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 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
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.