical actuators (1) DC motors (2) Stepper Motors (3) Solenoid Actuators (4) Servo Motors (5) BLDC	08

05	**Robots for Inspection and Material Handling** Robotic vision systems, Image representation, Object recognition and categorization, Depth measurement, Image data compression, Visual inspection, Software considerations Concepts of material handling, Principles and considerations in material handling systems design, Conventional material handling systems - Industrial trucks, Monorails, Rail guided vehicles, Conveyor systems, Cranes and Hoists, Advanced material handling systems, Automated guided vehicle systems, Automated storage and retrieval systems, Bar code technology, Radio frequency identification technology	08
06	**Humanoids** Wheeled and legged, Legged locomotion and balance, Arm movement, Gaze and auditory orientation control, Facial expression, Hands and manipulation, Sound and speech generation, Motion capture/Learning from demonstration, Human activity recognition using vision, touch, and sound, Vision, Tactile Sensing, Models of emotion and motivation, Performance, Interaction, Safety and robustness, Applications, Case studies	08

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based onapproximately 40% of contents and second test based on remainingcontents (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. Yoram Korean, “Robotics for engineers”, McGrew Hill Co.
2. M.P. Groover, M. Weiss, R.N. Nagel, and N.G. Odrey, “Industrial Robotics Technology programming and Applications”, McGraw-Hill,
3. Robotics: Fundamental Concepts and Analysis by AshitavaGhosal, Oxford University Press
4. R.K. Mittal and I.J. Nagrath, “Robotics and Control”, TMH Publications
5. Robert J. Schilling, “Fundamentals of Robotics Analysis and Control”, PHI Learning
6. Bijay K. Ghosh, Ning Xi, T.J. Tarn, Control in Robtics and Automation Sensor – Based integration, Academic Press
7. K.S.Fu, R.C.Gonzalex, and C.S.G.Lee, “Robotics Control Sensing, Vision and Intelligence”, McGrew hill Book co.
8. Hartenberg and Denavit, “Kinematics and Synthesis of linkages”, McGrew Hill Book Co.
9. A.S. Hall, “Kinematics and Linkage Design”, Prentice Hall
10. J.Hirchhorn, “Kinematics and Dynamics of Machinery”, McGrew Hill Book Company
11. P.A. Janaki Raman, “Robotics and Image Processing An Introduction”, Tata McGraw Hill Publishing company Ltd.

12. Richard D Klafter, Thomas A Chmielewski, and Michael Negin, “Robotics Engineering – An Integrated Approach”, Eastern Economy Edition, Prentice Hall of India P Ltd.
13. Roland Siegwart, Illah Reza Nourbakhsh, and DavideScaramuzza, “Introduction to Autonomous Mobile Robots”, Bradford Company Scituate, USA
14. Alonzo Kelly, Karl Iagnemma, and Andrew Howard, “Field and Service Robotics”, Springer
15. RiadhSiaer, “The future of Humanoid Robots- Research and applications”, Intech Publications

Course Code	Course Name	Credits
AEDLO6023	AUTOMOTIVE MATERIALS	4

Objectives

1. To familiarize the importance of different classes of materials in making of automobiles
2. To acquaint with improving efficiency of automobiles through proper selection of materials and processing methods.
3. To familiarize the recent trends used in making of various automotive components.

Outcomes: Learner will be able to…

1. Identify the need for new alternative materials to improve efficiency of automobiles.
2. Distinguish between the materials requirements for various types of automobiles.
3. Estimate the role of different classes of materials for various automotive systems
4. Select proper material while designing any automotive subsystem.
5. Select advanced materials for specific automobile components.
6. Comprehend Ashby charts for material selection

Module	Detailed Contents	Hrs.
01	**CONVENTIONAL MATERIALS AND THEIR PROCESSING & NEED OF NEW MATERIALS** Body design concepts with a focus on light weighting, Considerations in the use of Steel and Aluminium for car bodies. Evolution of casting technology, extrusion and sheet forming for making of car bodies for hatchback, utility vehicles, racing cars and heavy vehicles. Light weighting of vehicles with emphasis on material selection. Need to shift to new materials and risks in adopting new materials	09
02	**MATERIALS FOR THE INTERIOR** Various high performance plastics and composites used in making of dashboards and their processing. Materials used in Flooring, dashboard silencer, headliner, door trim, baffles, rear shelf and their functionality. Car seat-considerations and materials used. Airbag-materials used and their testing. Fabrics used in upholstery and their properties requirements	09
03	**MATERIALS FOR THE EXTERIOR** Application of various new materials including various types of composites in making of car bodies, bonnet, Alloy wheels and the processing method/s used to shape these parts. Reinforcement of fibres in composites - Woven fabrics - Non woven random mats - Various types of fibres in PMC processes - Hand lay-up processes - Spray up processes - Compression moulding - Reinforced reaction injection moulding -Resin transfer moulding -pultrusion- Filament winding - Injection moulding. Fibre reinforced plastics(FRP), Glass fibre reinforced plastics (GFRP)	09
04	**PAINTS AND GLASS TECHNOLOGY** Introduction to glass, properties and composition. Various approaches in tempering of glass for improved toughness and shatter resistance. Paint technology: basic concepts and sequences of application and current trends Use of nanoparticles in paints to make self cleaning, scratch resistant paints,nano coatings for corrosion resistance.	07

05	**Smart Concepts for Automobiles** Relevance of smart materials in the automobile industry, Recent developments in smart automobiles and Smart engines, Use of Electro- or magneto-rheological engine mounts. Engine blocks-cast iron, aluminium alloys. New trends in engines. Suspension systems: Use of MR fluids and ER fluids in dampers. Fuel Injector materials: high melting point materials-Use of ceramics as fuel injectors. Sintered Friction materials: Powder metallurgy process for making disc brake pads	**08**
06	**SELECTION OF MATERIALS** Introduction to Ashby charts for making a good selection of materials for different systems in automobiles. Case studies for materials developments by Ferrari, Land Rover, Honda, and FIAT in the making of a automobiles.	**06**

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.

Reference Books:

1. Mathews F.L. and Rawlings R.D., "Composite materials: Engineering and Science", Chapman and Hall, London, England, 1st edition, 1994.
2. Chawla K.K., "Composite materials", Springer - Verlag, 1987

Course Code	Course Name	Credits
AEL 601	Chassis and Body Engineering	01

Objective:

1. To help student understand and model various cross-sections used in chassis frame.
2. To give hands on experience to students on Designing and analysis of Chassis Frame.
3. To familiarize analysis of results from structural analysis of chassis frame.
4. To familiarize analysis of results from modal analysis of chassis frame.
5. To familiarize analysis of results from Harmonic analysis of chassis frame.

Outcome: Learner will be able to

1. Model various cross sections used in Chassis frame.
2. Calculate various loads acting on chassis frame
3. Perform structural analysis of chassis frame
4. Perform modal analysis of chassis frame
5. Perform harmonic analysis of chassis frame.
6. Analyse and understand behaviour of various Chassis cross sections.

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

A. List of Experiments

Analysis of Chassis Frame using any FEA Software's for different sections (C-section, I-section, L-section, O-section, Hat section, Tubular section etc)

1. Structural Analysis of Chassis Frame
2. Modal Analysis of Chassis Frame
3. Harmonic Analysis of Chassis Frame.

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

Minimum 3 A2 size sheets based on Vehicle body styles layouts for Car body, Bus body and Commercial Vehicle body details.

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

1) Laboratory work (Experiments) : **05 marks**
2) Mini project : **10 marks**
3) Assignment/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

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

Course Code	Course Name	Credits
AEL602	Machine Design –I *	1

Objectives:

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

Outcomes: Learner will be able to....

1. Design shaft under various conditions
2. Design Knuckle Joint / cotter joint
3. Design Screw Jack/C-clamp along with frame
4. Design Flexible flange couplings/ Leaf spring
5. Convert design dimensions into working/manufacturing drawing
6. Use design data book/standard codes to standardise the designed dimensions

Term Work: (Comprises a & b)

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) Screw Jack
3) Flexible flange couplings
4) Leaf springs
5) C-clamps along with the Frame

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

1) Bolted and welded joints
2) Combined stresses problem using theory of failure.
3) Shaft design (solid and hollow shaft)
4) Design against fluctuating loads (finite and infinite life)

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

- Part - a : 15 marks.
- Part--b : 05 marks.
- Attendance: 05 Marks.

Course Code	Course Name	Credits
AEL603	FINITE ELEMENT ANALYSIS*	1

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 & b)

a) List of Experiments: Students should use the commercial software or programmes form the text-books or self-developed programs, to verify the results obtained by manual calculations. The input data and output results of the problem solved using the computer programs should be included in the Journal. The proposed list is 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

While performing the analysis the students should understand the concepts of selection of element type, meshing and convergence of solution.

b) Course Project:

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

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

Part a:	15 marks.
Part b:	05 marks.
Attendance:	05 Marks.

Practical /Oral Examination:

1. Practical examination duration is 2 hours.
2. Assignment for the examination shall be based on the list of assignment mentioned in the term work.
3. The distribution of marks for practical / oral examination shall be as follows:
    a. Practical performance: 15 marks.
    b. Oral: 10 marks
4. Evaluation of practical examination to be done based on the experiment performed and the output of the experiments during practical examination.
5. Students work along with evaluation report to be preserved till the next examination.

Course Code	Course Name	Credits
AEL 604	Mechanical Vibrations	1

Objectives:

1. To acquaint with the principles of vibration measuring instruments.
2. To get acquainted with the use of data acquisition system (DAQ) and related software and hardware for gathering vibration data on live problem.
3. To study balancing of mechanical systems.

Outcomes: Learner will be able to

1. Estimate natural frequency of mechanical element/ system.
2. Analyse vibration response of mechanical element/system.
3. Determine damping coefficient of a system.
4. Demonstrate the use DAQ system with associated hardware and software to gather vibration data of a system.
5. Handle the vibration measuring instrument.
6. Balance rotating masses.

Term Work:

List of Experiments

Sr. No.	Title of Experiment	Laboratory Sessions
1	Determine natural frequency of compound pendulum, equivalent simple pendulum system.	2 Hrs.
2	Determine natural frequency for longitudinal vibrations of helical springs, and springs in series and parallel	2 Hrs
3	Determine natural frequency and nodal points for single rotor and two-rotor vibratory system	2 Hrs
4	Frequency and acceleration measurements of any one vibrating system using 'National Instruments' Lab VIEW software ,DAQ and accelerometer	2 Hrs
5	Determination of damping coefficient of any system/media	2 Hrs
6	Experimental balancing of single and multi-rotor system	2 Hrs
7	Measurement of vibration response of a system	2 Hrs
8	Vibration analysis of mechanical system using MATLAB/SCILAB/GNU Octave	2 Hrs
9	Experiment using Fullartor or Frahm tachometer to measure frequency of vibration or speed of rotating parts of a machine.	2Hrs
10	Experiment on whirling of shaft.	2 Hrs

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

Project Based Learning may be incorporated by judiciously reducing number of assignments

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

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

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

End Semester Practical/Oral Examination:

1. Pair of Internal and External Examiner should conduct practical/viva based on contents Distribution of marks for practical/viva 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

Subject Code	Subject Name	Credits
AEL 605	**Mechatronics Lab***	**01**

Objectives

1. To study sensors and actuators
2. To study control systems
3. To study automation

Outcomes: Learner will be able to…

1. Demonstrate implementation of interfacing sensors and actuators using microcontrollers
2. Demonstrate of interfacing various utilitieswith microcontrollers
3. Demonstrate discrete control system using PLC microcontroller
4. Design and develop a control system for specific use
5. Implement program to PLC system and demonstrate its application
6. Develop pneumatic circuits for a specific system

The laboratory experiments should be based on the following**..**

Group 1: Sensors & Actuators

1. Theoretical & Experimental Implementation of Interfacing of Sensors using microcontroller and determination of sensor characteristics such as Static Characteristics (Sensitivity, Accuracy, Range, Resolution etc.), Dynamic Characteristics (Transient Response and Frequency Response)
2. Measurement and Calibration of Load / Force (*It is suggested to determine all characteristics of sensor mentioned in previous experiments)*
3. Measurement, Calibration and Comparison of Temperature Sensors (Thermocouple, RTD and Thermistor) *(It is suggested to determine all characteristics of sensor mentioned in previous experiments)*
4. Interfacing of Stepper Motor with microcontroller and its programming for Rotational or XY table *(It is suggested to program to vary the position of rotary or XY table and compare the positioning accuracy using standard calibrated angular or linear sensor)*
5. Interfacing of DC Motor with microcontroller and its programming for characterization of DC motor setup *(It is suggested to program to vary the speed of DC motor and determine its load-speed characteristics)*
6. Interfacing of Water Heater with microcontroller and its programming for determination of its transient and steady state characteristics *(It is suggested to program to vary the input current to heater and determine its transient and steady state characteristics)*

Group 2: Control Systems

1. Experimental demonstration of Discrete control system using PLC microcontroller using standard PLC demo setup (Bottle filling Machine, Traffic Light Signal, Water heater and its stirring System etc.). *(here it is suggested to carry out ladder programing and demonstrate its operation)*
2. System Identification of Spring Mass Damper System for step input & harmonic input and determination of poles and zeros of system. *(Spring Mass Damper setup with all required position sensors mounted is to be characterized for step input, it is suggested to determine transfer function (i.e. input output relation) of the setup and plotting its transient and frequency response (Bode plot))*
3. Design & Experimental Implementation of PID control strategy for Spring Mass Damper Setup to control precisely position of mass. (*it is suggested to conduct experimental study on effect of variation of controller parameters on its transient characteristics also to study the changes in poles and zeros of system*).
4. Design & Experimental Implementation of PID control strategy for DC motor speed control under varying loading conditions and effect of variation of load is to be studied.
5. Design & Experimental implementation of PID control strategy for Real Time Temperature Control of furnace *(it is suggested to conduct experimental study on effect of variation of controller parameters on its transient characteristics also to study the changes in poles and zeros of system)*.
6. Modeling and design of control system for quarter car suspension model using any suitable modeling and analysis software.

Group 3: Automation

1. Real time Logic implementation for traffic Control demo setup and it is necessary to carry out ladder programming and implement program to PLC system and demonstrate its operations
2. IOT: Real time interfacing of sensors (temperature, humidity, position, level etc.) and actuator (stepper motor, dc motor, servo motor etc.) with microcontroller and Ethernet shield and controlling the actuator and monitoring of sensor output remotely using internet.
3. Robotics: Real Time demonstration of line following robot using standard robotic kit
4. Demonstration and study of functions of components of robotics arm.
5. Visualization of DH parameters in Roboanalyzer.(*Roboanalyzer is free software developed by IIT Delhi, available on www.roboanalyzer.com)
6. Designing sequential operation for two cylinders using electro-hydraulic circuits
7. Designing sequential operation for two cylinders using electro- pneumatic circuits
8. Development of pneumatic circuits to understand pneumatic components and their working

Term work

Term work shall consists of minimum Nine Experiments, Three from each group mentioned above

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

Laboratory Work:	20 marks.
Attendance:	05 Marks.

End Semester Practical /Oral Examination:

1. Pair of Internal and External examiner should conduct Practical/Oral based on contents.
2. Practical examination (in a group of not more than Four students) duration is 2 hours.
3. The distribution of marks for practical / oral examination shall be as follows:
    a. Practical performance: 15 marks.
    b. Oral: 10 marks
4. Evaluation of practical examination to be done based on the experiment performed and the output of the experiments during practical examination.
5. Students work along with evaluation report to be preserved till the next examination.