UNIVERSITY OF MUMBAI

Bachelor of Engineering

Mechatronics Engineering

(Second Year – Sem. III & IV, Third Year- Sem V & VI, and Final Year- Sem VII & VIII)

New course (N- 2015) from Academic Year 2015 -16, 2016-17, and 2017-18 respectively

Under

FACULTY OF TECHNOLOGY

(As per Credit Based Semester and Grading System)
Deans Preamble

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

Faculty of Technology, University of Mumbai, in one of its meeting unanimously resolved to introduce innovative undergraduate program in Mechatronics Engineering along with course objectives and outcomes to be clearly defined. I am happy to state that, the syllabus committee of mechatronics engineering has adhered to the resolutions passed by Faculty of Technology, and developed curriculum accordingly. In addition to outcome based education, credit based semester and grading system is also introduced to ensure quality of engineering education.

Credit based semester and grading system enables a much-required shift in focus from teacher-centric to learner-centric education. 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. The program of Mechatronics Engineering is introduced from the academic year 2014-2015.

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

Engineering education in India is expanding and is set to increase manifold. The major challenge in the current scenario is to ensure quality to the stakeholders along with expansion. Furthermore, to achieve the broad horizon of technology system development, the innovative program consisting of interdisciplinary approach is today’s need. Considering this requirement and recent thrust in technology, the innovative undergraduate program in Mechatronics Engineering is introduced first time in the University of Mumbai.

To ensure quality in higher education accreditation of program is essential. The major emphasis of this accreditation process is to measure the outcomes of the program that is being accredited. Program outcomes are essentially a range of skills and knowledge that a student will have at the time of graduation from the program. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating the philosophy of outcome based education in the process of curriculum development.

As the Chairman, Board of Studies in Mechanical Engineering of University of the Mumbai, I am happy to state here that, the Program Educational Objectives of this innovative program were finalized in a brainstorming session, which was attended by more than 20 senior faculty members from different affiliated Institutes of the University from the various disciplines such as Mechanical, Electrical, Electronics, and Computer Engineering. The Program Educational Objectives finalized for the undergraduate program in Mechatronics Engineering are listed below;

1. To prepare the Learner in building technology systems through the interdisciplinary approach.
2. To prepare the Learner to use modern tools embedding different disciplines of engineering in order to solve real life problems.
3. To prepare the Learner for career in Indian and Multinational Organisations and to excel in their Postgraduate studies. Furthermore to encourage and motivate the art of self-learning.
4. To inculcate a professional and ethical attitude, good leadership qualities in the Learner’s thought process.

In addition to Program Educational Objectives, for each course of undergraduate program, objectives and expected outcomes are also included in the curriculum. 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
# Program Structure for B.E. Mechatronics Engineering

## S. E. Mechatronics - (Semester III)

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Course common with Mechanical Engineering
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* Theory for entire class to be conducted,  
* Common for all Engineering Program
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# Program Structure for B E Mechatronics Engineering

## B. E. Mechatronics-(Semester VII)

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$^5$Course common with Mechanical Engineering
### Subject Code | Subject Name | Teaching Scheme (Contact Hours) | Credits Assigned | Examination Scheme |
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#### Examination Scheme

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<sup>a</sup> indicates work load of Learner (Not faculty) in VII and VIII semester for Project

Student group size and load of faculty per week for Project I and II shall be as follows:

- **Project Groups**: Students can form groups with minimum 2 (Two) and not more than 4 (Four)
- **Faculty Load**: In semester VII 1/2 hour per week per project group
  - In semester VIII 1 hour per week per project group
  - Each faculty is permitted to take (guide) maximum 4 (Four) project groups.

### Course codes

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### Elective II

- **Medical Mechatronics**
- **Robotics and Machine Vision**
- **Microfabrication Processes**
- **Machine Interface Design**
- **Product Design and Development**
Pre-requisite:
1. FEC101 Applied Mathematics I
2. FEC201 Applied Mathematics II

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

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

<table>
<thead>
<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs</th>
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</table>
| 1      | Laplace Transform  
1.1 Function of bounded variation, Laplace Transform of standard functions such as $1, t^n, e^{at}, \sin at, \cos at, \sinh at, \cosh at$  
1.2 Linearity property of Laplace Transform, First Shifting property, Second Shifting property, Change of Scale property of L.T. (without proof)  
$$L\left\{t^n f(t)\right\}, L\left\{\frac{f(t)}{t}\right\}, L\left\{\int_0^t f(u)du\right\}, L\left\{\int_0^t \frac{d^n f(t)}{dt^n}\right\}$$  
Heaviside Unit step function, Direc Delta function, Periodic functions and their Laplace Transform. | 6 |
| 2      | Inverse Laplace Transform  
2.1 Linearity property, use of theorems to find inverse Laplace Transform, Partial fractions method and convolution theorem.  
2.2 Applications to solve initial and boundary value problems involving ordinary differential equations with one dependent variable. | 6 |
| 3      | Complex variables:  
3.1 Functions of complex variable, analytic function, necessary and sufficient conditions for $f(z)$ to be analytic (without proof), Cauchy-Riemann equations in polar coordinates.  
3.2 Milne- Thomson method to determine analytic function $f(z)$ when it’s real or imaginary or its combination is given. Harmonic function, orthogonal trajectories.  
3.3 Mapping: Conformal mapping, linear, bilinear mapping, cross ratio, fixed points and standard transformations such as Rotation and magnification, inversion and reflection, translation. | 10 |
4 Complex Integral
4.1 Line integral of a function of a complex variable, Cauchy’s theorem for analytic function, Cauchy’s Goursat theorem (without proof), properties of line integral, Cauchy’s integral formula and deductions.
4.2 Singularities and poles:
4.3 Taylor’s and Laurent’s series development (without proof)
4.4 Residue at isolated singularity and its evaluation.
4.5 Residue theorem, application to evaluate real integral of type
\[ \int_{0}^{2\pi} f(\cos \theta, \sin \theta) d\theta, \quad \text{and} \quad \int_{-\infty}^{\infty} f(x) dx \]

5 Fourier Series
5.1 Orthogonal and orthonormal functions, Expressions of a function in a series of orthogonal functions. Dirichlet’s conditions. Fourier series of periodic function with period \( 2\pi \) & \( 2l \).
5.2 Dirichlet’s theorem (only statement), even and odd functions, Half range sine and cosine series, Parseval’s identities (without proof)
5.3 Complex form of Fourier series.

6 Partial Differential Equations
6.3 Heat equation, steady-state configuration for heat flow.
6.4 Two and Three dimensional Laplace equations.

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

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

Internal Assessment:
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

References:
1. Elements of Applied mathematics, P N & J N Wartikar, Pune VidyarthiGruhaPrakashan
2. Higher Engineering Mathematics, Dr B. S. Grewal, Khanna Publication
4. Integral Transforms and their Engineering Applications, Dr B. B. Singh, Synergy Knowledgeware, Mumbai
6. Numerical Methods, Kandasamy, S. Chand & CO.
CLASS: SE (Mechatronics)  
Subject Code: MTC302  
Semester: III

SUBJECT: Thermodynamics and Heat Transfer  
Credit: 4

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Pre-requisite:
1. FEC102 Applied Physics-I
2. FEC202 Applied Physics-II

Objectives:
1. Study of basic concepts and laws of thermodynamics.
2. Study of modes of heat transfer and governing laws.
3. Study and analysis of Boilers, turbines and heat exchangers

Outcomes: Learner will be able to...
1. Demonstrate understanding of basic concepts of thermodynamics
2. Analyze basic power cycles.
3. Identify & explain the three modes of heat transfer (conduction, convection and radiation).
4. Develop mathematical model for each mode of heat transfer
5. Demonstrate and explain mechanism of boiling and condensation
6. Design and analyze different heat exchangers

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs.</th>
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</table>
| 01 | **Introduction and Basic Concepts:** Application areas of thermodynamics, Systems and Control volumes, Properties of system, Continuum, State and equilibrium, Processes and cycles, Temperature and Zeroth law of thermodynamics, Heat and thermodynamic concept of work.  
**First Law of Thermodynamics:**  
Statement, Heat and work calculations, Application of first law to non-flow and flow systems, steady flow energy equation as applied to boiler, condenser, nozzle and turbine.  
**Second Law of Thermodynamics:**  
Statements and their equivalence, thermal energy reservoirs, concept of heat engine, refrigerator, heat pump and perpetual motion machines, Carnot cycle and principles.  
**Entropy:** Concept of entropy, Temperature- entropy plot, Clausius inequality, Principle of Increase of entropy, entropy balance. | 09 |
| 02 | **Boilers**  
Fire tube and Water tube boiler, Low pressure and high pressure boilers, once through boiler, examples, and important features of HP boilers, Mountings and accessories, Layout of a modern HP boiler, Boiler performance, Boiler efficiency. Properties of steam like dryness fraction; enthalpy; internal energy and entropy, Steam table and Mollier Diagram.  
**Steam Turbines**  
Impulse turbines, Reaction turbines, velocity diagram, degree of reaction, compounding of steam turbines, Parson’s turbine, condition for maximum efficiency. | 09 |
| 03 | Internal Combustion Engines  
Air standard cycles, Carnot, Otto, diesel, dual cycles and their comparison,  
Two stroke and Four stroke engines, CI and SI engines, Environmental and pollution control issues and remedies  
Gas Turbines  
Ideal and actual Brayton cycle, open and closed cycle gas turbine, Applications of gas turbine in aviation and power generation. |
| 04 | Heat Transfer  
Typical heat transfer situations, Modes of heat transfer  
Conduction  
Fourier’s law of heat conduction, thermal conductivity, differential equation of heat conduction with heat generation in unsteady state in the Cartesian coordinate system, Steady heat conduction in plane walls, composite walls,  
Concept of thermal resistance and thermal resistance network, Heat conduction in cylinders and spheres, (Derivation NOT INCLUDED for Cylindrical as well as Spherical coordinate systems), Critical thickness/radius of insulation and its importance.  
Transient Heat Conduction  
Lumped system analysis, One dimensional transient problems analytical solutions |
| 05 | Convection  
Physical mechanism of convection, Natural and Forced convection, Laminar flow heat transfer in circular pipe, constant heat flux and constant wall temperature, Turbulent flow heat transfer in circular pipes, Pipes of other cross sections, Heat transfer in laminar and turbulent flow over a flat plate,  
Principles of dimensional analysis and its application in convective heat transfer, Physical significance of various dimensionless numbers useful in natural and forced convection  
Radiation  
Basic laws of radiation (Plank’s law, Kirchhoff’s law, Stefan-Boltzman law, Wien’s displacement law, Lambert’s cosine law), Radiation exchange between black surfaces, Shape factor, Radiation exchange between gray surfaces, Radiation shield and the radiation effect |
| 06 | Boiling and Condensation  
Pool boiling, Flow boiling, Film condensation, Drop wise condensation  
Heat Exchangers  
Types of heat exchangers, Overall heat transfer coefficient, Analysis of heat exchangers, LMTD method, Effectiveness-NTU method |

**Internal Assessment:**  
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

**Theory Examination:**  
1. Question paper will comprise of 6 questions, each carrying 20 marks.  
2. Question number 1 will be compulsory and based on maximum contents of the syllabus  
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)  
4. Total four questions need to be solved.

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.
References:
1. Introduction to Thermodynamics and Heat Transfer, Yunus Cengel, 2nd ed, McGraw-Hill
2. Fundamentals of Thermodynamics, Sonntag, Borgnakke, Van Wylen, Wiley India Pvt. Ltd.
3. Applied Thermodynamics, Onkar Singh, 3rd ed, New Age International
4. Basic Engineering Thermodynamics, Rayner Joel, Longman Publishers
5. Basic Engineering Thermodynamics, Zemanski and Van ness, TMH
15. Heat Transfer, Y V C Rao, University Press
CLASS: SE (Mechatronics)  Subject Code: MTC303  Semester:-III

SUBJECT: Engineering Materials and Metallurgy  Credit-4

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Pre-requisite:
1. FEC103 Applied Chemistry-I
2. FEC203 Applied Chemistry -II

Objectives:
1. To prepare the students understand basic engineering materials, their properties & selection and applications.
2. To familiarize the students with various types and causes of failure of components in different engineering applications.
3. To acquaint the students with the new concepts of Nano Science and Technology.
4. To prepare the students acquire basic understanding of advanced materials, their functions and properties for technological applications.

Outcomes: Learner will be able to...
1. Distinguish different types of materials and composites used in manufacturing.
2. Select a material for specific applications
4. Demonstrate a deeper understanding of materials in engineering applications.

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<th>Hrs.</th>
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<td>01</td>
<td>1.1 Introduction: Classification of materials, functional classification and classification based on structure. 1.2 Solidification of Metals: Formation of solids from liquids of pure metals and alloys. Single crystal and polycrystalline structure. 1.3 Crystal Imperfection: Definition, classification, Point defects: their formation and effects. Dislocations: Edge and screw dislocations, their significance. Surface defects: Grain boundary, sub-angle grain boundary, stacking fault, and their significance.</td>
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</table>
### 3.2 Nonferrous Metals and Alloys:
- Basic treatment only. Important nonferrous materials like aluminium, copper, nickel, tin, zinc and their alloys, properties and applications.

### 3.3 Powder Metallurgy:
- Powder manufacturing methods; Powder Metallurgy Process. Applications such as oil impregnated Bearings and Cemented Carbides. Limitations of Powder Metallurgy.

| 05 | 5.1 Ceramics: | Definition, comparative study of structure and properties of Engineering Ceramics with reference to metallic materials. Toughening mechanisms in ceramics. Engineering application of Ceramics. |
| 06 | 6.1 Composites: | Definition; Classification; Particle-reinforced composites and fibre-reinforced composites. Rule of mixtures; Sandwich structures. Classification of composites on basis of matrix materials. |

| 08 | 5.2 Polymers: | Classification of polymers. Thermoplastics, effect of temperature on thermoplastics, mechanical properties of thermoplastics. Thermosetting polymers and elastomers. |
| 10 | 6.3 Modern Engineering Materials: | Smart materials, Shape memory alloys, Chromic materials (Thermo, Photo and Electro), Rheological fluids, Metallic glasses. |

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### Theory Examination:
1. Question paper will comprise of total 06 questions, each of 20 marks.
2. Only 04 questions need to be solved.
3. Question 01 will be compulsory and based on maximum part of syllabus.
4. Remaining questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

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

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### Internal Assessment:
- Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.
References:

### Subject: Digital Electronics

**Class:** SE (Mechatronics)  
**Subject Code:** MTC304  
**Semester:** III  
**Credit:** 4

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**Evaluation System**

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### Pre-requisite:
1. FEC105 Basic Electrical & Electronics Engineering

### Objectives:
1. To teach fundamental principles of digital circuit design
2. To impart the knowledge of programmable devices

### Outcomes:
Learner will be able to...
1. develop a logic and apply it to solve real life problems
2. design combinational and sequential digital logic circuits
3. demonstrate an understanding of logic families TTL and CMOS
4. Use hardware description languages for logic circuit design and program PLDs.

### Module 1.0 Fundamentals of Digital Design

1. **Logic Gates:** Basic gates, Universal gates, Sum of products and products of sum, minimization with Karnaugh Map (up to four variables) and realization.
2. **Logic Families:** Types of logic families (TTL and CMOS), characteristic parameters (propagation delays, power dissipation, Noise Margin, Fan-out and Fan-in), transfer characteristics of TTL NAND, Interfacing CMOS to TTL and TTL to CMOS.
3. **Combinational Circuits using basic gates as well as MSI devices:** Half adder, Full adder, Half Subtractor, Full Subtractor, multiplexer, demultiplexer, decoder, Comparator (Multiplexer and demultiplexer gate level up to 4:1). MSI devices IC7483, IC74151, IC74138, IC7485.

**Hrs.:** 12

### Module 2.0 Elements of Sequential Logic Design:

1. **Sequential Logic:** Latches and Flip-Flops, Conversion of flip flops (timing considerations and metastability are not expected)
2. **Counters:** Asynchronous, Synchronous Counters, Up Down Counters, Mod Counters, Ring Counters Shift Registers, Universal Shift Register

**Hrs.:** 11

### Module 3.0 Sequential Logic Design:

1. Mealy and Moore Machines, Clocked synchronous state machine analysis, State reduction techniques and state assignment, Clocked synchronous state machine design. (*Complex word problems like traffic light controller etc. are not expected*)
2. MSI counters (7490, 74163, 74169) and applications, MSI Shift registers (74194) and their applications.

**Hrs.:** 11

### Module 4.0 Memories and Programmable Logic Devices:

1. **Classification and characteristics of memory:** SRAM, DRAM, ROM, PROM, EPROM and FLASH memories
2. **Concepts of PAL and PLA:** Architecture of CPLD and FPGA, Xilinx XC 9500 CPLD Series and Xilinx XC 4000 FPGA Series.

**Hrs.:** 08
5.0 Simulation:
- 5.1 Functional Simulation, Timing simulation, Logic Synthesis, RTL
- 5.2 VHDL: Data types, Structural Modeling using VHDL, attributes, data flow, behavioral, VHDL implementation of basic combinational and sequential Circuits.

6.0 Testability: Fault Models, Stuck at faults, ATPG, Design for Testability, Boundary Scan Logic, JTAG and Built in self test.

Internal Assessment (IA):
Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination:
1. Question paper will comprise of total 06 questions, each of 20 marks.
2. Only 04 questions need to be solved.
3. Question 01 will be compulsory and based on maximum part of syllabus.
4. Remaining questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

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

References:
- Anil K. Maini, Digital Electronics, Principles, Devices and Applications, Wiley
Prerequisite:
1. FEC102 Applied Physics
2. FEC105 Basic Electricity and Electronics

Objectives:
1. Understand working and performance of electrical and electronic devices

Outcomes: Learner will be able to...
1. Analyze second order systems in time and frequency domain
2. Illustrate working and performance characteristics of DC Motors
3. Illustrate working and performance characteristics of three phase Induction Motor
4. Implement systems using low power motors like stepper motor, brushless DC Motor and single phase induction motor
5. Illustrate working of Junction Transistors as switch

Module | Detailed contents | Hrs.
--- | --- | ---
1 | **Time Domain Analysis of RLC circuits**
   1.1 *Time domain analysis of R-L and R-C circuits*: Forced and natural response, time constant, initial and final values
   1.2 *Solution using first order equation for standard input signals*: Transient and steady state time response, solution using universal formula
   1.3 *Time domain analysis of R-L-C circuits*: Second order forced and natural response and concept of damping | 08
2 | **Frequency domain analysis of RLC circuits**
   2.1 *S-domain representation, applications of Laplace Transform in solving electrical networks, driving point and transfer function*,
   2.2 *Poles and Zeros, calculation of residues by analytical and graphical method*,
   2.3 *Frequency response* | 08
3 | **Junction Transistors as Switch**
   3.1 *Junction Field Effect Transistor JFET*: Construction, pinch off voltage, transfer characteristic, trans-conductance
   3.2 *Metal-Oxide Effect Transistor (MOSFET): Working* of MOSFET, threshold voltage and MOSFET as switch
   3.3 *BJT*: Regions of operation, normally ON and normally OFF state biasing, working of BJT CE amplifier and BJT as a switch | 10
4 | **DC Motors**
   4.1 *Construction, principle of working, significance of commutator and brushes in DC machine, classification EMF equation*, Torque equation, characteristics of DC Motors
   4.2 *Starters* for shunt and series motors
   4.3 *Speed Control*: basic principle and working of different methods | 08
| 5 | Three Phase Induction Motor  
5.1 Construction, working principle of squirrel cage induction motor  
5.2 **Equivalent circuit**: Equivalent circuit development, torque speed characteristics, power  
5.3 Speed control methods  
5.4 **Starting methods**: Classification and working of different methods | 10 |
| 6 | Low Power Motors  
6.1 **Brushless DC Motors**: Unipolar brushless DC motor, Bipolar brushless DC motor, speed control, important features and applications  
6.2 **Stepper Motors**: Constructional features, working principle and applications  
6.3 **Single phase Induction Motors**: construction, working, starting methods, tor-speed characteristics and applications | 08 |
| | **Total** | 52 |

**Internal Assessment (IA):**
Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

**Theory Examination:**
1. Question paper will comprise of total 06 questions, each of 20 marks.
2. Only 04 questions need to be solved.
3. Question 01 will be compulsory and based on maximum part of syllabus.
4. Remaining questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

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

**References:**
<table>
<thead>
<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs.</th>
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<tbody>
<tr>
<td></td>
<td>*Theory</td>
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<td>*Theory for entire class to be conducted</td>
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<td></td>
<td>Practical to be conducted for batch of students</td>
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</tr>
<tr>
<td>1</td>
<td><strong>1.1 Solid Geometry</strong>: Intersection of surfaces and interpenetration of solids- Intersection of prism or cylinder with prism; cylinder or cone, both solids in simple position only. Primary auxiliary views and auxiliary projections of simple machine parts.</td>
<td>08</td>
</tr>
<tr>
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<td><strong>1.2 Machine Elements</strong>: Preparation of 2-D drawings of standard machine elements (nuts, bolts, keys, cotter, screws, spring etc.)</td>
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<td></td>
<td>**1.3 Conventional representation of assembly of threaded parts in external and sectional views, Types of threads; thread designation, Conventional representation of machine components and materials, Designation of standard</td>
<td>06</td>
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<td>01</td>
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<td>2.1 Limits fits and tolerances: Dimensioning with tolerances indicating various types of fits in details and assembly drawings. Types of assembly drawings, part drawings, drawings for catalogues and instruction manuals, patent drawings, drawing standards.</td>
<td>04</td>
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<td>2.2 Details and assembly drawing: Introduction to the unit assembly drawing, steps involved in preparing assembly drawing from details and vice-versa, Sequence in assembly.</td>
<td>02</td>
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<tr>
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<td>2.3 Preparation of details and assembly drawings of any two from: Clapper block, Single tool post, Lathe and Milling tail stock.</td>
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<td>2.4 Cotter, Knuckle joint, Keys and Couplings: keys-sunk, parallel woodruff, saddle, feather etc. Coupling: simple, muffy, flanged.</td>
<td>03</td>
</tr>
<tr>
<td></td>
<td>3.1 Preparation of details and assembly drawings of Bearings: Simple, solid, Bushed bearing. I.S. conventional representation of ball and roller bearing.</td>
<td>01</td>
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<td>3.2 Pedestal bearing, footstep bearing</td>
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<td></td>
<td>4.1 Preparation of details and assembly drawings of pulleys, Pipe joints: Classification of Pulleys, pipe joints</td>
<td>02</td>
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<tr>
<td></td>
<td>4.2 Pulleys: Flat belt, V-belt, rope belt, Fast and loose pulleys.</td>
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<td>4.3 Pipe joints (any two): Flanged joints, Socket and spigot joint, Gland and stuffing box, expansion joint.</td>
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<tr>
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<td>5.1 Preparation of details and assembly drawings of Valves, I.C. Engine parts: Types of Valves, introduction to I.C. Engine</td>
<td>02</td>
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<tr>
<td></td>
<td>5.2 Preparation of details and assembly drawings of (any three): Air cock; Blow off cock, Steam stop valve, Gate valve, Globe valve, Non return Valve, I.C. Engine parts: Piston, Connecting rod, Cross head, Crankshaft, Governor, Fuel injector, Thermostat, Crank pin.</td>
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<tr>
<td></td>
<td>6.1 Preparation of details and assembly drawings of Jigs and Fixtures: Introduction to Jigs and fixtures.</td>
<td>01</td>
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<tr>
<td></td>
<td>6.2 Jigs and Fixtures (any two from each)</td>
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<tr>
<td></td>
<td>6.3 Reverse Engineering of a physical model: disassembling of any physical model having not less than five parts, sketch the minimum views required for each component, measure all the required dimensions of each component, convert these sketches into 3-D model and create an assembly drawing with actual dimensions.</td>
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</tbody>
</table>

**Term work:**
A. Minimum two questions from theory part of each module should be solved as a home work in A-3 size sketch book.
B. A-3 size Printouts/plots of the problems solved in practical class from the practical part of each module

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

The distribution of marks for term work shall be as follows:
Home work sketch book ....... 20 marks
Printouts/Plots ....... 20 marks
Attendance (Theory and practical’s) ....... 10 marks
Practical/Oral examination:

1. Practical examination duration is three hours, based on Part-B of the Term work, and should contain two sessions as follows:

   **Session-I**: Preparation of 3-D models of parts, assembling parts and preparing views of assembly from given 2-D detailed drawing.

   **Session-II**: Preparation of minimum five detailed 3-D part drawings from given 2-D assembly drawing. 
   *Oral examination should also be conducted to check the knowledge of conventional and CAD drawing.*

2. Questions provided for practical examination should contain minimum five and not more than ten parts.

3. The distribution of marks for practical examination shall be as follows:
   - **Session-I** ….. 20 marks
   - **Session-II** ….. 20 marks
   - **Oral** ……..10 marks

4. Evaluation of practical examination to be done based on the printout of students work

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

References:

9. Engineering Drawing by P J Shah
10. Engineering Drawing by N D Bhatt
Pre-requisites:
1. FEC 205 Structured Programming Approach

Objectives:
1. To study the concepts of Object oriented programming.
2. To study solving of the real world problem using top down approach.
3. To study Java programming constructs.

Outcomes: Learner will be able to...
1. Solve basic computational problems using Java programming constructs like if-else, control structures, array and strings.
2. Model real world scenario using class diagram.
3. Exhibit communication between two objects.
4. Implement relationships between classes.
5. Demonstrate programs on exceptions, multithreading.

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Th. Hours</th>
</tr>
</thead>
</table>
| 1      | **Introduction to Object Oriented Programming**  
1.1 Principle of Object Oriented Programming  
1.2 Differences and similarity between C++ and Java  
1.3 Advantages of object oriented programming | 04 |
| 2      | **Java Fundamentals**  
2.1 Features of Java  
2.2 Introduction to Java Environment ,JDK,  
2.3 Structure of a Java Program  
2.4 Looping and Methods  
2.5 Developing a simple Java Program | 06 |
| 3      | **Java classes and objects**  
3.1 Arrays, Vectors ,Strings and Wrapper classes  
3.2 Constructor and Finalize  
3.3 Parameterized Methods and classes  
3.4 Exception Handling  
3.5 I/O Processor | 08 |
| 4      | **Inheritance**  
4.1 Understanding Inheritance  
4.2 Forms of Inheritance  
4.3 Super and Final Key words  
4.4 Abstract classes and Interfaces  
4.5 Multithreading and Packaging | 08 |
Term Work:
Term work shall consist of
1. Minimum two assignments covering the entire syllabus.
2. Minimum 10 experiments and one mini project (in a group of maximum three) covering entire syllabus should be set to have well predefined inference and conclusion.

Term Work Evaluation: 50 Marks (Total marks) = 30 Marks (Experiment) +10 Marks (mini project) +10 Marks (Attendance)

The practical and oral examination will be based on entire syllabus.

Practical’s:
All the programs and mini project should be implemented in Java under Windows, Linux or Ubuntu environment.

References:
CLASS: SE (Mechatronics)  Subject Code: MTL308  Semester:-III

SUBJECT: Applied Electronics Laboratory-I  Credit: 1

Practical to be conducted for batch of students  Practical  Slot of 02 hours per week

Prerequisite:
1. FEC102  Applied Physics
2. FEC105  Basic Electricity and Electronics

Objectives:
1. Characterization of electrical and electronics circuits
2. Characterization of electrical and electronics actuators

Outcomes: Learner will be able to..
1. analyze second order systems in time and frequency domain
2. characterize TTL family
3. characterize MOS family
4. Implement combinational and sequential circuits using MSI devices.

List of experiments:
1. Time domain response of RC circuit
2. Time domain response of R-L-C series circuit: under, over and critically damped. This can be studied by writing a simple programme using any software tool. Plot time domain response and study effect of change in values of R-L-C
3. Write a simple programme for the transfer function of any R-L-C circuit. Plot frequency domain response and study effect of change in values of R-L-C
4. Speed control of DC shunt and series motor
5. Plot torque speed characteristics of DC shunt motor
6. Speed control of three phase Induction Motor
7. Stepper Motor control
8. Starting of capacitor start/run single phase Induction Motor
9. BJT as electronic ON/OFF switch
10. JFET as electronic ON/OFF switch
11. MOSFET as electronic ON/OFF switch
12. Developing ON/OFF control for Stepper Motor
13. Developing ON/OFF control for permanent magnet DC motor

Term Work:

Term work shall consist of minimum 10 experiments and should be set to have well predefined inference and conclusion.

Term Work Evaluation: 25 Marks (Total marks) = 20 Marks (Experiment) +05 Marks (Attendance)

Practical / Oral Examination:
Practical examination of 2 hours duration based on any one of the experiments mentioned in the list above.
The distribution of marks for oral-practical examination shall be as follows:

Practical Examination  ......  15 marks
Oral  ......  10 Marks
1. Evaluation of practical examination to be done based on the performance of design task.
2. Students work along with evaluation report to be preserved till the next examination.
CLASS: SE (Mechatronics)  
Subject Code: MTL309  
Semester:-III

SUBJECT: Engineering Materials and Metallurgy Laboratory  
Credit: 1

Practical to be conducted for batch of students  
Practical  
Slot of 02 hours per week

Pre-requisites:
1. FEC103 Applied Chemistry-I
2. FEC202 Applied Physics –II
3. FEC203 Applied Chemistry –II

Objectives:
1. To prepare the students understand basic engineering materials, their properties & selection and applications.
2. To prepare the students acquire basic understanding of advanced materials, their functions and properties for technological applications.

Outcomes: Learner will be able to...
1. Distinguish different types of materials and composites used in Manufacturing.
2. Demonstrate a deeper understanding of heat treatment processes for engineering applications.
3. perform non-destructive technique (NDT)

List of Experiments:
1. Preparation of specimen (minimum two metals/alloys) for microscopic examination.
2. Heat treatment process (Annealing, Normalizing and Hardening).
3. Jominy end Quench test for hardenability.
4. NDT (at least two).

Term Work:
Term work shall consist of
1. Assignments: On topics drawn from syllabus.
2. Factory report: Preparation of equipment, process, quality control and failure analysis of engineering components reports after visit to important industrial plants.
3. All experiments mentioned in the list of experiments shall be performed.

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

- Laboratory work (assignments, Practicals): 10 Marks.
- Report on Factory visit: 10 Marks
- Attendance (Practicals): 05 Marks.

TOTAL: 25 marks
Pre-requisites:
1. FEC101 Applied Mathematics-I
2. FEC201 Applied Mathematics-II

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

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

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<thead>
<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs</th>
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<tbody>
<tr>
<td>1</td>
<td>Matrices</td>
<td>09</td>
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<tr>
<td></td>
<td>1.1 Brief revision of vectors over a real field, inner product, norm, Linear Dependance and Independence and orthogonality of vectors.</td>
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<td></td>
<td>1.2 Characteristic polynomial, characteristic equation, characteristic roots and characteristic vectors of a square matrix, properties of characteristic roots and vectors of different types of matrices such as orthogonal matrix, Hermitian matrix, Skew-Hermitian matrix, Cayley Hamilton theorem (without proof) Functions of a square matrix, Minimal polynomial and Derogatory matrix.</td>
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<tr>
<td>2</td>
<td>Vector calculus</td>
<td>11</td>
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<tr>
<td></td>
<td>2.1 Brief revision of Scalar and vector point functions, Gradient, Divergence and curl.</td>
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<td>2.2 Line integrals, Surface integrals, Volume integrals. Green’s theorem (without proof) for plane regions and properties of line integrals, Stokes theorem (without proof), Gauss divergence theorem (without proof) related identities and deductions. (No verification problems on Stoke’s Theorem and Gauss Divergence Theorem)</td>
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<td>3</td>
<td>Non Linear Programming</td>
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<tr>
<td>3.1</td>
<td>Unconstrained optimization, problems with equality constraints Lagranges Multiplier method.</td>
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<tr>
<td>3.2</td>
<td>Problem with inequality constraints Kuhn-Tucker conditions.</td>
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<tr>
<th>4</th>
<th>Probability Distributions</th>
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<tbody>
<tr>
<td>4.1</td>
<td>Discrete and Continuous random variables, Probability mass and density function, Probability distribution for random variables, Expected value, Variance.</td>
</tr>
<tr>
<td>4.2</td>
<td>Probability Distributions: Binomial, Poisson and Normal Distributions for detailed study.</td>
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<tr>
<th>5</th>
<th>Sampling Theory</th>
</tr>
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<tbody>
<tr>
<td>5.1</td>
<td>Sampling distribution. Test of Hypothesis. Level of significance, critical region. One tailed and two tailed tests. Interval Estimation of population parameters. Large and small samples.</td>
</tr>
<tr>
<td>5.2</td>
<td>Test of significance for Large samples: Test for significance of the difference between sample mean and population means, Test for significance of the difference between the means of two samples.</td>
</tr>
<tr>
<td>5.3</td>
<td>Student’s t-distribution and its properties. Test of significance of small samples: Test for significance of the difference between samples means and population means, Test for significance of the difference between the means of two Samples, paired t-test.</td>
</tr>
<tr>
<td>5.4</td>
<td>Analysis of Variance(F-Test): One way classification, Two-way classification(short-cut method)</td>
</tr>
<tr>
<td>5.5</td>
<td>Chi-square distribution and its properties, Test of the Goodness of fit and Yate’s correction.</td>
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<th>6</th>
<th>Correlation and Regression</th>
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<tr>
<td>6.1</td>
<td>Correlation, Co-variance, Karl Pearson Coefficient of Correlation &amp; Spearman’s Rank Correlation Coefficient (non-repeated &amp; repeated ranks)</td>
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<tr>
<td>6.2</td>
<td>Regression Coefficients &amp; lines of regression</td>
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**Internal Assessment:**

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

**Theory Examination:**

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

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.
References:
1. Fundamentals of Mathematical Statistics, S C Gupta & V K Kapoor, S. Chand & Co
2. Higher Engineering Mathematics, Dr B. S. Grewal, Khanna Publication
5. Operations Research, S.D. Sharma, S. Chand & CO.
6. Vector Analysis by Murray R. Spiegel, Shaum Series
7. Operations Research, Kantiswarup, Manmohan, P K Gupta, S. Chand & CO.
CLASS: SE (Mechatronics)  Subject Code: MTC402  Semester: IV

SUBJECT: Kinematics of Machinery  Credit: 4

Periods per week: 1 Period of 60 min.

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<thead>
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<th>Lecture</th>
<th>Tutorial</th>
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Evaluation System

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<tr>
<th>Evaluation System</th>
<th>Hours</th>
<th>Marks</th>
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<tr>
<td>Theory Examination</td>
<td>3</td>
<td>80</td>
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<tr>
<td>Internal Assessment</td>
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<td>20</td>
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<td>TOTAL</td>
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Pre-requisites:
1. FEC104 Engineering Mechanics

Objectives:
1. To provide basic concepts of kinematics of machine elements.
2. To understand velocity and acceleration analysis of mechanisms.
3. To study basics of power transmission by belts, chains, gears.
4. To analyse cam and follower mechanisms.

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

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Details</th>
<th>Hrs</th>
</tr>
</thead>
</table>
| 1       | 1.1 Kinetics of Rigid Bodies  
          D’Alembert’s Principle, Application of motion of bars, cylinders and spheres only. Kinetics of Rigid Bodies: Kinetic energy in translating motion, Rotation about fixed axis and in general plane motion.  
          1.2 Basic Kinematics:  
          Kinematic link, Types of links, Kinematic pair, Types of constrained motions, Types of Kinematic pairs, Kinematic chain, Types of joints, Mechanism, Machine, Degree of freedom (Mobility), Kutzbach criterion, Grubler’s criterion Four bar chain and its inversions, Double slider crank chain and its inversions. | 07  |
| 2       | Mechanisms:  
          Straight line generating Mechanisms: Exact Straight Line Generating Mechanisms – Peaucellier approximate Straight Line Generating Mechanisms – Watt, Grasshopper and Tchebicheff’s. Compliant mechanisms, Flexure based straight line mechanism. Offset slider crank mechanisms, Pantograph,  
          Overview of mechanisms used in mechatronics systems: image scanner, 3D printer. | 08  |
| 3       | Velocity & Acceleration analysis of Mechanisms  
          3.1 Velocity Analysis of mechanisms (mechanisms up to 6 links).  
          Velocity analysis by instantaneous center of rotation method (Graphical approach)  
          Velocity analysis by relative velocity method (Graphical approach) Analysis is extended to find rubbing velocities at joints, mechanical advantage (Graphical approach). Velocity analysis of low | 09  |
degree complexity mechanisms (Graphical approach). Auxiliary point method
3.2 Velocity and Acceleration analysis of mechanism.
Velocity and Acceleration – analysis by relative method (mechanisms up to 6 link) including pairs involving Coriolis acceleration (Graphical Approach).

| 4 | **Synthesis of Mechanisms and linkages**: Classification of Synthesis Problem, precision points for function Generation, Graphical synthesis of four bar mechanism, Three position synthesis, Four point synthesis, coupler-curve synthesis, Graphical synthesis of slider crank mechanism, Least square technique, Synthesis of four bar mechanism for body guidance. | 10 |

| 5 | **Belts and Chains**
5.1 Belt – Types of belts, velocity ratio, slip & creep, length of belt for open & cross system. Law of belting, Dynamic analysis- driving tensions, centrifugal tension, initial tension, condition of maximum power transmission.
5.2 Chains – types of chains, chordal action, variation in velocity ratio, Length of chain.
5.3 Gears
Law of gearing, Involute and Cycloid gear tooth profile, Construction of Involute profile. Path of contact, arc of contact, contact ratio for involutes and cycloidal tooth profile, Interference in involutes gears. Critical Numbers of teeth for interference free motion. Static force analysis in gears- spur, helical, worm & worm wheel.
5.4 Gear Trains
Kinematics and dynamic analysis of - simple gear trains, Module compound gear trains, reverted gear trains, epicyclic gear trains with spur or bevel gear combination. | 10 |

| 6 | **Cams and Followers**
Cam and its Classifications.
Followers and its Classification.
Motion analysis and plotting of displacement-time, velocity-time, acceleration- time, jerk-time graphs for uniform velocity. UARM, SHM.
Motion analysis of simple cams – R-R cam, D-R-R and D-R-D-R cam operating radial translating follower.
Layout of cam profiles. | 08 |

**Internal Assessment:**
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

**Theory examinations:**
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.
References:
1. Theory or Mechanisms and Machines by Amitabh Ghosh and A. Kumar Mallik.
2. Theory of Machines and Mechanism by John Uiker, Garden Pennock & Late. J. F. shigley
4. Theory of Machines by S. S. Rattan
5. Kinematics of Machines by R T Hinckle (Prentice Hall Inc.)
6. Kinematics By V.M. Fairs (McGraw Hill)
CLASS: SE (Mechatronics)  
Subject Code: MTC403  
Semester:-IV

SUBJECT: **Fluid Mechanics and Machinery**  
Credit-4

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<th>Periods per week: 1Period of 60 min.</th>
<th>Lecture</th>
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<tbody>
<tr>
<td>Tutorial</td>
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</tr>
<tr>
<td>Evaluation System</td>
<td>Hours</td>
<td>Marks</td>
</tr>
<tr>
<td>Theory Examination</td>
<td>3</td>
<td>80</td>
</tr>
<tr>
<td>Internal Assessment</td>
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<td>20</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Pre-requisites:
1. FEC104 Engineering Mechanics

Objectives:
1. To study the properties of the fluids.
2. To study the dynamics of fluids.
3. To study the transport of mass, momentum and energy.
4. To study the applications of the conservation laws to flow though pipes and hydraulics machines.

Outcomes: Learner will be able to…
1. Illustrate the physical properties and characteristic behavior of fluids.
2. Illustrate the principle and applications of continuity equation.
3. Learn about the Euler’s equations along the streamlines.
4. Apply the principles of turbulent Vs laminar flow to flow systems
5. Apply the concepts of friction and determine friction factors.
6. Illustrate dimensional analysis for model and similitude of hydraulic machines.
7. Illustrate the working principle of hydraulic turbines.
8. Illustrate the working principle of hydraulic pump.

<table>
<thead>
<tr>
<th>Module</th>
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</thead>
<tbody>
<tr>
<td>02</td>
<td><strong>FLUID KINEMATICS AND FLUID DYNAMICS:</strong> Fluid kinematics: stream line, path line and streak lines and stream tube, classification of flows-steady &amp; unsteady, uniform, non uniform, laminar, turbulent, rotational, and irrotational flows-equation of continuity for one dimensional flow. Fluid dynamics: surface and body forces –Euler’s and Bernoulli’s equations for flow along a stream line, Bernoulli’s equation - applications - Venturi meter – Orifice meter Pitot tube. Momentum equation and its application on force on pipe bend. Applications of momentum equations.</td>
<td>8</td>
</tr>
</tbody>
</table>
04 DIMENSIONAL ANALYSIS: Dimension and units: Buckingham’s II theorem. Discussion on dimensionless parameters. Models and similitude. Applications of dimensionless parameters. Model analysis Dimensionless number and their significance, model laws, Reynolod’s model law, Fraude’s model law, Euler’s model law, Weber’s model law, Mach’s Model law, Type of models, scale effect in model, limitation of hydraulic similitude.

05 HYDRAULIC TURBINES: Hydro turbines: Definition and classification, turbines, impulse and reaction turbines, Pelton wheel, Francis turbine and Kaplan turbine - working proportions, work done, efficiencies, hydraulic design – draft tube- theory- functions and efficiency.

06 HYDRAULIC PUMPS: Pumps: definition and classifications - Centrifugal pump; classifications, working principle, velocity triangles, Work done - Reciprocating pump: classification, working principle, Basic principles of indicator diagram. Performance parameters and characteristics of pumps and turbines; Positive displacement pumps.

Internal Assessment:
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

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

References:
SUBJECT: **Strength of Material**

**Pre-requisites:**
1. FEC104 Engineering Mechanics
2. MTC 303 Engineering Materials and Metallurgy

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

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

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<tr>
<th>Module</th>
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<tbody>
<tr>
<td>1</td>
<td><strong>Moment of Inertia:</strong> Mass Moment of Inertia , Area Moment of Inertia, Parallel Axis theorem, Polar Moment of Inertia, Principal axes, Principal moment of inertia. <strong>Stress and Strain:</strong> Definition, Stress- strain, uni-axial, bi-axial and tri-axial stresses, tensile &amp; compressive stresses, shear stress-Elastic limit, Hooke’s Law. <strong>Elastic Constants:</strong> Poisson’s Ratio, Modulus of elasticity, Modulus of rigidity, Bulk modulus, Yield stress, Ultimate stress. State of simple shear, relation between elastic constants, Volumetric strain, Volumetric strain for tri-axial loading, Deformation due to self-weight, Stresses in bars of varying sections, composite sections. Thermal Stress.</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td><strong>Stresses Analysis:</strong> General case of two-dimensional stress, Principal Stresses, Directions of Principal Stresses; Principal Planes, Shearing Stresses on Principal Planes, Maximum Shearing Stresses, Normal Stresses on Planes of Maximum Shearing Stress, Mohr’s Circle, Determination of Principal Stresses by Mohr’s Circle, Determination of Stresses on Arbitrary plane by Mohr’s Circle. Principal Stresses for a General State of Stress, Mohr’s Circle for General State of stress.</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td><strong>Shear Force and Bending Moment in Beams:</strong>&lt;br&gt; Axial force, shear force and bending moment diagrams for statically determinate beams including beams with internal hinges for different types of loading, relationship between rates of loading, shear force and bending moment.</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td><strong>Stresses in Beams:</strong>&lt;br&gt; Theory of pure Bending, Assumptions, Flexural formula for straight beams, moment of resistance, bending stress distribution, Section moduli for different sections, beams for uniform strength, Flitched beams.&lt;br&gt;&lt;br&gt;<strong>Direct &amp; Bending Stresses:</strong>&lt;br&gt; Core of Section, Chimneys subjected to wind pressure&lt;br&gt;&lt;br&gt;<strong>Shear Stress in Beams:</strong>&lt;br&gt; Distribution of shear stress, across plane sections used commonly for structural purposes, shear connectors.</td>
<td>9</td>
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<tr>
<td>5</td>
<td><strong>Torsion:</strong>&lt;br&gt; Torsion of circular shafts-solid and hollow, stresses in shafts when transmitting power, shafts in series and parallel.&lt;br&gt;&lt;br&gt;<strong>Strain Energy:</strong>&lt;br&gt; Resilience, proof Resilience, strain energy stored in the member due to gradually applies load, suddenly applied load, impact load. Strain energy stored due to Shear, Bending and Torsion.</td>
<td>9</td>
</tr>
<tr>
<td>6</td>
<td><strong>Deflection of Beams:</strong>&lt;br&gt; Deflection of Cantilever, simply supported and over hanging beams using double integration and Macaulay’s Method for different type of loadings.&lt;br&gt;&lt;br&gt;<strong>Thin Cylindrical and Spherical Shells:</strong>&lt;br&gt; Cylinders and Spheres due to internal pressure. Cylindrical Shell with hemispherical end.</td>
<td>9</td>
</tr>
</tbody>
</table>

**Theory Examination:**

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

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

**Internal Assessment:**

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.
References:
5. Elements of Strength of Materials, Timoshenko and Young Affiliated East-West Press.
CLASS: SE (Mechatronics)  Subject Code: MTC405  Semester: IV

SUBJECT: Application of Integrated Circuits  Credit: 4

<table>
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Pre-requisite:
1. MTC304 Digital Electronics
2. MTC305 Applied Electrical and Electronics Engineering

Objectives:
1. To teach fundamental principles of standard linear integrated circuits.
2. To develop a overall approach for students from selection of integrated circuit, study its specification, the functionality, design and practical applications

Outcomes: Learner will be able to..
1. Demonstrate an understanding of fundamentals of integrated circuits.
2. Analyze the various applications and circuits based on particular linear integrated circuit.
3. Select and use an appropriate integrated circuit to build a given application.
4. Design an application with the use of integrated circuit

<table>
<thead>
<tr>
<th>Module</th>
<th>Topics</th>
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<tbody>
<tr>
<td>1</td>
<td><strong>Fundamentals of Operational Amplifier</strong></td>
<td>06</td>
</tr>
<tr>
<td></td>
<td>1.1 Ideal Op Amp, characteristics of op-amp, op-amp parameters, high frequency effects on op-amp gain and phase, slew rate limitation, practical determination of op-amp parameters, single supply versus dual supply op-amp</td>
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<td></td>
<td>1.2 Operational amplifier open loop and closed loop configurations, Inverting and non-inverting amplifier</td>
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<tr>
<td>2</td>
<td><strong>Linear Applications of Operational Amplifier</strong></td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>2.1 <strong>Amplifiers</strong>: Adder, subtractor, integrator, differentiator, current amplifier, difference amplifier, instrumentation amplifier and application of Op-Amp in Transducer Measurement System with detail design Procedure.</td>
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<tr>
<td></td>
<td>2.2 <strong>Converters</strong>: Current to voltage converters, voltage to current converters</td>
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<td></td>
<td>2.3 <strong>Active Filters</strong>: First order filters, Second order active finite and infinite gain low pass, high pass, band pass and band reject filters.</td>
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<td>2.4 <strong>Sine Wave Oscillators</strong>: RC phase shift oscillator and Wien bridge oscillator</td>
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<tr>
<td>3</td>
<td><strong>Non-Linear Applications of Operational Amplifier</strong></td>
<td>12</td>
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<tr>
<td></td>
<td>3.1 <strong>Comparators</strong>: Inverting comparator, non-inverting comparator, zero crossing detector, window detector and level detector.</td>
<td></td>
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<td></td>
<td>3.2 <strong>Schmitt Triggers</strong>: Inverting and non-inverting Schmitt trigger</td>
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<td></td>
<td>3.3 <strong>Waveform Generators</strong>: Square wave generator and triangular wave generator with duty cycle modulation</td>
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<td></td>
<td>3.4 <strong>Precision Rectifiers</strong>: Half wave and full wave precision rectifiers and their applications.</td>
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<tr>
<td></td>
<td>3.5 Peak Detectors, Sample &amp; Hold Circuits, voltage to frequency converter, frequency to voltage converter, logarithmic converters and antilog converters</td>
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</tr>
</tbody>
</table>
4 | Data Converters  
4.1 Analog to Digital: Performance parameters of ADC, Single Ramp ADC, ADC using DAC, Dual Slope ADC, Successive Approximation ADC, Flash ADC, ADC0808/0809 and its interfacing  
4.2 Digital to Analog: Performance parameters of DAC, Binary weighted register DAC, R/2R ladder DAC, Inverted R/2R ladder DAC, DAC0808 and its interfacing

5 | Special Purpose Integrated Circuits  
5.1 Functional block diagram, working, design and applications of Timer 555.  
5.2 Functional block diagram, working and applications of VCO 566, PLL 565, multiplier 534, waveform generator XR 2206, power amplifier LM380.

6 | Voltage Regulators  
6.1 Functional block diagram, working and design of three terminal fixed (78XX, 79XX series) and three terminal adjustable (LM 317, LM 337) voltage regulators.  
6.2 Functional block diagram, working and design of general purpose 723 (LVLC, LVHC, HVLC and HVHC) with current limit and current foldback protection, Switching regulator topologies, Functional block diagram and working of LT1070 monolithic switching regulator.

**Total** 52

**Internal Assessment (IA):**

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

**Theory Examination:**

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No.1 will be compulsory preferably objective type and based on entire syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

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

**References:**

CLASS: SE (Mechatronics )
Subject Code: MTC406
Semester:-IV

<table>
<thead>
<tr>
<th>SUBJECT: Signals and Systems</th>
<th>Lecture</th>
<th>4</th>
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<tbody>
<tr>
<td>Periods per week: 1Period of 60 min.</td>
<td>Tutorial</td>
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</table>

Pre-requisite:
1. MTC305: Applied Electrical and Electronics Engineering

Objectives:
1. To introduce students to the idea of signal and system analysis and characterization in time and frequency domain.
2. To provide foundation to numerous other courses that deal with signal and system concepts directly or indirectly.

Outcomes: Learner will be able to...
1. Classify various types of signals and systems.
2. Analyze continuous time systems intime domain and Laplace, z, and frequency domains.
3. Explain and apply the properties Laplace transform/z-transform/Fourier series/transform in solving numerical problems.
4. Demonstrate their written and oral communication skills for this subject.

Module | Details | Hrs.
--- | --- | ---
1.0 | Introduction:  
1.1 Signals and systems: Examples of signals & systems as seen in everyday life, and in various branches of engineering: electrical, mechanical, hydraulic, thermal, and biomedical. Extracting the common essence and requirements of signal and system analysis from these examples.  
1.2 Continuous time signals: elementary signals, exponential, sine, step, impulse, ramp, rectangular, triangular and operations on signals  
1.3 Classification of signals: Continuous and discrete time, deterministic and non-deterministic, periodic and aperiodic, symmetric (even) and asymmetric (odd), energy and power, causal and anti-causal signals | 06 |
2.0 | Time domain analysis of Continuous Time Systems  
2.1 Classification of systems: Static and dynamic, time variant and time invariant, linear and nonlinear, causal and non-causal, stable and unstable systems.  
2.2 Linear Time Invariant (LTI) systems: Representation of systems using differential equation, Impulse, step and exponential response, system stability, examples on applications of LTI systems, convolution, impulse response of interconnected systems, auto-correlation, cross correlation and properties of correlation | 12 |
3.0 | Laplace Transform  
3.1 Overview of Laplace Transform: Laplace Transform and properties, relation between continuous time Fourier Transform and Laplace Transform, unilateral Laplace Transform.  
3.2 Analysis of continuous time LTI systems using Laplace Transform: Transfer Function, causality and stability of systems, solution of differential equation using Laplace Transform. | 06 |
4.0 | z – Transform  
4.1 z-Transform of finite and infinite duration sequences, relation between discrete time Fourier Transform and z-Transform, properties, Inverse z- | 08 |
Transform, one sided $z$– Transform.

4.2 **Analysis of discrete time LTI systems using $z$-Transform:** Transfer Function, causality and stability of systems, frequency response, relation between Laplace Transform and $z$-Transform.

<table>
<thead>
<tr>
<th>5.0</th>
<th>Fourier series of continuous and discrete time signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>Review of Fourier series: trigonometric and exponential Fourier series representation of signals, magnitude and phase spectra, power spectral density and bandwidth. Gibbs phenomenon.</td>
</tr>
<tr>
<td>5.2</td>
<td>Properties of Fourier Series: Linearity, time shifting, time reversal, frequency shifting, time scaling, differentiation, symmetry. Parseval’s relation. Examples based on properties, analogy between Continuous Time Fourier Series (CTFS) and Discrete Time Fourier Series (DTFS).</td>
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</tbody>
</table>

<table>
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<tr>
<th>6.0</th>
<th>Continuous Time Fourier Transform (CTFT) and Discrete Time Fourier Transform (DTFT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td>Fourier Transform: Fourier Transform and Inverse Fourier Transform on periodic and non-periodic signals, limitations of Fourier Transform and need for Laplace and $z$-Transform</td>
</tr>
<tr>
<td>6.2</td>
<td>Properties of Fourier Transform: Linearity, time shifting, time reversal, frequency shifting, time and frequency scaling, modulation, convolution in time domain, differentiation in time domain, differentiation in frequency domain, symmetry. Parseval’s relation. Energy, power spectral density and bandwidth. Definition and problems on DTFT</td>
</tr>
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</table>

Internal Assessment (IA):

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. The students need to solve total 4 questions.
3. Question No.1 will be compulsory and based on entire syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)

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

References:

CLASS: SE (Mechatronics)       Subject Code: MTL407       Semester: IV

SUBJECT: Applied Electronics Laboratory-II       Credit: 1

Practical to be conducted for batch of students       Practical       02 hours per week

Pre-requisite:
1. MTL308: Applied Electronics Laboratory-I

Objectives:
1. Study of electronic amplifier
2. Study of interfacing
3. Time domain analysis of systems

Outcomes: Learner will be able to...
1. Characterize op-amp
2. do interfacing
3. do time domain characterization of the systems

List of Experiments:
1. Experiment on op amp parameters
2. Experiment on design of application using op amp
3. Experiment on implementation of op amp application e.g. oscillator
4. Experiment on nonlinear application (e.g. comparator or peak detector) of op amp
5. Experiment on ADC and DAC interfacing
6. Experiment on IC 555
7. Experiment on voltage regulator
8. Simulation experiment based on time domain analysis of continuous time systems
9. Simulation experiment on Laplace/z-Transform
10. Simulation experiment on CTFT and DTFT

Term Work:
Term work shall consist of performance of above mentioned 10 experiments with well predefined inference and conclusion.

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

Term Work Evaluation: 25 Marks (Total marks) = 20 Marks (Experiment) + 05 Marks (Attendance)

Practical exam (15 marks) will be on any one of the experiments from the list and oral exam (10 marks) will be based on the entire syllabus of the laboratory.
<table>
<thead>
<tr>
<th>CLASS: SE (Mechatronics)</th>
<th>Subject Code: MTL408</th>
<th>Semester: - IV</th>
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<tbody>
<tr>
<td>SUBJECT: Electrical and Electronics Workshop</td>
<td>Credit: 1</td>
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</table>

Practical to be conducted for batch of students  
Practical  
02 hours per week

**Pre-requisite:**  
1. MTL308: Applied Electronics Laboratory-I

**Objectives:**  
1. To inculcate skill for electrical engineering works  
2. To inculcate skill for electronics engineering works

**Outcome:** Learner will be able to...  
1. demonstrate PCB design and soldering skills  
2. demonstrate computer assembly skills  
3. demonstrate skills in handling electrical components

**Syllabus:**  
The primary objective is to encourage students to design and implement innovative ideas by development of engineering skills. This will give them in depth practical knowledge from design to the final verification stage. Documentation is important for any activity and students are expected to document their work properly.

**Part A:**  
1. Soldering Techniques and PCB Design  
2. Computer hardware  
3. Various electrical components (relays, fuses, transformers, motors etc.)  
4. Electrical wiring

**Part B:**  
Mini Project: Design and implementation of any real life application preferably based on syllabus of ETC405 (Application of Integrated Circuits). Each student should separately design PCB, solder and test the different circuit.

**Term Work:**  
Four hands on exercises from Part A should be set to have well predefined inference and conclusion. Few computation/simulation based experiments are encouraged.

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

**Term Work Evaluation:**  
50 Marks (Total marks) = 20 Marks (Part A: Experiment) + 20 Marks (Part B: mini project) + 10 Marks (Attendance)

Practical and Oral exam will be based on Part A and Part B.
Pre-requisites:
1. FEC104 Engineering Mechanics
2. MTC 303 Engineering Materials and Metallurgy

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

Outcomes: Learner should be able to ....
1. Perform tension test.
2. Perform hardness test
3. Perform torsion test
4. Perform impact test
5. Perform flexural test

Term Work:

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

Distribution of marks for Term work shall be as follows:

Laboratory work (experiments/assignments): 20 marks

Attendance (Theory and practical’s): 05 marks

Practical and Oral Examination:
Practical examination of 2 hours duration based on any one of the experiments mentioned in the list above.
Marks distribution: 25 Marks (Total marks) = 15 Marks (Practical) + 10 Marks (Oral)
CLASS: TE (Mechatronics)  Subject Code: MTC501  Semester: - V

SUBJECT: Manufacturing Processes  Credit - 4

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Pre-requisite:
1. FEL 101 Basic Workshop Practice - I
2. FEL 201 Basic Workshop Practice - II

Objectives:
1. To prepare the students understand basic manufacturing processes used in industries.
2. To make the students understand various hot and cold working processes and sheet metal forming methods and its applications.
3. To prepare the students understand various machine tools and basic machining processes as well as understand the fundamentals of metal cutting.
4. To familiarize the students with IC and PCB fabrication techniques.

Outcomes: Learner should be able to…
1. Distinguish between the conventional and modern machine tools as well as various methods of machining processes.
2. Illustrate unconventional machining processes and various applications.
3. Illustrate various Rapid prototyping techniques as well additive manufacturing practices such as 3D printing.
4. Illustrate various methods of electronics component fabrication.

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<tr>
<th>Modules</th>
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<th>Hrs.</th>
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<tbody>
<tr>
<td>01</td>
<td>1.1 Manufacturing: Definition, classification of manufacturing processes. 1.2 Casting: Introduction to casting, patterns, types, pattern materials, allowances. Molding types, molding sand, gating and risering, Cores &amp; Core making. Special Casting Process - Shell, Investment, Die casting, Centrifugal Casting. 1.3 Shaping Processes for Plastics: Extrusion, injection molding, blow molding, rotational molding, thermoforming, compression and transfer molding.</td>
<td>07</td>
</tr>
<tr>
<td>02</td>
<td>2.1 Hot and Cold Working - Rolling, Forging, Wire Drawing, Extrusion-types - Forward, backward and tube extrusion. 2.2 Sheet Metal Operations - Blanking- blank size calculation, drawing, draw ratio, drawing force, Piercing, Punching, Trimming, Stretch forming, Shearing, Bending- simple problems- Bending force calculation, Tube forming - Embossing and coining, Types of dies: Progressive, compound and combination dies.</td>
<td>08</td>
</tr>
<tr>
<td>03</td>
<td>3.1 Theory of Metal Cutting: Definition of machining, orthogonal and oblique cutting, mechanics of orthogonal cutting - Shear angle and its significance, types of chips- Simple problems on machining mechanics. Classification of cutting tools - single, multipoint. Tool Nomenclature, cutting tool materials, Tool wear and tool life, machinability, cutting fluids.</td>
<td>12</td>
</tr>
</tbody>
</table>

04

4.1 Welding: Arc welding, resistance welding, oxyfuel gas welding, forge welding, friction stir welding and ultrasonic welding.
4.2 Brazing: types of brazed joints, brazing methods.
4.3 Soldering and Adhesive Bonding: Joint designs in soldering, solders and fluxes, soldering methods. Adhesive joint designs, adhesive types, adhesive application technology, advantages and limitations.

05

5.1 Unconventional machining processes: classification according to type of energy used for machining, basic principles, machines and applications of, Electrical discharge machining (EDM), Electron beam machining (EBM), Plasma arc machining (PAM), Laser beam machining (LBM), Electrochemical machining (ECM), Chemical machining (CHM), Ultrasonic machining (USM).
5.2 Additive Manufacturing: Fundamentals of rapid prototyping, stereo lithography, laminated object manufacturing, fused deposition modeling, 3D printing, selective laser sintering.

06

6.1 Processing of Integrated Circuits: processing sequence, silicon processing, photolithography, layer processes used in IC fabrication, IC packaging.
6.2 Electronic assembly and packaging: PCB structure, types and materials. Processes used in PCB fabrication, PCB assembly.

07

Internal Assessment:
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination:
1. Question paper will comprise of total six questions.
2. Each question will be of 20 marks.
3. Question one will be compulsory and based on maximum part of syllabus.
4. Remaining questions will be mixed in nature (for example supposed Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
5. Only four question need to be solved.
In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.

References:
CLASS: TE (Mechatronics)  |  Subject Code: MTC502  |  Semester:-V

SUBJECT: Machine Design  |  Credit-4

| Periods per week: 1Period of 60 min. | Lecture | 4 |
| | Tutorial | -- |

| Evaluation System | Theory Examination | 3 | 80 |
| | Internal Assessment | | 20 |
| | TOTAL | | 100 |

Pre-requisite:
1. MTL306 Computer Aided Machine Drawing Laboratory
2. MTL309 Engineering Materials and Metallurgy Laboratory
3. MTC 404 Strength of Materials

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

Outcomes: Learner will able to…
1. Demonstrate understanding of various design considerations.
2. Apply basic principles of machine design
3. Design machine elements on the basis of strength and standardization.
4. Use design data books and various standard codes of practices.
5. Acquire skill in preparing production drawings of various components designed.

<table>
<thead>
<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Design Considerations</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>Joints:</td>
<td>09</td>
</tr>
<tr>
<td></td>
<td>Cotter Joint, Knuckle Joint, Turn Buckle, Bolted and welded joints for direct and eccentric loading.</td>
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</tr>
<tr>
<td>3</td>
<td>Springs;</td>
<td>07</td>
</tr>
<tr>
<td></td>
<td>Design of Helical Springs under static and variable axial loading, Design of Leaf Springs.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Shafts and Couplings:</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Design of shafts for power transmission under static and fatigue criteria, Types of keys and suitability on shafting conditions. Classification of Couplings, Design of split muff, flange, bushed pin type Couplings.</td>
<td></td>
</tr>
</tbody>
</table>
| 5 | **Bearings:**  
Design of Hydro dynamically lubricated bearings (Self Contained),  
Selection of rolling contact bearings based on various loading and speed conditions. Mechanical Seals (Types and Selection) | 08 |
| 6 | **Flywheels:**  
Crankshaft torque, Turning moment diagrams, fluctuation of Energy,  
Design of Flywheels for IC Engines and punching presses. | 06 |

**Internal Assessment:**
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

**Theory examinations:**
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

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

**Note:** Use of standard design data books like PSG Data Book, Design Data Book by Mahadevan & Reddy is permitted at the examination and shall be supplied by the college.

**References:**
5. Mechanical Engineering Design - J. E. Shigley - McGray Hill
6. Recommended Data Books - PSG, K. Mahadevan
7. Machine Design - Reshetov - Mir Publication
11. Design of Machine Elements - V.M. Faires
<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs.</th>
</tr>
</thead>
</table>
| **01** | Significance of Sensor Measurements, Classification of Sensors, Analog vs Digital Sensors  
**Static characteristics:** Static calibration, Linearity, Static Sensitivity, Accuracy, Static error, Precision, Reproducibility, Threshold, Resolution, Hysteresis, Drift, Span & Range etc.  
**Dynamic Characteristics:** Sensor bandwidth and frequency response  
**Signal conditioning:** Amplifier, Conversion, Filtering, Impedance Buffering  
**Types of errors:** Effect of component errors, Probable errors.  
Selection criteria of sensors for mechatronic systems | 10 |
| **02** | Displacement Measurement: Transducers for displacement, displacement measurement, potentiometer, LVDT, Capacitance Types, Digital Transducers (optical encoder),  
**Strain Measurement:** Theory of Strain Gauges, gauge factor, temperature Compensation, Wheatstone Bridge circuit, orientation of strain gauges for force and torque, Strain gauge based load cells and torque sensors  
**Measurement of Angular Velocity:** Tachometers, Digital tachometers and Stroboscopic Methods.  
**Acceleration Measurement:** theory of accelerometer and vibrometers, practical accelerometers, strain gauge based and piezoelectric accelerometers. | 08 |
| **03** | Pressure Measurement: Microphones, Elastic pressure transducers, bellows and piezoelectric pressure sensors, High Pressure Measurements, Bridge man gauge. Vacuum measurement,  
**Flow Measurement:** Bernoullis flowmeters, Ultrasonic Flowmeter, Magnetic flow meter, rotameter.  
**Temperature Measurement:** Electrical methods of temperature measurement, Resistance thermometers, Thermistors and thermocouples, Pyrometers, thermal cameras  
**Special Sensors:** Chemical Sensors, Hall Effect Sensors, Optical Light sensors, Tactile/Touch sensors, Cameras and image analysis | 08 |
Electrical Actuating systems


Induction motors: Three phase motor, induction motor characteristics

Linear Actuators: Voice Coil Actuators, solenoids

Pneumatic and Hydraulic actuating systems
Components of pneumatic and hydraulic systems, pumps, compressor, filter, control valves, pressure regulation, relief valves, accumulator.

Harmonic drive, Comb drive.

Smart Material Actuators: Piezoelectric transducers, Electroactive polymers, Shape Memory alloys, Artificial Muscle materials

Consideration during with actuator selection: Actuator bandwidth and frequency response, actuator range, power and energy considerations, tradeoffs between force/displacement or torque/speed, control systems and electronics, industrial considerations

Internal Assessment
Assessment consists of two tests out of which: one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

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

References:
1. Sensors and Actuators: Control System Instrumentation -Clarence W Silva, CRC Press USA
8. Optomechatronics: Fusion of Optical and Mechatronics Engineering By Hyungsuck Cho
### Pre-requisite:
1. MTC402 Kinematics of Machinery
2. MTC305 Applied Electrical and Electronics Engineering

### Objectives:
1. To study open loop and closed loop system
2. To study the time response of first and second order system
3. To study the concept of stability and criteria for stability and solve the problem based on it
4. To study the frequency response through polar plot.
5. To study the compensation technique used to stabilize the system

### Outcomes:
Learner will be able to..
1. Define the open loop and closed loop system
2. Design time response of first and second order system and basic state variable analysis.
3. Sketch the frequency response of second order systems using polar plot and bode plots.
4. Design a compensator to make a stabilize the unstable system.

### Module Detailed contents Hrs.
1.0 Introduction to Control System and components
   - **Introduction** to basic terms, classifications & types of Control Systems, Block diagrams & Signal flow graphs; Transfer function- determination of transfer function using block diagram reduction techniques. Determination of transfer functions of thermal, fluid, and mechanical spring-mass-damper system. Mason’s Rule, Signal-Flow Graphs of State Equations.  10
2.0 Time –Domain Analysis and Response
   - **Modeling in the Time Domain**: General State-Space Representation, Applying the State-Space Representation, Converting a Transfer Function to State Space, Converting from State Space to a Transfer Function.
3.0 Root Locus Method
<table>
<thead>
<tr>
<th>Frequency Response Analysis</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymptotic Approximations: Bode Plots, Polar Plots; Stability Analysis-Gain Margin and Phase Margin with Bode Plots, Closed-Loop Transient and Open-Loop Frequency Responses, Relation Between- Closed-Loop Transient and Closed-Loop Frequency Responses, Steady-State Error Characteristics from Frequency Response.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stability &amp; Compensation Techniques</th>
<th>09</th>
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</thead>
</table>

<table>
<thead>
<tr>
<th>Analog and Digital Control</th>
<th>06</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog and Digital Control:</td>
<td></td>
</tr>
<tr>
<td>Introduction to Digital control systems, comparison with analog control systems, Case study of analog control system design with practical approach- Temperature Control system.</td>
<td></td>
</tr>
</tbody>
</table>

Internal Assessment:
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

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

References:
**CLASS:** TE (Mechatronics)  
**Subject Code:** MTC505  
**Semester:** V

<table>
<thead>
<tr>
<th>SUBJECT: <strong>Embedded Systems</strong></th>
<th>Credit-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Periods per week: 1 Period of 60 min.</td>
<td>Lecture: 4</td>
</tr>
<tr>
<td></td>
<td>Tutorial: --</td>
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<tr>
<td></td>
<td>Hours</td>
</tr>
<tr>
<td>Evaluation System</td>
<td>Theory Examination: 3</td>
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<td></td>
<td>Internal Assessment:</td>
</tr>
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<td>TOTAL:</td>
</tr>
</tbody>
</table>

**Pre-requisite:**
1. MTC304: Digital Electronics
2. MTC305: Applied Electrical and Electronics Engineering
3. MTC405: Application of Integrated Circuits

**Objectives:**
1. To develop background knowledge and core expertise in area of embedded systems.
2. To teach applications of microcontrollers in embedded systems

**Outcomes:** Learner will be able to...
1. Describe architecture, interface peripherals and program 8051 microcontrollers.
2. Describe architecture, interface peripherals and program ARM7 microcontrollers
3. Illustrate the basic terminologies of software development and real time operating system.
4. Design microcontroller based embedded systems for various applications

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed contents</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>General Concepts</td>
<td>4</td>
</tr>
<tr>
<td>1.1 <strong>Basic Concepts:</strong> Microprocessor and Microcontroller, Von Neumman and Harward, Intel 8085 microprocessor architecture (only)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2 <strong>Introduction to Embedded systems:</strong> Design Metrics, Examples of embedded systems, hardware/software co-design, Embedded microcontroller cores (ARM, RISC, CISC, and SOC), Embedded memories, Architecture of Embedded Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>8051 Microcontroller</td>
<td>12</td>
</tr>
<tr>
<td>2.1 <strong>Architecture:</strong> Features, architecture and pin configurations, CPU timing and machine cycle, Input / Output ports, Memory organization, Counters and timers, Interrupts, Serial data input and output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2 <strong>8051 Assembly Language Programming:</strong> Instruction set, Addressing mode, Assembler directives and programs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3 <strong>8051 Interfacing:</strong> LED, LCD, seven segment display, keyboard, ADC, DAC, Stepper Motor, Relay and Serial Communication</td>
<td></td>
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</tr>
<tr>
<td>3.0</td>
<td>ARM7: A 32-bit Microcontroller</td>
<td>12</td>
</tr>
<tr>
<td>3.1 <strong>Architecture:</strong> Features of ARM Microcontroller, Operating modes, Architecture, Registers, CPSR, Pipeline, Exceptions, interrupt vector table, memory management, ARM7 processor families</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.2 <strong>ARM7 Programming:</strong> Instruction set, Addressing mode and programs</td>
<td></td>
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<tr>
<td>4.0</td>
<td>Embedded Software Development</td>
<td>08</td>
</tr>
<tr>
<td>4.1 Assemblers, linkers and loaders. Binary file formats for processor executable files. Typical structure of timer-interrupt driven programs. GNU-GCC compiler introduction, programming with Linux environment and gnu debugging, gnu insight with step level trace debugging, make file interaction, building and execution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.2 <strong>Embedded C-programming concepts:</strong> Optimizing for Speed/Memory needs, Interrupt service routines, macros, functions, modifiers, data types, device drivers</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 5.0 Real Time Operating System


5.2 Example of OSs for embedded systems - RT Linux.

### 6.0 Low power hardware design and applications of Embedded Systems

6.1 MSP 430: Features, architecture and programming

6.2 Case Studies:
- Consumer and Home
- Industrial and Automation
- Medical
- Robotics
- Security and communication
- Image processing

---

**Internal Assessment:**

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

**Theory Examination:**

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

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

**References:**

1. Microprocessor architecture and applications with 8085: By Ramesh Gaonkar (Penram International Publication).
CLASS: TE (Mechatronics)  Subject Code: MTC506  Semester: -V

SUBJECT: Operating System  Credit-2

<table>
<thead>
<tr>
<th>Periods per week: 1 Period of 60 min.</th>
<th>Lecture</th>
<th>2</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Tutorial</td>
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</tr>
<tr>
<td>Evaluation System</td>
<td>Theory Examination</td>
<td>2</td>
</tr>
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<td></td>
<td>Internal Assessment</td>
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<tr>
<td>TOTAL</td>
<td></td>
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</table>

Prerequisite:
1. Basic Computer Hardware Knowledge

Objective:
1. To provide an introduction to the internal operation of modern operating systems.
2. To Study processes and CPU scheduling, memory management, and file systems.

Outcomes: Learner will be able to..
1. Illustrate the role of OS
2. Differentiate between OSs and their features
3. Illustrate the memory, IO, process and file management

<table>
<thead>
<tr>
<th>Module</th>
<th>Topics</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Introduction to Operating System: Overview of operating systems, functionalities and characteristics of OS Hardware concepts related to OS, Difference between 32-bit and 64 –bit operating system. CPU states, I/O channels, microprogramming</td>
<td>2</td>
</tr>
<tr>
<td>4.0</td>
<td>File Management: File organization: blocking and buffering, file descriptor, directory structure. File and Directory structures, blocks and fragments, directory tree, inodes, file descriptors, UNIX file structure. Concept of I/O management</td>
<td>6</td>
</tr>
<tr>
<td>5.0</td>
<td>Real time operating systems: Introduction, Scheduling Real-time task, thread and Process, Introduction to mucos and Vxworks operating systems, features of operating systems, applications of operating systems, embedded system, VoIP, Fault tolerant Application and control systems, Comparison between mucos &amp; Vxworks</td>
<td>5</td>
</tr>
</tbody>
</table>
Internal Assessment:

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of the curriculum) and the other is either a class test (on minimum 70% of the curriculum) or assignment on live problems or course project.

Theory Examination:

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

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

References:
5. Rajkamal “ Embedded Systems” TMH Publication
6. Dr.K.V.K.K. Prasad “ Embedded Real time systems”
### SUBJECT: Business Communication & Ethics

<table>
<thead>
<tr>
<th>Module</th>
<th>Unit No.</th>
<th>Topics</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1.0</td>
<td>Report Writing</td>
<td>07</td>
</tr>
<tr>
<td></td>
<td>1.1</td>
<td>Objectives of report writing</td>
<td></td>
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<tr>
<td></td>
<td>1.2</td>
<td>Language and Style in a report</td>
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<tr>
<td></td>
<td>1.3</td>
<td>Types of reports</td>
<td></td>
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<td></td>
<td>1.4</td>
<td>Formats of reports: Memo, letter, project and survey based</td>
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<tr>
<td>2.0</td>
<td>2.0</td>
<td>Technical Proposals</td>
<td>02</td>
</tr>
<tr>
<td></td>
<td>2.1</td>
<td>Objective of technical proposals</td>
<td></td>
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<tr>
<td></td>
<td>2.2</td>
<td>Parts of proposal</td>
<td></td>
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<tr>
<td>3.0</td>
<td>3.0</td>
<td>Introduction to Interpersonal Skills</td>
<td>07</td>
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<tr>
<td></td>
<td>3.1</td>
<td>Emotional Intelligence</td>
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<td></td>
<td>3.2</td>
<td>Leadership</td>
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<td>3.3</td>
<td>Team Building</td>
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<td>3.4</td>
<td>Assertiveness</td>
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<td>3.5</td>
<td>Conflict Resolution</td>
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<td>3.6</td>
<td>Negotiation Skills</td>
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<td>3.7</td>
<td>Motivation</td>
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<td>3.8</td>
<td>Time Management</td>
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</tbody>
</table>

**Pre-requisite:**
1. FEC206 Communication Skill

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

**Outcomes:** A learner will be able to …..
1. Communicate effectively in both verbal and written form and demonstrate knowledge of professional and ethical responsibilities
2. Participate and succeed in Campus placements and competitive examinations like GATE, CET.
4. Have education necessary for understanding the impact of engineering solutions on Society and demonstrate awareness of contemporary issues.
### List of Assignments:

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

### Term Work:

Term work shall consist of all assignments from the list.

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

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

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

6. R.C Sharma and Krishna Mohan, "Business Correspondence and Report Writing"
10. Dr. K. Alex, "Soft Skills", S Chand and Company
11. Dr. K. Alex, "Soft Skills", S Chand and Company
CLASS: TE (Mechatronics)  Subject Code: MTL508  Semester:-V

SUBJECT: Machine Design Laboratory  Credit: 1

Practical to be conducted for batch of students  Practical  02 hours per week

Pre-requisite:
1. MTL306 Computer Aided Machine Drawing Laboratory
2. MTL309 Engineering Materials and Metallurgy Laboratory
3. MTC 404 Strength of Materials

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

Outcomes: Learner will able to…
1. Demonstrate understanding of various design considerations.
2. Apply basic principles of machine design
3. Design machine elements on the basis of strength and standardization.
4. Use design data books and various standard codes of practices.
5. Acquire skill in preparing production drawings of various components designed.

List of Design exercises:
Design exercises in the form of design calculations with sketches and or drawings on following machine system
1. Cotter joint / Knuckle joint / Turn buckle
2. Coil spring, leaf spring
3. Shafts
4. Couplings
5. Bearings
6. Flywheel

Term Work:
Term work shall consist of
A. Above 6 design exercises
B. Minimum 3 design exercises from the list which may include computer aided drawing on A3 size sheets
C. Stress analysis of any machine element mentioned in the syllabus using any application software and programming language

The distribution of marks for term work shall be as follows:
1. Part A : 10 marks
2. Part B : 10 marks
3. Part C : 05 marks

The final certification and acceptance of term work ensures the satisfactory performance of Design and drawing work and minimum passing in the term work.
CLASS: TE (Mechatronics)  
Subject Code: MTL509  
Semester:-V

SUBJECT: Sensors and Actuators Laboratory  
Credit: 1

Practical to be conducted for batch of students  
Practical  
Slot of 02 hours per week

Pre-requisite:
1. MTC305 Applied Electrical and Electronics Engineering
2. MTC406 Signals and Systems

Objectives:
1. Study of means of measuring various physical variables.
2. Study of different types of sensors and actuators.

Outcomes: Learner will be able to...
1. Illustrate how different physical variables are measured and illustrate their working principles
2. Identify and select proper sensors for specific applications
3. Illustrate issues of implementation of different sensors including calibration and error analysis
4. Demonstrate different types of actuators and their implementation

<table>
<thead>
<tr>
<th>Expt. No.</th>
<th>List of the Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Design of virtual instrumentation set up for measurement of any mechanical characteristics using any software platform</td>
</tr>
<tr>
<td>02</td>
<td>Design of virtual instrumentation set up for actuating mechanical system using any software platform</td>
</tr>
<tr>
<td>02</td>
<td>Experimental characterization of DC motor</td>
</tr>
<tr>
<td>03</td>
<td>Experimental characterization of any one of the sensor.</td>
</tr>
<tr>
<td>05</td>
<td>Study of smart material actuators</td>
</tr>
<tr>
<td>06</td>
<td>Dynamic characterization and error analysis of any one of the measurement system</td>
</tr>
<tr>
<td>07</td>
<td>Characterization of LVDT</td>
</tr>
<tr>
<td>08</td>
<td>Design based exercise for development of hydraulic/pneumatic circuit for an industrial application</td>
</tr>
<tr>
<td>09</td>
<td>Design based experiment aiming selection of actuator for industrial application.</td>
</tr>
</tbody>
</table>

Distribution of marks for Term work shall be as follows:

- Laboratory work (experiments) : 20 marks
- Attendance (practical’s) : 05 marks

Practical and Oral Examination:

Practical examination of 2 hours duration based on any one of the experiments mentioned in the list above. Oral exam will be on entire syllabus.

Marks distribution: 25 Marks = Practical examination (15 Marks) + Oral examination (10 Marks).
SUBJECT: Control Systems Laboratory
Credit: 1
Practical to be conducted for batch of students
Practical Slot of 02 hours per week

Pre-requisite:
1. MTC 504 Control Systems.

Objectives:
1. To study the time response of first and second order system
2. To study the error analysis of different control system
3. To study the compensation technique used to stabilize the system

Outcomes: Learner will be able to...
1. Define the open loop and closed loop system
2. Design time response of first and second order system.
3. Simulate the control system for getting different response analysis.
4. Design a compensator to make and stabilize the unstable system.

List of experiments:
1. Experiment on components of control system
2. Transient response of 1st order & 2nd order system
3. Frequency response of 1st order & 2nd order system
4. Steady state error analysis of different types of systems
5. D.C. servomotor and A. C. servomotor
6. Synchro Transmitter and receiver
7. Simulation of block diagram
8. Simulation of Time response analysis
9. Simulation of Frequency response analysis
10. Simulation for Stability analysis

Term Work:
Term work shall consist of 10 experiments mentioned above and should be set to have well predefined inference and conclusion. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.

Distribution of marks for Term work shall be as follows:
Laboratory work (experiments): 20 marks
Attendance (Practicals): 05 marks

Practical and Oral Examination:
Practical examination of 2 hours duration based on any one of the experiments mentioned in the list above. Oral exam will be on entire syllabus.

Marks distribution: 25 Marks = Practical examination (15 Marks) + Oral examination (10 Marks).
CLASS: TE (Mechatronics)  |  Subject Code: MTL511  |  Semester:-V

| SUBJECT: Embedded Systems Laboratory | Credit: 1 |

Practical to be conducted for batch of students | Practical | Slot of 02 hours per week

Pre-requisite:
1. MTC305 Applied Electrical and Electronics Engineering
2. MTC406 Signals and Systems
3. MTL407 Applied Electronics Laboratory-II
4. MTC405 Application of Integrated Circuits

Objectives:
1. To develop background knowledge and core expertise in area of embedded systems.
2. To teach applications of microcontrollers in embedded systems

Outcomes: Learner will be able to...
1. Describe architecture, interface peripherals and program 8051 microcontrollers.
2. Describe architecture, interface peripherals and program ARM7 microcontrollers
3. Explain the basic terminologies of software development and real time operating system.
4. Design microcontroller based embedded systems for various applications

List for Practical:
1. Experiment on programming of 8051
2. Two Experiments on interfacing of 8051
3. Experiment on programming of ARM
4. Two Experiments on interfacing of ARM
5. Experiment on MSP430
6. Experiment on interfacing of MSP430
7. Experiment on RTOS. Converting Existing Windows and LINUX as RTOS by configuring QNX Neutrino (using Virtual Machine)
8. Mini project

Term Work:
Term work shall consist of 8 experiments mentioned above and should be set to have well predefined inference and conclusion. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.

Distribution of marks for Term work shall be as follows:
- Laboratory work (experiments/assignments): 20 marks
- Attendance (Theory and practical’s): 05 marks

Oral Examination:
Oral exam will be based on the entire syllabus.
CLASS: TE (Mechatronics)  Subject Code: MTC601  Semester: VI

SUBJECT: CNC Technology  Credit: 4

Periods per week: 1 Period of 60 min.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Lecture</th>
<th>Tutorial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours</td>
<td>4</td>
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</tbody>
</table>

Evaluation System

<table>
<thead>
<tr>
<th>Evaluation System</th>
<th>Theory Examination</th>
<th>Hours</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory Examination</td>
<td>3</td>
<td></td>
<td>80</td>
</tr>
<tr>
<td>Internal Assessment</td>
<td>20</td>
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<tr>
<td>TOTAL</td>
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<td>100</td>
</tr>
</tbody>
</table>

Pre-requisite:
1. MTC402 Kinematics of Machinery
2. MTC502 Machine Design
3. MTC504 Control Systems
4. MTC503 Sensors and Actuators

Objectives:
1. To understand the importance of NC and CNC technology in manufacturing industry.
2. To understand the application of CAD/CAM systems in generating Part Programmes, in particular for complex models.
3. To understand and apply the use of various transducers, encoders and feedback devices.
4. Identify and select proper NC tooling’s.

Outcomes: Learner will be able to…
1. Understand the principles of Numerical Control (NC) technology and describe the range of machine tools to which it is applied.
2. Outline the various routes for part programming in NC and CNC.
3. Explain the application of CNC for Machining & Turning Centers.

<table>
<thead>
<tr>
<th>Module No.</th>
<th>Details</th>
<th>Hrs</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Numerical Control of Machines</td>
<td>06</td>
</tr>
<tr>
<td></td>
<td>1 Introduction-NC Machine, CNC Machines, DNC, Advantages and Disadvantages of CNC Machines, Applications of CNC</td>
<td></td>
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<tr>
<td></td>
<td>2 Components of Numerical Control System-Basic Components, Programme of Instructions</td>
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</tr>
<tr>
<td></td>
<td>3 Classification of Numerical Control Machines</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 Engineering Analysis of NC Positioning Systems</td>
<td></td>
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<tr>
<td>2</td>
<td>CNC Control System</td>
<td>07</td>
</tr>
<tr>
<td></td>
<td>CNC motion controller, Linear, circular, parabolic, cubic, helical interpolator, Positioning and contouring control loops, MCU</td>
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<tr>
<td></td>
<td>Output Transducers</td>
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<tr>
<td></td>
<td>Introduction, positional transducers, optical gratings, encoders, Inductosyns, Magne scales.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Tooling for CNC machines</td>
<td>08</td>
</tr>
<tr>
<td></td>
<td>Introduction, Cutting tools materials, types of cutting tools, tool selection, ISO specifications, clamping systems in tool holders. Latest CNC tool materials and manufacturing, Tool probing and presetting, Automatic Pallet Changer (APC) and Automatic Turret Changer (ATC), Study of various probes and special tools.</td>
<td></td>
</tr>
</tbody>
</table>


Internal Assessment:
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory examinations:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

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

References:
<table>
<thead>
<tr>
<th>Subject Code: MTC602</th>
<th>Semester:-VI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SUBJECT: Metrology and Quality Engineering</strong></td>
<td>Credit-4</td>
</tr>
</tbody>
</table>

**Pre-requisite:**
1. MTC501 Manufacturing Processes

**Objectives:**
1. To study the fundamentals of modern quality concepts and statistical techniques.
2. To study fundamentals of inspection methods and systems.
3. To acquaint with operation of precision measurement tools and equipment’s.

**Outcomes:** Learner will be able to…
1. Apply inspection gauge and checking systems.
2. Demonstrate the understanding of purpose of critical dimensions in manufacturing.
3. Analyze simple parts for dimensional accuracy and functionality.

<table>
<thead>
<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>1.1 Introduction to Metrology, Fundamental principles and definitions, measurement standards / primary and tertiary standards, distinction between precision and accuracy. 1.2 Limits, fits and tolerances, Tolerance grades, Types of fits, IS919, GO and NO GO gauges- Taylor’s principle, design of GO and NO GO gauges, filler gauges, plug gauges and snap gauges.</td>
<td>08</td>
</tr>
<tr>
<td>02</td>
<td>2.1 Comparators: Constructional features and operation of mechanical, optical, electrical/electronics and pneumatic comparators, advantages, limitations and field of applications. 2.2 Principles of interference, concept of flatness, flatness testing, optical flats, optical interferometer and laser interferometer. 2.3 Surface texture measurement: importance of surface conditions, roughness and waviness, surface roughness standards specifying surface roughness parameters- Ra, Ry, Rz, RMS value etc., surface roughness measuring instruments – Tomlinson and Taylor Hobson versions, surface roughness symbols.</td>
<td>10</td>
</tr>
<tr>
<td>03</td>
<td>3.1 Screw Thread measurement: Two wire and three wire methods, floating carriage micrometer. 3.2 Gear measurement: Gear tooth comparator, Master gears, measurement using rollers and Parkinson’s Tester. 3.3 Special measuring Equipments: Principles of measurement using Tool Maker’s microscope, profile projector &amp; 3D coordinate measuring machine.</td>
<td>10</td>
</tr>
<tr>
<td>04</td>
<td>Quality Control  Introduction, definition and concept of quality &amp; quality control, set up policy and objectives of quality control, quality of design and quality of conformance, compromise between quality &amp; cost, quality cost and planning for quality.</td>
<td>08</td>
</tr>
</tbody>
</table>
**SQC and SQC tools**
Importance statistical methods in QC, measurement of statistical control variables and attributes, pie charts, bar charts/ histograms, scatter diagrams, pareto chart, GANT charts, control charts, X chart, X bar charts, R charts, P charts, np charts their preparation, analysis and applications. Elementary treatment on modern SQC tools.

**Sampling Techniques**
Sampling inspection and basic concepts, OC curves, consumer & producer risk, single & double sampling plans and use of sampling tables.

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**Internal Assessment:**
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

**Theory Examination:**
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

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

**References:**
7. *Statistical Quality control*, R.C. Gupta
### Subject: Dynamics of Machinery

<table>
<thead>
<tr>
<th>Periods per week: 1 Period of 60 min.</th>
<th>Lecture</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Evaluation System</td>
<td>Theory Examination</td>
<td>3</td>
</tr>
<tr>
<td>2. Evaluation System</td>
<td>Internal Assessment</td>
<td>2</td>
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</tbody>
</table>

<table>
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<tr>
<th>Hours</th>
<th>Marks</th>
<th>TOTAL</th>
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<tr>
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<td>100</td>
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</tbody>
</table>

**Pre-requisite:**
1. MTC402 Kinematics of Machinery
2. MTC502 Machine Design

**Objectives:**
1. To acquaint with working principles and applications of governors and gyroscope
2. To understand basic principles of vibrations.
3. To study the vibration control and measurement techniques.
4. To study balancing of mechanical systems

**Outcomes:** Learner will be able to...
1. Demonstrate working mechanism of different governors and analyze gyroscopic effects.
2. Develop mathematical model to represent dynamic system, estimate natural frequency
3. Able to identify vibration control technique and know the working principles of vibration measurement instruments.
4. Remove unbalance in various mechanical systems.

<table>
<thead>
<tr>
<th>Modules</th>
<th>Details</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Controlling Mechanisms – Gyroscope: Gyroscope: Introduction - Gyroscopic couple and its effect on spinning bodies, Gyroscopic effect on naval ships during steering, pitching and rolling, Ship stabilization with gyroscopic effect. Effect of gyroscopic and centrifugal couples, maximum permissible speeds on curve paths, Gyroscopic effect due to lateral misalignment of rigid disc mounted on shaft.</td>
<td>06</td>
</tr>
<tr>
<td>3</td>
<td>Basic Concepts of Vibration Vibration and oscillation, causes and effects of vibrations, Vibration parameters – spring, mass, damper, Damper models, Motion – periodic, non periodic, harmonic, non harmonic, Degree of freedom, static equilibrium position, Vibration classification, Steps involved in vibration analysis. Modeling of Single Degree of Freedom Dynamic System Longitudinal, transverse, torsional vibration system, Methods for formulation of differential equations by Newton, Energy, Lagrangian and Rayleigh’s Method.</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>Free Un-damped and damped Single Degree of Freedom Vibration System Free vibration of undamped translation and torsional systems. Free vibration of viscous damped system – under damped, critically damped, over damped; Logarithmic decrement; Coulomb’s damping;</td>
<td>10</td>
</tr>
</tbody>
</table>
Combined viscous and coulomb’s damping.

**Forced Single Degree of Freedom Vibratory System**
Analysis of linear and torsional systems subjected to harmonic force excitation and harmonic motion excitation (excluding elastic damper).

5

**Vibration Measurement and Control:**

**Vibration Control:**
Force Transmissibility, Motion Transmissibility. Vibration isolation with rigid, flexible, and partially flexible foundation, shock isolation, Typical isolators and Mounts. Undamped dynamic vibration absorber, Damped dynamic vibration absorber, active vibration control.

**Vibration Measurement:**
Vibration pickups: Principle of seismic instruments, vibrometer, accelerometer, phase distortion, filters. Sensor characteristics, transducer response to transient inputs, accelerometer cross-axis sensitivity, calibration, environmental factors, Basic processes and operating principle of a digital frequency analyser.

6

**Introduction to Conditioning Monitoring and Fault Diagnosis:**
Vibration severity criteria, Machine maintenance techniques, machine conditioning monitoring techniques, vibration monitoring techniques, instrumentation systems, choice of monitoring parameter.

**Balancing:**
Static and dynamic balancing of rotating masses, balancing of single and multi-cylinder engines, balancing of linkages, balancing machines, balancing of discs and rotors.

**Internal Assessment:**
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

**Theory examinations:**
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

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

**References:**
1. Theory of Machines - Thomas Bevan - C. B. S. Publishers
6. Theory of Machines - W. G. Green – Bluckie & Sons Ltd.
7. Mechanics & Dynamics of Machinery - J. Srinivas, Scitech
9. Mechanical Vibrations by S. S. Rao
Pre-requisite:
1. EXC305: Applied Electrical and Electronics Engineering

Objectives:
1. To teach power semiconductor switches and power converters.
2. To teach different controlling methods for industrial drives.

Outcomes: Learner will be able to...
1. Discuss tradeoffs involved in power semiconductor switches
2. Analyze different types of power converters.
3. Analyze issues involved in controlling of AC and DC drives.
4. Realize drive considerations for different industrial applications.

Module | Topics | Hrs
--- | --- | ---
1.0 | **Power Semiconductor Switches**
1.1 SCR: Principle of operation, static and dynamic characteristics, gate characteristics, turn-on and turn-off methods, protection.
1.2 Principle of operation and characteristics of: TRIAC, power BJT, power MOSFET, IGBT. | 10

2.0 | **AC-DC Converters**
2.2 Switched-mode rectifiers: Principle of operation. | 08

3.0 | 3.1 DC-DC converters: Basic principle of step up and step down choppers. Buck, Boost, Buck-Boost, Cuk regulators.
3.2 Inverters (DC-AC): Single phase half / full bridge voltage source inverters with R load, Voltage control of single phase inverters using PWM techniques. | 08

4.0 | 4.1 AC voltage Controllers: Single phase AC voltage controller – on – off control and phase control.
4.2 Cycloconverters: principle of operation of single phase step-up and step-down cycloconverters. | 06

5.0 | 5.1 DC Drive Operation: Introduction to Four quadrant operation – Motoring, Plugging, Dynamic and Regenerative Braking.
5.2 Control of DC Drive by phase controlled converter: Speed control of DC drives, Single phase, semi/ full converter drive for separately excited dc motor.
5.3 Control of DC Drive by Chopper regulators: Single quadrant, Two – quadrant and four quadrant chopper fed dc separately excited motors, Continuous current operation, Output voltage and current wave forms, Speed torque expressions, speed torque characteristics. | 10
6.0 AC Drives
Induction Motor Characteristics, Current Source Inverter fed Induction motor drive, Speed control methods: Stator voltage, Variable frequency, Rotor resistance, V/F control, PWM Control, Closed-loop control.

Total 52

Internal Assessment:
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory examinations:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

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

References:
7. P.S. Bimbhra, Power Electronics, Khanna Publications.
## SUBJECT: Instrumentation and Control

### Subject Code: MTC605

<table>
<thead>
<tr>
<th>Periods per week: 1 Period of 60 min.</th>
<th>Lecture</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutorial</td>
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</table>

### Evaluation System

<table>
<thead>
<tr>
<th>Evaluation System</th>
<th>Theory Examination</th>
<th>3</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Internal Assessment</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
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<td>100</td>
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</table>

### Pre-requisite:
1. MTC504 Control Systems
2. MTC503 Sensors and Actuators

### Objectives:
1. To teach fundamental Process controller and its design
2. To educate students the criteria for selection of suitable transmitters (Sensor/Actuators)
3. To help students in enhancing their knowledge about different controllers

### Outcomes:
Learner will be able to...
1. Select proper transmitter for different parameters
2. Use suitable actuators for different situations
3. Design controller for different processes and applications
4. Write the ladder diagram programs for in industrial application.

### Module Topics

<table>
<thead>
<tr>
<th>Module</th>
<th>Topics</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td><strong>Fundamentals of process and control</strong></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Elements of process control loop, Concept of Process variables, set point, controlled variable, manipulated variable, load variable. Representation of Process loop components using standard symbols (basics with reference to control loop), and Examples of process loops like temperature, flow, level, pressure etc. Current to pneumatic converter &amp; Pressure to Current converter.</td>
<td>08</td>
</tr>
<tr>
<td>2.0</td>
<td><strong>Transmitters:</strong></td>
<td>08</td>
</tr>
<tr>
<td>2.1</td>
<td>Need of transmitter (concept of field area &amp; control room area), Need for standardization of signals, Current, voltage, and pneumatic signal standards, Concept of live &amp; dead zero</td>
<td></td>
</tr>
<tr>
<td>2.2</td>
<td>Types of transmitters: Two and four wire transmitters, Electronic and Pneumatic transmitters Electronic Differential Pressure Transmitter</td>
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<tr>
<td>3.0</td>
<td><strong>Actuators</strong></td>
<td>10</td>
</tr>
<tr>
<td>3.1</td>
<td>Control valve : Necessity, comparison with other final control elements, Control valve Characteristics (Inherent &amp; Installed) Control valve terminology: Range ability, Turndown, valve capacity, viscosity index, AO, AC (Fail Safe Action) etc. Classification of control valve based on: valve body, Construction, type of actuation, application etc. Construction, Advantages, Disadvantages &amp; applications of Globe: Single, double, 3way, angle, Gate, Needle, Diaphragm, Rotary valves, Ball, Butterfly.</td>
<td></td>
</tr>
<tr>
<td>3.2</td>
<td>Types of actuators: Construction, Advantages, Disadvantages &amp; applications: Spring Diaphragm &amp; Smart actuators. Control valve accessories: Positioners:</td>
<td></td>
</tr>
</tbody>
</table>
Applications/Need, Types, Effect on performance of Control valves. Volume boosters, Pressure boosters, Reversing relay, Solenoid valves, Air lock, Position indicating switches, Electro pneumatic converter, Hand wheel, Motors.

### 4.0 Controller

**4.1 Discontinuous:** ON/OFF, Multi-position Control, Floating Control.

**4.2 Continuous:** Proportional (offset), Integral (Reset windup), Derivative, Proportional- Integral, Proportional- Derivative, Proportional- Integral-derivative, Anti-reset windup, Rate before Reset, Concept of Bump less transfers in PID controller, Effect of process characteristics on PID combination, Selection & application of controller actions.

### 5.0 Tuning of controller:

**5.1 Different Criteria:** Quarter Amplitude Decay Ratio, Loop disturbance, Optimum Control, Measure of Quality, Stability Criteria Tuning Methods: Process Reaction Curve (open loop), Ziegler Nichols (closed loop),& Frequency Response Method.

**5.2 Digital PID controllers:** Velocity & Position algorithm, Block Schematic, Faceplate of Digital controller, Direct Digital Control. Continuous versus Discrete Process Control, Relay based ladder diagram using standard symbols, Limitations of relay based system.

### 6.0 Programmable Logic Controller (PLC)

**6.1 Architecture of PLC, Types of Input & Output modules (AI, DI, DO, AO), Wiring diagram,**

**6.2 PLC Basic instructions, Timers & Counters, PLC ladder diagram, PLC programming for process applications,**

**6.3 Interfacing pneumatic & Hydraulic systems to PLC, Fixed & Modular PLC (Rack, slot, grouping), PLC specifications, PLC manufacturers,**

Internal Assessment:
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

**Theory examinations:**
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

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

References:
1. Process control and Instrument technology, C.D.Johnson, TMH
2. Instrumentation for Process measurement and control , N.A. Anderson, CRC Press
4. Programmable Logic Controller, Webb, PHI Reference Books
5. Tuning of Industrial control systems, ISA
6. Control valve Handbook, ISA
9. Programmable Logic Controller, NIIT
10. Fundamentals of Process Control Theory, Paul Murrill, ISA
### SUBJECT: APPLIED HYDRAULICS AND PNEUMATICS

**Credit:** 4

<table>
<thead>
<tr>
<th>Periods per week: 1 Period of 60 min.</th>
<th>Lecture</th>
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<tr>
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<td>3</td>
</tr>
<tr>
<td></td>
<td>Internal Assessment</td>
<td>20</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>

**Pre-requisite:**
1. MTC503 Sensors and Actuators

**Objectives:**
1. To study fundamentals of fluid power system.
2. To study pneumatics & hydraulic system and its components.
3. To study PLC system and its applications.

**Outcomes:** Learner will be able to...
1. Design the pneumatic and electro-pneumatic system.
2. Design hydraulic and electro-hydraulic system.
3. Design PLC for various applications.

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Fluid Power Systems and Fundamentals</strong>&lt;br&gt;Introduction to fluid power, Advantages of fluid power, Application of fluid power system. Types of fluid power systems, Properties of hydraulic fluids, General types of fluids, Fluid power symbols. Basics of Hydraulics, Applications of Pascals Law, Laminar and Turbulent flow, Reynold’s number, Darcy’s equation, Losses in pipe, valves and fittings.</td>
<td>06</td>
</tr>
<tr>
<td>3</td>
<td><strong>Design of Hydraulic Circuits</strong>&lt;br&gt;Construction of Control Components : Directional control valves, Shuttle valve, check valve, pressure control valve, pressure reducing valve, counter balance valve, unloading valves, sequence valve, Flow control valve – Fixed and adjustable, Accumulators and Intensifiers: Types of accumulators – Accumulators circuits, intensifier – Applications of Intensifier – Intensifier circuit, regenerative circuit, Meter in and meter out circuit, sequence circuit.</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td><strong>Pneumatic Systems and Components</strong>&lt;br&gt;Pneumatic Components: Properties of air, Compressors, Filter, Regulator, Lubricator Unit, classification of pneumatic actuators, Air control valves, Quick exhaust valves, directional control valves, non-return valves, logic valves, time delay valves, pressure sequence valve,</td>
<td>08</td>
</tr>
<tr>
<td>5</td>
<td><strong>Design of Pneumatic Circuits</strong>&lt;br&gt;Pneumatic logic circuits for various applications. Displacement step diagram, Speed control circuits, hydro-pneumatic circuit, sequential circuit design for various applications using cascade and shift register method.</td>
<td>10</td>
</tr>
</tbody>
</table>
## Development of circuits for industrial automation
Electro-pneumatic systems, electrical control solenoid valves, Relays, Dominant OFF and Dominant ON circuit, Electro-hydraulic system, hydro-pneumatic system, Programmable Logic Controller (PLC) in automation: Basic structure, I/O processing, Ladder logic diagram, PLC for industrial process control, Selection of PLC.

### Internal Assessment:
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

### Theory examinations:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus.
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3).
4. Four total questions need to be solved.

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

### References:
4. Industrial Hydraulics: Pippenger
5. Vickers Manual on Hydraulics
8. Pneumatic Controls by Joji P, Wiley India Pvt.Ltd
9. Pneumatic Circuits and Low Cos by Fawcett J.R.
10. Fundamentals of pneumatics: Festo series
11. Fundamentals of hydraulics: Festo series
12. Mechatronics, A. Smaili, F. Mrad, OXFORD Higher Education.
Pre-requisite:
1. MTC501 Manufacturing Processes
2. MTC503 Sensors and Actuators

Objective:
1. To give a job oriented training on the CNC Lathe and CNC Milling Machine.
2. To study programming and machining on CNC Lathe and CNC Milling.
3. To study select/apply/implement tooling, machine setting, work holding techniques etc. along with basic maintenance

Outcomes: Learner will be able to ...
1. Illustrate the importance of NC and CNC technology in manufacturing industry.
2. Generate Part Programming with application of CAD/CAM systems in particular for complex models.
3. Identify and select proper NC toolings.

<table>
<thead>
<tr>
<th>Modules</th>
<th>Details</th>
<th>Hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Study and operation of CNC Lathe</td>
<td>01</td>
</tr>
<tr>
<td>2</td>
<td>Study and operation of CNC Milling Center</td>
<td>01</td>
</tr>
<tr>
<td>3</td>
<td>Manufacturing Simulation using Software like Master CAM</td>
<td>02</td>
</tr>
<tr>
<td>4</td>
<td>Part programming and operation of CNC Lathe for facing, turning and threading operations</td>
<td>05</td>
</tr>
<tr>
<td>5</td>
<td>Part programming and operation of CNC Milling Center</td>
<td>05</td>
</tr>
</tbody>
</table>

Term work:
Distribution of marks for Term work shall be as follows:
- Laboratory work (experiments): 20 marks
- Attendance (Practicals): 05 marks

Practical and Oral Examination:
Practical examination of 3 hours duration based on part programming and operation on any one of the CNC centre.

Marks distribution: 25 Marks = Practical examination (20 Marks) + Oral examination (05 Marks).
Practical and Oral examination is to be conducted by pair of internal and external examiners
References:

Pre-requisite:  
1. MTC501 Manufacturing Processes

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

Outcomes: Learner will be able to…  
1. Apply inspection gauge and checking systems.  
2. Demonstrate the understanding of purpose of critical dimensions in manufacturing.  
3. Analyse simple parts for dimensional accuracy and functionality.

List of Experiments:  
1. Use of comparators.  
2. Thread measurement.  
3. Gear measurement.  
4. Use of Profile projectors.  
5. Use of linear and angular measuring instruments.  

Term Work:  
Term work shall consist of 7 experiments from the list and presented with inferences and one assignment on each module

The distribution of marks for term work shall be as follows:  
1. Laboratory work (Experiments) : 10 marks  
2. Assignments : 10 marks  
3. Attendance (Practicals): 05 marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.
CLASS: TE (Mechatronics)  
Subject Code: MTL609  
Semester:-VI

SUBJECT: Instrumentation and Control Laboratory  
Credit: 1

Practical to be conducted for batch of students  
Practical  
Slot of 02 hours per week

Pre-requisite:
1. MTC504 Control Systems
2. MTC503 Sensors and Actuators

Objectives:
1. To study the basic of instrumentation
2. To study control strategies

Outcomes: Learner will be able to...
1. Demonstrate basic integrated circuits
2. Use PID controller
3. Implement PLC programming for process
4. Develop automation circuits for industrial applications

List of Practical’s:
1) Demonstration of I(Current)/P(Pressure) and P(Pressure)/I(Pressure) converter using integrated Circuits
2) P, PI, PD and PID Controller its performance and tuning
3) PLC programming( Ladder diagram, Instruction list and Functional Block Diagram )
4) Electro-pneumatic controller (Counters, switches and Cylinders)
5) Electro- hydraulic controller
6) Simulation case studies based on the syllabus

Term Work:
Term work shall consist of 6 experiments from the list and presented with inferences and one assignment on each module.
The distribution of marks for term work shall be as follows:

1. Laboratory work (Experiments) : 10 marks
2. Assignments (Practicals): 10 marks
3. Attendance 05 marks

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

Practical and Oral Examination:
Practical examination of 2 hours duration based on experiments mentioned in the list.
Marks distribution: 25 Marks = Practical examination (15 Marks) + Oral examination (10 Marks).
Practical and Oral examination is to be conducted by pair of internal and external examiners
CLASS: TE (Mechatronics)  Subject Code: MTL610  Semester:-VI

SUBJECT: APPLIED HYDRAULICS AND PNEUMATICS LABORATORY  Credit: 1

Practical to be conducted for batch of students  Practical  Slot of 02 hours per week

Pre-requisite:
1. MTC503 Sensors and Actuators

Objectives:
1. To study fundamentals of fluid power system.
2. To study pneumatics & hydraulic system and its components.
3. To study PLC system and its applications.

Outcomes: Learner will be able to...
1. Design the pneumatic and electro-pneumatic system.
2. Design hydraulic and electro-hydraulic system.
3. Demonstrate use of PLC for various industrial applications.

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Design and implementation of pneumatics and electro-pneumatic circuits using hardware and software</td>
<td>04</td>
</tr>
<tr>
<td>2</td>
<td>Design and implementation of hydraulics and electro-hydraulics circuits using hardware and software</td>
<td>04</td>
</tr>
<tr>
<td>3</td>
<td>Characteristics of reciprocating pumps, gear pump etc.</td>
<td>02</td>
</tr>
<tr>
<td>4</td>
<td>Case studies on PLC for industrial automation</td>
<td>04</td>
</tr>
</tbody>
</table>

(Usage of simulation software, fluidsim, Automation studio etc shall be encouraged to design and simulate experiments based on hydraulics, pneumatics, electro pneumatics, electro hydraulics and PLC).

Term Work:
Term work shall consist of performance of above mentioned experiments from the list and 2 numerical / case studies on each Module.
The distribution of marks for term work shall be as follows:
- Laboratory work (Experiments) : 10 marks
- Assignments / Case studies : 10 marks
- Attendance : 05 marks
The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Practical and Oral examination:
Practical and Oral (based on term work) examination is to be conducted by pair of internal and external examiners. Practical examination of 2 hours duration based on performance based experiments mentioned from the list of experiments.
Marks distribution: 25 Marks = Practical examination (15 Marks) + Oral examination (10 Marks).
### Subject Code: MTC701

#### Subject: CAD/CAM/CAE

<table>
<thead>
<tr>
<th>Periods per week: 1 Period of 60 min.</th>
<th>Lecture</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutorial</td>
<td>--</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Evaluation System</th>
<th>Theory Examination</th>
<th>3</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Internal Assessment</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Pre-requisites:
1. MTC502: Machine Design
2. MTL306: Computer Aided Machine Drawing Laboratory

#### Objectives:
1. To introduce new and exciting field of Intelligent CAD/CAM/CAE with particular focus on engineering product design and manufacturing.
2. To develop a holistic view of initial competency in engineering design by modern computational methods.

#### Outcome:
1. Identify proper computer graphics techniques for geometric modelling.
2. Transform, manipulate objects and store and manage data.
3. Prepare part programming applicable to CNC machines.
4. Use rapid prototyping and tooling concepts in any real life applications.
5. Identify the tools for Analysis of a complex engineering component.

#### Modules

<table>
<thead>
<tr>
<th>Modules</th>
<th>Details</th>
<th>Hrs.</th>
</tr>
</thead>
</table>
| 01 | **Computer Graphics and Techniques for Geometric Modeling**  
Computer Graphics: Two dimensional computer graphics, vector generation, the windowing transformation, Three dimensional Computer graphics, viewing transformation, Homogeneous coordinates, Perspective projection, Hidden line removal & hidden surface removal algorithm, light & shade ray tracing. The parametric representation of geometry, Bezier curves, Cubic Spline curve, B-Spline curve, parametric representation of line, circle, ellipse & parabola. Constructive solid geometry (CSG), Boundary Representation (B-Rep), Wire Frame Modeling, Solid Modeling, Surface Modeling, Parametric Modeling, feature based modeling, Feature recognition, Design by feature. | 08 |
| 02 | **Transformation, Manipulation & Data Storage**  
2D & 3D Transformations (Translation, Rotation, & Scaling & Magnification), Concatenations, Matrix representation, Problems & object oriented programming on Transformations. Object transformation, mirror transformation, Artificial Intelligence in Design & Manufacturing, Representation of Knowledge, and Knowledge base Engineering. | 08 |
| 03 | **NC & CNC Technology**  
programming with interactive graphics. Constructional details of CNC machines, Feedback devices- Velocity & displacement, Machining Centers and its types, Automated Material Handling & storage Systems like Robots, AGVs and AS/RS etc.

<table>
<thead>
<tr>
<th>Course</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>04</strong> Computer Aided Engineering (CAE)</td>
<td>Fundamentals of computer aided engineering, CAE includes mass property calculations, kinematic analysis and animation (movement, visualization, simulation and FEA). Case study based on modeling and analysis of structural, thermal/fluid, and dynamic (vibration analysis) system. Parameter optimization.</td>
</tr>
<tr>
<td><strong>05</strong> Computer Integrated Manufacturing &amp; Technology Driven Practices</td>
<td>Introduction, Evolution, Objectives, CIM Hardware and Software, CIM Benefits, Nature and role of the elements of CIM, Identifying CIM needs, Data base requirements of CIM, Role of CAD/CAM in CIM, Obstacles to Computer Integrated Manufacturing, Concept of the future CIM systems, Socio - techno- economic aspects of CIM.</td>
</tr>
</tbody>
</table>

**Internal Assessment:**
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems.

**Theory Examination:**
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.
References:
4. “CAD/CAM Principles, Practice and Manufacturing Management” by Chris McMahon, Jimmie Browne, Pearson Education
5. “CAD/CAM/CIM” by P. Radhakrishnan, S. Subramanyan, V. Raju, New Age International Publishers
8. David L. Goetsch, Fundamental of CIM technology, Delmar publication
18. “Rapid Prototyping” Chee Kai Chua World Scientific Publishing
CLASS: BE (Mechatronics)  |  Subject Code: MTC702  |  Semester: VII

SUBJECT: **Manufacturing Planning and Control**  |  Credit: 4

<table>
<thead>
<tr>
<th>Periods per week: 1 Period of 60 min.</th>
<th>Lecture</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutorial</td>
<td>--</td>
<td></td>
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</tbody>
</table>

<table>
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<tr>
<th>Evaluation System</th>
<th>Theory Examination</th>
<th>3</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal Assessment</td>
<td>--</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>--</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

**Pre-requisites:**
1. MTC501: Manufacturing Processes
2. MTC601: CNC Technology

**Objectives:**
1. To provide the students with a comprehensive exposure to Manufacturing Planning & Control (MPC) and its significance in Industries.
2. To acquaint the students with various activities of MPC.
3. To provide an insight into the ongoing & futuristic trends in the control of inventory.
4. To appraise the students with the need and benefits of planning functions related to products and processes.
5. To give the students an exposure to concepts of production scheduling and sequencing.

**Outcomes:** The learner will be able to...
1. Illustrate manufacturing planning functions and manage manufacturing functions in an organization in an optimum manner.
2. Develop competency in scheduling and sequencing in manufacturing operations and effect affordable manufacturing lead time.
3. Manage and control inventory with cost effectiveness.
4. Get conversant with various documents procedural aspects and preparation of orders for various manufacturing methods.

<table>
<thead>
<tr>
<th>Modules</th>
<th>Details</th>
<th>Hrs.</th>
</tr>
</thead>
</table>
| 01 | **Manufacturing Planning and control System:**
1.1 Manufacturing transformation process, Manufacturing as competitive advantage. Manufacturing system components and types. Types of products. 
MPC system overview objectives and functions such as planning routing, scheduling, dispatching and follow up.
1.2 Forecasting:
Need for forecasting, Types of forecast. Extrapolative methods- Moving average method, Exponential smoothing method, Forecast errors, Linear trend model. Causal methods- Simple regression analysis. | 09 |
| 02 | **Planning Function:** Capacity planning and aggregate planning.
Master production schedule, Shop floor Control. | 07 |
| 03 | **Inventory Control:**
3.1 Basic concepts of inventory, purpose of holding stock and influence of demand on inventory.
3.2 Ordering procedures, Two Bin system, ordering cycle, economical order quantity and economical lot size, ABC analysis and reorder procedures.
3.3 Recent trends- computer integrated PP systems, JIT system and MRP-I, MRP-II and ERP (only theory). | 09 |
04 Scheduling & Sequencing:
4.1 Inputs for scheduling, loading and scheduling devices, factors influencing scheduling, scheduling techniques, use of Gantt Charts and basic scheduling problems.
4.2 Product sequencing, dispatching: progress report & expectation of manufacturing lead time technique for aligning completion time & due dates.
4.3 Project management: concepts of project planning, monitoring and control, elements of network analysis – PERT & CPM, cost analysis & crashing.

05 Advanced concepts in production planning I:
Mathematical programming approaches - Linear programming problem, Formulation, Simplex method for maximization and minimization, concept of duality.

06 Advanced concepts in production planning II:
Assignment model, Transportation model.

Simulation:
Need for simulation, Monte Carlo technique.

Internal Assessment:
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination:
1. Question paper will comprise of total six questions, each of 20 Marks
2. Only 04 questions need to be solved.
3. Question 01 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
5. Emphasize on numerical problem to reflect the concept learnt in the module 5 and 6.

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

References:
5. Operation Research by Wayne Winston, Cengage Learning
6. Operation Research by Shah, Ravi, Hardik Soni, PHI Learning
7. Operation Research by Panneerselvam, PHI Learning
8. Production Operation Research by Adam Ebert, PHI Learning
11. Industrial and Production management by Martand Telsang, S.Chand
13. Operation Research by J K Sharma, Macmillan
14. Production Planning and Inventory Control by S.L.Narasimhan and other. Prentice Hall
CLASS: BE (Mechatronics)  
Subject Code: MTC703  
Semester: VII

SUBJECT: Communication Systems  
Credit: 4

Periods per week: 1  
Lecture: 4  
Tutorial: --  

Evaluation System
| Theory Examination | 3 | 80 |
| Internal Assessment | 20 |
| TOTAL | 100 |

Pre-requisite:
1. MTC305: Applied Electrical and Electronics Engineering  
2. MTC406: Signals and Systems

Objectives:
1. To teach fundamental principles of basic communication systems.  
2. To teach the various characteristics of different types of antennas.  
3. To teach the cellular concepts.

Outcomes: Learner will be able to...
1. Compare and contrast the significance and limitations of analog and digital communication systems.  
2. Demonstrate the knowledge of antennas in communication systems  
3. Demonstrate a clear understanding of fundamentals of wireless and mobile communication systems and standards.

<table>
<thead>
<tr>
<th>Module No.</th>
<th>Topics</th>
<th>Hrs.</th>
</tr>
</thead>
</table>
| 1.0 | Basics of Communication System  
1.1 Block diagram, electromagnetic spectrum, signal bandwidth and power, types of communication channels  
1.2 Types of noise, signal to noise ratio, noise figure, and noise temperature | 06 |
| 2.0 | Analog Communication  
2.1 Amplitude Modulation: Basic concept, signal representation, need for modulation, Spectrum, waveforms, modulation index, bandwidth, voltage distribution, and power calculation.  
2.2 DSBFC: Principles, modulating circuits, low level and high level transmitters  
DSB suppressed carrier: Multiplier modulator, nonlinear modulator, and switching modulator  
2.3 Amplitude demodulation: Diode detector, practical diode detector, and square law detector. | 10 |
| 3.0 | 3.1 Frequency modulation (FM): Basic concept, mathematical analysis, frequency spectrum of FM wave, sensitivity, phase deviation and modulation index, frequency deviation and percent modulated waves, bandwidth requirement of angle modulated waves, deviation ratio, narrow Band FM, and Wide Band FM.  
3.2 Transmitter: Direct FM transmitter, indirect FM Transmitter, noise triangle in FM, pre-emphasis and de-emphasis.  
3.3 Phase modulation (PM): Principle and working of Transistor direct PM modulator and relationship and comparison between FM and PM. | 10 |
3.4 **FM demodulation:** Balance slope detector, Foster-Seely discriminator, ratio detector, Phase lock loop (PLL) FM demodulator, amplitude limiting and thresholding, comparison between FM demodulators, comparison between AM, FM and PM.

**4.0 Digital Communication**

4.1 Introduction to digital communication system, significance of AWGN channel, pulse dispersion in the channel.
4.2 Digital Modulation formats, coherent and non-coherent reception.
4.3 **Binary Modulation Techniques:** BPSK, BFSK and BASK.
4.4 **M-ary Modulation techniques:** QPSK, M-ary PSK, MSK, M-ary FSK, M-ary QAM, Differential encoded BPSK & D-QPSK.

**5.0 Antennas and Wave Propagation**

5.1 **Antenna Parameters:** Radiation intensity, directive gain, directivity, power gain, beam width, band width, gain and radiation resistance of current element.
5.2 **Half-wave dipole and folded dipole:** Reciprocity principle, effective length and effective area, radiation from small loop and its radiation resistance, Helical antenna.
5.3 **Types of wave propagation:** Ground, space, and surface wave propagation, tilt and surface waves, impact of imperfect earth and earth’s behavior at different frequencies.

**6.0 Wireless Networks and Mobile Communication Systems**

6.1 Description of cellular system, Frequency Reuse, Co-channel and Adjacent channel interference, Propagation Models for Wireless Networks, Multipath Effects in Mobile Communication, Models for Multipath Reception.

**Internal Assessment:**

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

**Theory Examination:**

1. Question paper will comprise of total six questions, each of 20 Marks
2. Only 04 questions need to be solved.
3. Question 01 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
5. Emphasize on numerical problem to reflect the concept learnt in the module 5 and 6.

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

**References:**

2. Taub Schilling and Saha, “*Principles Of Communication Systems*”, Tata Mc-Graw Hill,
3. Third Ed.
CLASS: BE (Mechatronics)  Subject Code: MTC704  Semester: VII

SUBJECT: Automotive Electronics  Credit: 4

Periods per week: 1 Period of 60 min.  
<table>
<thead>
<tr>
<th>Lecture</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutorial</td>
<td>--</td>
</tr>
</tbody>
</table>

Evaluation System  
| Theory Examination | 3 | 80 |
| Internal Assessment | -- | 20 |
| TOTAL | -- | 100 |

Prerequisite:  
1. FEC102  Applied Physics  
2. FEC105  Basic Electricity and Electronics  
3. MTC305  Applied Electrical and Electronics Engineering

Objective:  
1. To study working principles of sensors and actuators used in automobiles  
2. To study working of microcontroller based systems used in automobile  
3. To study working of electric vehicle and electronic transmission

Outcomes: Learner will be able to ..  
1. Identify and select sensors and actuators for specific task in automobile  
2. Design microcontroller based system for automobile functions  
3. Synthesize digital engine control system  
4. Analyse electric vehicles

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed content</th>
<th>Hrs.</th>
</tr>
</thead>
</table>
| 1      | Fundamentals of Automotive Electronics  
1.1 Current trends in modern automobiles  
1.2 Open and closed loop control strategies, PID control, look up tables,  
1.3 Introduction to modern control strategies like fuzzy logic and adaptive control.  
1.4 Parameters to be controlled in SI and CI engines. | 10 |
| 2      | Sensors and Actuators  
2.1 Hall Effect, hot wire, thermistor, piezoelectric and piezoresistive based sensors.  
2.2 Introduction, basic sensor arrangement, types of sensors, oxygen concentration sensor, lambda sensor, crankshaft angular position sensor, cam position sensor  
2.3 Mass air flow (MAF) rate, Manifold absolute pressure (MAP), Throttle plate angular position, engine oil pressure sensor, vehicle speed sensor, stepper motors, relays, detonation sensor, emission sensors | 10 |
| 3      | Microcontroller Based Systems  
3.1 Ideal ADC and DAC converters, quantization noise, performance limitations, different methods of ADC and DAC  
3.2 Microprocessors, microcontrollers, types of memory, memory interface, interrupts, input/output interfacing  
3.3 Engine control module, powertrain control module, hardware and software components, interfacing with sensors, system integration | 10 |
4 Digital Engine Control System
   4.1 Open loop and close loop control system
   4.2 Engine cooling and warm up control, idle speed control, acceleration and full load enrichment, deceleration fuel cutoff.
   4.3 Fuel control maps, open loop control of fuel injection and closed loop lambda control exhaust emission control, on-board diagnostics, diagnostics
   4.4 Future automotive electronic systems, electronic dash board instruments – Onboard diagnosis system

5 Electric Vehicles
   5.1 Layout of an electric vehicle, traction motor characteristics, tractive effort
   5.2 Transmission requirements, vehicle performance, energy consumption, advantage and limitations, specifications, system components, electronic control system

6 Transmission Electronics
   Multiplexing and De-multiplexing electronically controlled automatic transmission system

Total 52

Internal Assessment:
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination:
1. Question paper will comprise of total six questions, each of 20 Marks
2. Only 04 questions need to be solved.
3. Question 01 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
5. Emphasize on numerical problem to reflect the concept learnt in the module 5 and 6.

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

References:
<table>
<thead>
<tr>
<th>Subject Code: MTL706</th>
<th>Semester: VII</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SUBJECT: CAD / CAM / CAE Laboratory</strong></td>
<td>Credit: 1</td>
</tr>
</tbody>
</table>

Practical to be conducted for
batch of students

| Practical | Slot of 02 hours per week |

### Pre-requisites:
1. MTL607: CNC Technology Laboratory
2. MTL306: Computer Aided Machine Drawing Laboratory
3. MTC502: Machine Design

### Objectives:
1. To introduce new and exciting field of Intelligent CAD/CAM/CAE with particular focus on engineering product design and manufacturing.
2. To develop a holistic view of initial competency in engineering design by modern computational methods.

### Outcome:
A learner will be able to:
1. Identify proper computer graphics techniques for geometric modelling.
2. Transform, manipulate objects and store and manage data.
3. Prepare part programming applicable to CNC machines.
4. Use rapid prototyping and tooling concepts in any real life applications.
5. Identify the tools for Analysis of a complex engineering component.

### List of Exercises:
1. Programming for transformations,
2. Solid modeling using any 3D modeling software
3. Part programming and part fabrication on CNC trainer (Turning / Milling)
5. Development of physical 3D mechanical structure using any one of the rapid prototyping processes.
6. Rapid tooling for any one of the engineering or medical applications.

### Term Work:

Term work shall consist of all exercises from the above list and a course project in a group of not more than three (3) students on either computer aided engineering or rapid prototyping and tooling.

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

1. Exercises : 15 Marks
2. Course Project : 05 Marks
3. Attendance (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.
**Practical / Oral Examination:**

Practical examination of 2 hours duration based on any one of the following.

1) Programming for Algorithms, transformations.
2) Part designing and fabrication on 3D printer.
3) 3D modeling on software.
4) Analysis of component for optimization

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

- Practical Examination: 15 marks
- Oral: 10 Marks

1. Evaluation of practical/oral examination to be done based on the performance of design task.
2. Students work along with evaluation report to be preserved till the next examination.
Practical to be conducted for batch of students

Pre-requisite:
1. MTC305: Applied Electrical and Electronics Engineering
2. MTC406: Signals and Systems

Objectives:
1. To teach fundamental principles of basic communication systems.
2. To teach the various characteristics of different types of antennas.
3. To teach the cellular concepts.

Outcomes: Learner will be able to..
1. Compare and contrast the significance and limitations of analog and digital communication systems.
2. Demonstrate the knowledge of antennas in communication systems
3. Demonstrate a clear understanding of fundamentals of wireless and mobile communication systems and standards.

List of Experiments:
1. Experiment on amplitude modulation
2. Experiment on amplitude demodulation
3. Experiment on frequency modulation
4. Experiment on FM demodulation
5. Experiment on digital communication
6. Experiment on digital communication
7. Experiment on antennas
8. Experiment on antennas
9. Experiment on wireless networks
10. Experiment on mobile communication

Term Work:
Term work shall consist of all exercises from the above list.

The distribution of marks for term work shall be as follows:
1. Exercises : 20 Marks
2. Attendance (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.

Practical / Oral Examination:
Practical exam will be based on the performance of one of the experiments mentioned in the list.
The distribution of marks for oral-practical examination shall be as follows: Practical Examination ...... 15
oral marks

Oral ...... 10 Marks

1. Evaluation of practical/oral examination to be done based on the performance of design task.
2. Students work along with evaluation report to be preserved till the next examination.
SUBJECT: Digital Signal Processing

<table>
<thead>
<tr>
<th>Periods per week: 1 Period of 60 min.</th>
<th>Lecture</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tutorial</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Evaluation System</th>
<th>Hours</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory Examination</td>
<td>3</td>
<td>80</td>
</tr>
<tr>
<td>Internal Assessment</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Pre-requisite:
1. MTC406: Signals and Systems

Objectives:
1. To introduce transform domain analysis of LSI systems, discrete Fourier transform and its computation
2. To teach design of FIR and IIR digital filters
3. To teach finite-word length effect, architecture of DSP processor and cover some applications of DSP

Outcomes: Learner will be able to ...
1. Analyze LSI systems in z-transform domain.
2. Apply algorithms for efficient computation of DFT in solving numerical problems.
3. Design FIR and IIR digital filters based on given specifications.
5. Explain basic architecture of DSP processors & some of the applications of DSP.
6. Demonstrate spoken, written and presentation skills in the subject of DSP.

<table>
<thead>
<tr>
<th>Module</th>
<th>Topics</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Transform Analysis of Linear Shift Invariant (LSI) System</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>1.1 Review of z-transform and its properties, response to sinusoidal and complex exponential signals, steady-state response to periodic input signals, response to aperiodic input signals, relationships between the system function and the frequency response function, computation of the frequency response function.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.2 LSI systems as frequency-selective filters like; low pass, high pass, band pass, notch, comb, all-Pass filters, and digital resonators.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.3 Invertibility of LSI systems, minimum-phase, maximum-phase, mixed-phase systems.</td>
<td></td>
</tr>
<tr>
<td>2.0</td>
<td>The Discrete Fourier Transform and Efficient Computation.</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>2.1 Frequency domain sampling and reconstruction of discrete time signals, discrete Fourier transform (DFT), DFT as a linear transformation, properties of the DFT, relationship of the DFT to other transforms.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.2 Fast Fourier Transform: Radix-2 and split-radix fast Fourier transform (FFT) algorithms and their applications</td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>Design of Digital filters and Implementation</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>3.1 Design of Infinite Impulse Response (IIR) filters using impulse invariant method and bilinear transformation method, Butterworth and Chebyshev filter approximation.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.2 Concepts of Finite Impulse Response (FIR) filter, symmetric and anti-symmetric FIR filter, FIR filter design using window method and frequency sampling method.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.3 Realization structures for IIR and FIR filters using direct form structures, cascade, parallel structures, and lattice, ladder structure (only conceptual understanding)</td>
<td></td>
</tr>
</tbody>
</table>
4.0 Analysis of Finite Word length effects:
Representation of Numbers in Digital System - Fixed and Floating point Numbers, Finite word length effects, Errors due to quantization, rounding and truncation, Limit cycle oscillation.

5.0 Introduction to Digital Signal Processors
5.1 Introduction to TMS320C54 Processor architecture
5.2 Features of digital signal processor, Central processing unit, MAC Unit, CSSU, Memory, Addressing modes, Pipelining.

6.0 Applications of Digital Signal processing:
6.1 Dual –Tone multi frequency signal detection, spectral analysis of sinusoidal signals, spectral analysis of non-stationary signals, and spectral analysis of random signals.
6.2 Application to Digital Communications: Pulse Code Modulation, Time-Division Multiplexing, Spread Spectrum & Orthogonal Frequency-Division Multiplexing.

Internal Assessment:
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination:
1. Question paper will comprise of total six questions, each of 20 Marks
2. Only 04 questions need to be solved.
3. Question 01 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

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

References:
Pre-requisite:
1. MTC406: Signals and Systems

Objectives:
1. To simulate & analyze basic signals & systems for enhanced understanding of concepts studied during theory class for MTE7051 subject.
2. To implement basic algorithms for signal processing on a DSP processor based kit.

Outcomes: Learner will be able to...
1. Demonstrate programming skills for enhanced understanding of digital signal processing concepts (e.g., convolution, correlation, DFT, FIR & IIR filters, etc.) by analyzing digital signals & systems in time & frequency domain.
2. Demonstrate application of DSP theory in practice by implementing a few real-time signal processing algorithms, such as filtering for noise reduction, generation of PWM signal, etc.

Teacher can conduct any ten experiments based on the syllabus of MTE7051 (Digital Signal Processing). At least two experiments should be conducted on the DSP processors.

Suggested list of experiments:
1. Generation of various basic digital signals and analyzing them in time & frequency domain.
2. Understanding concept of convolution by passing sum of sinusoidal through a digital low-pass filter.
5. Concept of minimum phase system.
6. Concept of frequency resolution & zero-padding.
7. Analyzing various types of windows with respect to transition width & stop band attenuation.
8. Design of basic FIR filter based on windowing.
9. Design of basic FIR filter based on frequency domain sampling method.
10. Design of basic IIR filter.
11. Implementing linear filter using circular convolution.
15. Computation of DFT using DSP processor.
17. Real-time filtering of speech signal using DSP processor.

Term Work:
The distribution of marks for term work shall be as follows:
1. Exercises : 20 Marks
2. Attendance (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.

Practical / Oral Examination:
Practical exam will be based on the performance of one of the experiments mentioned in the list.
The distribution of marks for oral-practical examination shall be as follows:

<table>
<thead>
<tr>
<th>Practical Examination</th>
<th>15 marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral</td>
<td>10 Marks</td>
</tr>
</tbody>
</table>

1. Evaluation of practical/oral examination to be done based on the performance of design task.
2. Students work along with evaluation report to be preserved till the next examination.
### Subject: Neural Network and Fuzzy Logic

#### Pre-requisites:
1. FEC101: Applied Mathematics-I
2. FEC201: Applied Mathematics-II
3. FEC205: Structured Programming Approach

#### Objectives:
1. To conceptualize the working of human brain using Artificial Neural Network.
2. To become familiar with neural networks that can learn from available examples and generalize to form appropriate rules for inference systems.
3. To introduce the ideas of fuzzy sets, fuzzy logic and use of heuristics based on human experience.

#### Outcomes:
Learner will be able to ...
1. Analyze and appreciate the applications which can use Neural Network and fuzzy logic.
2. Identify and describe NNFL techniques and their roles in building intelligent machines.
3. Design inference systems for decision making in manufacturing industries.
4. Realize the difference between learning and programming and explore practical applications of Neural networks (NN).
5. Demonstrate the use of Neuro-fuzzy network for various industry applications.

#### Module Detailed Contents Hours
1. **Introduction:** Soft computing techniques.
   - 1.1 **Basics of Neural Networks:** Introduction to Neural Networks, Biological Neural Networks, McCulloch Pitt model.
   - 1.2 **Supervised Learning algorithms:** Perceptron (Single Layer, Multi layer), Linear separability, Delta learning rule, Back Propagation algorithm.
   - 1.3 **Un-Supervised Learning algorithms:** Hebbian Learning, Winner take all, Self-Organizing Maps, Learning Vector Quantization.
   10
2. **Fuzzy Logic: Introduction to fuzzy logic:**
   - 2.1 **Classical Sets (Crisp sets):** Crisp Sets and Fuzzy Sets, Operations on crisp sets, Properties of crisp sets.
   - 2.2 **Fuzzy Sets:** Membership functions, Basic Fuzzy set operations, Properties of Fuzzy sets.
   08
3. **Fuzzy Relations:**
   - 3.1 **Crisp Relations:** Cartesian product, operations on Relations.
   - 3.2 **Fuzzy Relations:** Fuzzy Cartesian product, Operations on Fuzzy Relations.
   07
4. **Fuzzy System:**
   - **Fuzzy Logic and application:** Fuzzy qualifiers, Fuzzy inference, Fuzzy Inference System(FIS), Types of FIS, Fuzzification, defuzzification methods, design of fuzzy controllers.
   08
5  Hybrid system: Introduction to genetic algorithm
   5.1 Integration of Neural networks, Fuzzy logic and genetic algorithms: Introduction to Adaptive Neuro Fuzzy Inference System (ANFIS) and its application for electromechanical industries.
   5.2 Fuzzy back propagation (Fuzzy BP) Network: Fuzzy Neuron, Fuzzy BP Architecture, Learning in Fuzzy BP.

6  Case Studies using Neural network and Fuzzy Logic:
   Expert System design for sensor and actuator selection, Fuzzy Controller design for Metro Train, Washing Machine, Refrigerator, Air Conditioners., Applications of fuzzy logic in pattern recognition and Image processing for electromechanical industries, Model for computing Automobile Fuel Efficiency, Model for color recipes prediction.

Internal Assessment:
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination:
1. Question paper will comprise of total six questions, each of 20 Marks
2. Only 04 questions need to be solved.
3. Question 01 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

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

References:
1. Timothy J. Ross "Fuzzy Logic With Engineering Applications" Wiley.
Subject: Neural Network and Fuzzy Logic Laboratory

Pre-requisites:
1. FEC101: Applied Mathematics-I
2. FEC201: Applied Mathematics-II
3. FEC205: Structured Programming Approach

Objectives:
1. To conceptualize the working of human brain using Artificial Neural Network.
2. To become familiar with neural networks that can learn from available examples and
generalize to form appropriate rules for inference systems.
3. To introduce the ideas of fuzzy sets, fuzzy logic and use of heuristics based on human
experience.

Outcomes: Learner will be able to…
1. To analyze and appreciate the applications which can use Neural Network and fuzzy logic.
2. To identify and describe NNFL techniques and their roles in building intelligent machines.
3. To design inference systems for decision making in manufacturing industries.
4. To realize the difference between learning and programming and explore practical applications
   of Neural networks (NN).
5. To demonstrate the use of Neuro-fuzzy network for various industry applications.

List of Experiments:
All the programs should be implemented in C/C++/Java/MATLAB under Windows or Linux or
Ubuntu environment. Experiments can also be conducted using available open source tools like
OCTAVE and SCILAB.
1. One case study on Fuzzy/Neural/GA based papers published in IEEE/ACM/ Springer or any
   prominent journal.
2. To implement activation function and problems on linear separability
3. To implement Fuzzy sets and Relations.
4. To implement Fuzzy Controllers. (Application to be designed for electromechanical industry)
5. To implement Basic Neural Network learning rules.
6. To implement any Supervised Learning algorithm.
7. To implement any Unsupervised Learning algorithm.
8. To implement a simple application using ANFIS. (Eg. Color recipes prediction, Automobile
   Fuel Efficiency Prediction)

Any other practical’s covering the syllabus topics and subtopics can be conducted.

Term Work:
Term work shall consist of all exercises from the above list.

The distribution of marks for term work shall be as follows:
1. Exercises : 20 Marks
2. Attendance (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.

Practical / Oral Examination:
Practical exam will be based on the performance of one of the experiments mentioned in the list.
The distribution of marks for oral-practical examination shall be as
follows: Practical Examination …… 15 marks
Oral …… 10 Marks
1. Evaluation of practical/oral examination to be done based on the performance
   of design task.
2. Students work along with evaluation report to be preserved till the next examination.
### Class: BE (Mechatronics)

<table>
<thead>
<tr>
<th>Subject Code: MTE7053</th>
<th>Semester: VII</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Subject:</strong> Micro-Electro Mechanical Systems</td>
<td>Credit: 4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Periods per week: 1 Period of 60 min.</th>
<th>Lecture</th>
<th>4</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Tutorial</td>
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</table>

<table>
<thead>
<tr>
<th>Evaluation System</th>
<th>Theory Examination</th>
<th>3</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Internal Assessment</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td>100</td>
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</tbody>
</table>

#### Pre-requisites:
1. MTC303: Engineering Materials and Metallurgy
2. MTC501: Manufacturing Processes

#### Objectives:
1. To gain an understanding of MEMS and its applications
2. To know the understanding of the fundamental principles behind the operation of MEMS
3. To understand the unique fabrication processes used in development of MEMS
4. To understand the technique used for characterization of MEMS.

#### Outcome:
Learner will be able to...
1. Design fabrication process plan for development of MEMS
2. Identify characterization and assembly techniques for developed MEMS.
3. Develop physics based model of MEMS.

#### Modules

<table>
<thead>
<tr>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>01</strong> Introduction to MEMS &amp; Applications</td>
</tr>
<tr>
<td>• Introduction to Micro-Electro-Mechanical Systems,</td>
</tr>
<tr>
<td>• Applications and materials for MEMS,</td>
</tr>
<tr>
<td>• Advantages &amp; disadvantages of micro-sensors, and micro-actuators.</td>
</tr>
<tr>
<td><strong>02</strong> Sensors and Actuators in Micro-domain</td>
</tr>
<tr>
<td>• Concept of sensors &amp; actuators,</td>
</tr>
<tr>
<td>• Sensing &amp; Actuation principles: Mechanical Sensing, Capacitive, Electrostatic, Electromagnetic, Piezo Resistive, Piezo Electric, Thin Films, Shape Memory Alloys</td>
</tr>
<tr>
<td>• Comb Drive Actuation &amp; Sensing. Micro-mechanisms, Air-Bag Sensors, Chemical Sensors</td>
</tr>
<tr>
<td>• Sensors &amp; Actuators for Automotive, Biomedical, Industrial applications</td>
</tr>
<tr>
<td><strong>03</strong> Fabrication Methods</td>
</tr>
<tr>
<td>Microfabrication Methods (VLSI Techniques)</td>
</tr>
<tr>
<td>• Positive and Negative Photoresists,</td>
</tr>
<tr>
<td>• Bulk Micromachining,</td>
</tr>
<tr>
<td>• Surface Micromachining,</td>
</tr>
<tr>
<td>• Etching (Isotropic and Anisotropic),</td>
</tr>
<tr>
<td>• Deposition techniques such as CVD (Chemical Vapor Deposition), Metallization Techniques.</td>
</tr>
<tr>
<td>3D High Aspect Ratio Techniques</td>
</tr>
<tr>
<td>• LIGA,</td>
</tr>
<tr>
<td>• Microstereolithography,</td>
</tr>
<tr>
<td>• IIB-Process,</td>
</tr>
<tr>
<td>• Ion-beam Lithography</td>
</tr>
<tr>
<td>Bulk Lithography (layer-less 3D microfabrication)</td>
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<table>
<thead>
<tr>
<th>Hrs.</th>
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<tbody>
<tr>
<td>6</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>12</td>
</tr>
</tbody>
</table>
### Modelling and Simulation Techniques
- Scaling Laws, Governing Equations
- Modelling of Mechanical Structures via classical methods, Newtons Laws, Thermal Laws, Fluid Flow Analysis
- Micro-mechanism modelling and analysis techniques : Lumped Parameter Modelling and Distributed Parameter Modeling
- Modelling of Micro-channel as heat exchanger, accelerometers
- Numerical Methods used for analysis of MEMS.

### Characterization Techniques
#### Topography Methods (Optical, Electrical and Mechanical Methods)
- Microscopy, STM (Scanning Tunneling Microscopes),
- SEM (Scanning Electron Microscopes), AFM (Atomic Force Microscopes)

#### Mechanical Structure Analysis
- Deformation & Vibration Measurement Techniques (Piezo resistive and piezo electric)

#### Interferometry Techniques
- ESPI (Electronic Speckle Pattern Interferometry),
- Laser Techniques, Laser Doppler Vibro-meters,

#### Fluid, Thermal and Chemical Techniques
- Fluid Flow Pattern Analysis, Electro-chemical Analysis,
- PIV Techniques
- Spectroscopy

### Introduction to Nanotechnology
- CNT (Carbon Nano Tubes) Applications, its properties, and Fabrication Method,
- Nano-mechanical Systems (NEMS),
- Nano-tribology, & nano-indentation techniques,
- Domestic and Industrial Applications of nanotechnology.

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**Internal Assessment:**
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

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

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

**References:**
CLASS: BE (Mechatronics)  Subject Code:MTEL7053  Semester:-VII
SUBJECT: Micro-Electro Mechanical Systems Laboratory  Credit-1

Practical to be conducted for batch of students  Practical  Slot of 02 hours per week

Pre-requisites:
1. MTC303: Engineering Materials and Metallurgy
2. MTC501: Manufacturing Processes

Objectives:
1. To know the overview of essentials for MEMS laboratory
2. To provide insight of fabrication and characterization techniques for MEMS

Outcome: Learner will be able to…
1. Design the process plan for fabrication of microstructure for MEMS
2. Identify the characterization technique for the MEMS

<table>
<thead>
<tr>
<th>Expt. No.</th>
<th>Aim of the Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Study of essentials infrastructure, manufacturing, and characterization facility for MEMS laboratory</td>
</tr>
<tr>
<td>02</td>
<td>Study of Wafer characterization, Wafer cleaning &amp; Thermal oxidation and Wafer stress measurements</td>
</tr>
<tr>
<td>03</td>
<td>Study of LPCVD Nitride deposition, LPCVD Polysilicon deposition, and Doping.</td>
</tr>
<tr>
<td>04</td>
<td>Study of thin-film metal deposition techniques.</td>
</tr>
<tr>
<td>05</td>
<td>Study of photolithography for fabrication of high aspect ratio polymer microstructures</td>
</tr>
<tr>
<td>06</td>
<td>Study of photolithography for fabrication of 3D ceramic and metal microstructures</td>
</tr>
<tr>
<td>07</td>
<td>Study of Reactive Ion Etching technique</td>
</tr>
<tr>
<td>08</td>
<td>Experiment on fabrication and characterization of polymer microlens array type structure</td>
</tr>
<tr>
<td>09</td>
<td>Experiment on fabrication and characterization of polymer microcantilever sensor</td>
</tr>
<tr>
<td>10</td>
<td>Experiment on fabrication and characterization of polymer-carbon black microcantilever sensor</td>
</tr>
<tr>
<td>11</td>
<td>Experiment on analysis of stiction effect in high aspect ratio arrayed microstructures.</td>
</tr>
</tbody>
</table>

Term Work:
Term work shall consist of all exercises from the above list.

The distribution of marks for term work shall be as follows:
1. Exercises : 20 Marks
2. Attendance (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.

Practical / Oral Examination:
Practical examination of 2 hours duration based on any one of the performance (fabrication) based experiments mentioned in the list above. The distribution of marks for oral-practical examination shall be as follows:

- Practical Examination …… 15 marks
- Oral …… 10 Marks

1. Evaluation of practical/oral examination to be done based on the performance of design task.
2. Students work along with evaluation report to be preserved till the next examination.

University of Mumbai, Mechatronics Engineering (Second, Third and Final Year) New Course (N-2015)
SUBJECT: Optimization

Periods per week: 1 Period of 60 min.

<table>
<thead>
<tr>
<th>Lecture</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutorial</td>
<td>--</td>
</tr>
</tbody>
</table>

Evaluation System

| Theory Examination | 3 | 80 |
| Internal Assessment | 20 |
| TOTAL | 100 |

Pre-requisites:
1. MTC301: Applied Mathematics-III
2. MTC401: Applied Mathematics-IV

Objectives:
1. To familiarize the students with the use of practice oriented mathematical applications for optimization functions in an organization.
2. To familiarize the students with various tools of optimization, probability, statistics and simulation, as applicable in particular scenarios in industry for better management of various resources.

Outcomes: Learner will be able to…..
1. Illustrate the need to optimally utilize the resources in various types of industries.
2. Apply and analyze mathematical optimization functions to various applications.
3. Demonstrate cost effective strategies in various applications in industry.

<table>
<thead>
<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td><strong>Linear Programming:</strong> Linear Programming Problem Formulation, Graphical solution, Simplex method, Twophase method, Big-M method, Principle of Duality, Dual Simplex, Sensitivity Analysis.</td>
<td>12</td>
</tr>
<tr>
<td>02</td>
<td><strong>Transportation problem:</strong> Formulation - Optimal solution, Degeneracy. <strong>Assignment problem:</strong> Formulation - Optimal solution, Traveling Salesman problem. <strong>Sequencing:</strong> Introduction - Flow Shop sequencing - n jobs through two machines - n jobs through three machines - Job shop sequencing - two jobs through ‘m’ machines.</td>
<td>08</td>
</tr>
<tr>
<td>03</td>
<td><strong>Replacement:</strong> Introduction - Replacement of items that deteriorate with time - when money value is not counted and counted - Replacement of items that fail completely, group replacement. <strong>Queuing Models:</strong> Introduction -Single Channel - Poisson arrivals - Exponential service times - with infinite population and finite population models, Multichannel - Poisson arrivals - Exponential service times with infinite population single channel Poisson arrivals.</td>
<td>08</td>
</tr>
<tr>
<td>04</td>
<td><strong>Game Theory:</strong> Introduction - Minimax (Maximin) -Criterion and optimal strategy - Solution of games with saddle points – Rectangular games without saddle points - 2 X 2 games - dominance principle - m X2 &amp; 2 X n games, graphical method.</td>
<td>08</td>
</tr>
<tr>
<td>05</td>
<td><strong>Inventory Models</strong>: Introduction - Single item - Deterministic models - Purchase inventory models with one price break and multiple price breaks - shortages are not allowed - Stochastic models - demand may be discrete variable or continuous variable - Instantaneous production - Instantaneous demand and continuous demand and no set up cost.</td>
<td></td>
</tr>
</tbody>
</table>
**Simulation**: Definition - Types of simulation models - phases of simulation - applications of simulation - Inventory and Queuing problems - Advantages and Disadvantages - Simulation Languages. |
| | **08** |

**Internal Assessment:**
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

**Theory Examination:**
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

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

**References:**
8. *Introduction to O.R*, Hiller & Libermann (TMH)
Pre-requisites:
1. MTC301: Applied Mathematics-III
2. MTC401: Applied Mathematics-IV

Objectives:
1. To familiarize the students with the use of practice oriented mathematical applications for optimization functions in an organization.
2. To familiarize the students with various tools of optimization, probability, statistics and simulation, as applicable in particular scenarios in industry for better management of various resources.

Outcomes: Learner will be able to…..
1. Illustrate the need to optimally utilize the resources in various types of industries.
2. Apply and analyze mathematical optimization functions to various applications.
3. Demonstrate cost effective strategies in various applications in industry.

Term Work
Term work shall consist of;
1. Assignments: On topics drawn from syllabus of subject MTE7054 “Optimization” [At least 1 assignment per module].
2. Based on topics from syllabus, minimum 06 problems are to be solved and presented with inferences.
3. Exposure to problem solving using MS Office Excel and software packages such as
4. TORA, WinQSB and LINDO is recommended.

The distribution of marks for term work shall be as follows;
- Laboratory work (problem solving: manual/programs and journal): 10 marks
- Assignments: 10 marks
- Attendance (Theory and Practical): 05 marks

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

Practical/oral Examination:
Practical examination of 2 hours duration based on any one of the problem solving technique on software platform. Oral examination will be based on entire syllabus.
CLASS: BE (Mechatronics)  Subject Code: MTE7055  Semester: VII
SUBJECT: Finite Element Analysis  Credit: 4

<table>
<thead>
<tr>
<th>Periods per week: 1 Period of 60 min.</th>
<th>Lecture</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tutorial</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>Hours</td>
<td>Marks</td>
</tr>
<tr>
<td>Evaluation System</td>
<td>Theory Examination</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Internal Assessment</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>TOTAL</td>
<td>100</td>
</tr>
</tbody>
</table>

Prerequisites:
1. MTC301: Applied Mathematics-III
2. MTC401: Applied Mathematics-IV

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

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

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td><strong>Introduction</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.1 Introductory Concepts: Introduction to FEM, Historical Background, General FEM procedure. Applications of FEM in various fields. Advantages and disadvantages of FEM.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.2 Mathematical Modeling of field problems in Engineering, Governing Equations, Differential Equations in different fields.</td>
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<tr>
<td></td>
<td>1.3 Approximate solution of differential equations-- Weighted residual techniques, Least squares, Galerkin methods, Boundary Value problems.</td>
<td></td>
</tr>
<tr>
<td>02</td>
<td><strong>FEA Procedure</strong></td>
<td>08</td>
</tr>
<tr>
<td></td>
<td>2.1 Discrete and continuous models, Weighted Residual Methods – Ritz Technique – Basic concepts of the Finite Element Method.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>03</td>
<td><strong>One-Dimensional Problems</strong></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>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)</td>
<td></td>
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<tr>
<td></td>
<td>3.3 Analysis of Plane Trusses, Analysis of Beams.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.4 Solution of one Dimensional structural and thermal problems using FE Software, Selection of suitable Element Type, Modeling, Meshing, Boundary Condition, Convergence of solution, Result analysis, Case studies.</td>
<td></td>
</tr>
</tbody>
</table>

University of Mumbai, Mechatronics Engineering (Second, Third and Final Year) New Course (N-2015)
**Two Dimensional Finite Element Formulations**

4.1 Introduction, Three noded triangular element, four noded rectangular element, four noded quadrilateral element, eight noded quadrilateral element.

4.2 Natural coordinates and coordinates transformations; serendipity and Lagranges methods for deriving shape functions for triangular and quadrilateral element

4.3 Sub parametric, Isoperimetric, super parametric elements. Compatibility, Patch Test, Convergence criterion, Sources of errors.

**Two Dimensional Vector Variable Problems**

5.1 Equations of elasticity – Plane stress, plane strain and axisymmetric problems.

5.2 Jacobian matrix, stress analysis of CST and four node Quadratic element

5.3 Solution of 2-D Problems using FE Software (structural and Thermal), selection of element type, meshing and convergence of solution. (Can be covered during practical hours).

**Finite Element Formulation of Dynamics and Numerical Techniques**

6.1 Applications to free vibration problems of rod and beam. Lumped and consistent mass matrices.

6.2 Solutions Techniques to Dynamic problems, longitudinal vibration frequencies and mode shapes. Fourth Order Beam Equation, Transverse deflections and Natural frequencies of beams.

6.3 Finding frequencies of beam using FE Software (Can be covered during practical hours).

**Internal Assessment:**

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

**Theory Examination:**

1. Question paper will comprise of 6 questions, each carrying 20 marks.

2. Question number 1 will be compulsory and based on maximum contents of the syllabus

3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)

4. Total four questions need to be solved.

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

**References:**


3. Chandrupatla and Belegundu, “Introduction to Finite Elements in Engineering” PHI /


Pre-requisites:
1. MTC301: Applied Mathematics-III
2. MTC401: Applied Mathematics-IV
3. MTC502: Machine Design
4. MTL706: CAD/CAM/CAE Laboratory

Objectives:
1. To introduce the concepts of use of FEA software.
2. To study the applicability of FEM to a range of Engineering Problems.
3. To acquaint with applications of numerical techniques for solving problems.

Outcomes: Learner will be able to...
1. Use FEA software for solutions of various engineering problems.

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

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

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

Term Work:
Term work shall consist of minimum 06 exercises and course project. The distribution of marks for term work shall be as follows:
- Laboratory work (experiments/assignments): 10 Marks.
- Course project: 10 Marks.
- Attendance: (Theory and Practicals): 05 Marks

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

Practical/oral examination:
1. Practical examination duration is 2 hours.
2. Assignment for the examination shall be based on the list of exercises mentioned in the term work.
3. The distribution of marks for practical/oral examination shall be as follows:
   i. Practical performance: 15 marks
   ii. Oral: 10 marks
4. Evaluation of practical examination to be done based on the experiment performed and the output of the experiments during practical examination.
5. Students work along with evaluation report to be preserved till the next examination.
Objective:
1. To acquaint with the process of undertaking literature survey/industrial visit and identifying the problem
2. To familiarize the process of solving the problem in a group
3. To acquaint with the process of applying basic engineering fundamental in the domain of practical applications
4. To inculcate the process of research

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

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

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

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

University of Mumbai, Mechatronics Engineering (Second, Third and Final Year) New Course (N-2015)
<table>
<thead>
<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Introduction to mechatronics systems. Basic building blocks of mechatronic systems. Mechatronics key elements, Mechatronics in home, office and industry automation, Scope of Mechatronics. Advantages of Mechatronics, pre-requisites for Mechatronics.</td>
<td>05</td>
</tr>
<tr>
<td>02</td>
<td><strong>Mechanical Engineering and Machines in Mechatronics</strong>: Mechanical translation and rotational systems, Fluid systems, guideways, Mechanism used in mechatronics (High resolution scanning mechanisms, Indexing mechanisms), compliant mechanisms, Assembly techniques, Hydraulic and pneumatic actuators, microactuators. Piezoelectric actuators.</td>
<td>08</td>
</tr>
<tr>
<td>03</td>
<td>Electrical systems, Electrical actuators, brushless permanent magnet DC motor, Interfacing of DC motors, stepper motor, interfacing of stepper motors, AC servomotor, Drive selection and its applications. Analog to Digital Conversion, Digital to Analog conversion. Performance characteristics of sensors and transducers. Selection criteria for sensors and actuators, interfacing of sensors and actuators.</td>
<td>09</td>
</tr>
</tbody>
</table>
Advance Approaches in Mechatronics: Servo control, Process Control, Supervisory Control, Shop Floor Control, Plant Control.


Design of cantilever beam vibration control system based on piezo sensors and actuators: Introduction, Modeling of the Cantilever Beam and PZT Actuator (Modeling of the Beam, Modeling of the PZT Actuator, Modeling of the Sensor), Beam Experimental Setup (properties and dimensions of the beam, dimensions and bonding techniques), instrumental setup (Charge amplifier, Voltage amplifier, Data Acquisition), Controller and Software (Development of the PID VI).


Internal Assessment:
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems.

Theory Examination:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

In question paper weightage of each module will be proportional to number of respective lecture hours as mention in the syllabus.
References:
1. Mechatronics, Kenji Uchino and Jayne R. Giniewicz, publication: Marcel Dekker, Inc.
6. Mechatronics - Electromechanics and Control Mechanics, Mill Springer-Verlag
10. Introduction to Mechatronics, Appu Kuttan K.K., OXFORD Higher Education
11. The Art of Electronics, Horowitz and Hill Cambridge, University Press
20. Mechatronics, HMT
22. Design with Microprocessors for Mechanical Engineers, Stiffler McGraw-Hill
CLASS: BE (Mechatronics)  Subject Code: MTC802  Semester:-VIII

SUBJECT: Engineering Management and Economics  Credit-4

<table>
<thead>
<tr>
<th>Periods per week: 1Period of 60 min.</th>
<th>Lecture</th>
<th>4</th>
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<tbody>
<tr>
<td></td>
<td>Tutorial</td>
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</table>

<table>
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<tr>
<th>Evaluation System</th>
<th>Hours</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory Examination</td>
<td>3</td>
<td>80</td>
</tr>
<tr>
<td>Internal Assessment</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>

Pre-requisites:
1. MTC501: Manufacturing Processes
2. MTC702: Manufacturing Planning and Control

Objectives:
1. To prepare the students understand and appreciate the basic fundamentals of management concepts, theory and application.
2. To make the students understand the building blocks of various management processes in organizations.
3. To prepare the students to understand the impact of Globalization on business practices.
4. To introduce the students to the concepts of Micro and Macro Economics.
5. To prepare the students, such that they are able to comprehend the need, definition, functions and economic significance of financial institutions and markets.

Outcomes: Learner will be able to…
1. Understand and appreciate the basics of managerial concepts and practices used in day to day practices in organizations.
2. Appreciate the need to prepare oneself for holistic thinking and effectively managing organizations.
3. Correlate various micro and macro-economic variables.
4. Understand Economic policies, their relevance and implications.

<table>
<thead>
<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs.</th>
</tr>
</thead>
</table>
| 01     | **Introduction to management:**
|        | Brief history of Indian business scenario and recent changes, Globalization and competition, Need for managerial knowledge and skills. |
|        | **Management:**
| 02     | **Decision making:**
|        | Importance and limitations of rational decision making, Rationality in decision making, Evaluation of alternatives, Selecting an alternative- three approaches, Programmed and Non-programmed decisions. |
|        | **Organizing:** The nature and purpose of organizing, formal and informal organization. Organization levels and Span of management, Principle of span of management and the factors determining an effective span. The structure and process of organizing, Matrix organization, Strategic business units, Line & staff concepts, Functional authority. Benefits and limitations of staff, Decentralization of authority, Delegation of authority. |
|        | 08      | 11   |
| 03 | **Planning:**

**Staffing:**
 HRM and selection: Definition of Staffing, Systems approach to HRM: Overview of staffing, Situational factors affecting staffing. Selection-matching the person with the job, Systems approach to selection, Position requirements and job design, Skills and personal characteristics needed by managers, Matching qualifications with position requirements, Selection process, techniques and instruments, Performance appraisal and its purpose, Choosing the appraisal criteria.

**Leading:**

**Leadership:**
 Definition, Ingredients of leadership, Leadership behavior and styles, Communication: Communication process, Communication in an enterprise, Barriers and breakdowns in communications, Effective communication.

**Controlling:**
 Basic control process, Critical control points and standards, Control as a feedback system, Feed forward control, Requirements for effective controls, Control techniques: Budget and Non-budgetary control devices. |

| 04 | **Introduction to economics :**
 Definition of Economy, Central problems of an economy: what, how and for whom to produce; concepts of production possibility frontier and opportunity cost. Economics, its scope and importance. Introduction to Micro and Macro economics and their comparison. |

| 05 | **MICRO ECONOMICS :**
 5.1 Consumer's Behaviour : meaning of utility, marginal utility and law of diminishing marginal utility.
 5.2 Conditions of consumer's equilibrium using marginal utility analysis:
    - Concept of ordinal utility, law of demand and relation between law of demand & law of diminishing marginal utility.
 5.3 Producer's Behaviour: law of supply, variation in supply, Types of elasticity of supply. Types of Market: perfect competition, pure competition, Monopoly and Multi-plant monopoly. |

| 06 | **MACRO ECONOMICS:**
 6.3 Functions of Central Bank, Functions of Commercial Banks credit creation, Credit Control Methods, Theory of Inflation, Concepts of Inflation, Effects of Inflation and Anti-inflationary policies. |
**Internal Assessment:** Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems.

**Theory Examination:**
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

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

**References:**
1. *Introduction to Managerial Accounting*, Larry M. Walther, Christopher J. Skousen
2. *Managerial and Cost Accounting*, Larry M. Walther, Christopher J. Skousen
3. *Essentials of Microeconomics*, Krister Ahlersten
CLASS: BE (Mechatronics) | Subject Code: MTC803 | Semester: VIII

SUBJECT: Modeling and Simulation | Credit: 4

| Per periods per week: 1 Period of 60 min. | Lecture | 4 |
| | Tutorial | -- |

Evaluation System | Theory Examination | 3 | 80 |
| | Internal Assessment | 20 |
| TOTAL | 100 |

Pre-requisite:
1. MTC504 Control Systems
2. MTC605 Instrumentation and Controller Design

Objectives:
1. To teach the significance of modeling
2. To highlight the importance of simulation

Outcomes:
1. Demonstrate a clear understanding of model for any system
2. Analyze any model for the given system.
3. Realize any system with the help of model and the tool for simulation
4. Demonstrate the simulation skill for any given system

Module  | Detailed content | Hrs.
--- | --- | ---
1.0 | System Modeling
1.1 Types of model Static and dynamic physical and mathematical model
1.2 Step response method two, three and four parametric model | 06 |
2.0 | Mathematical Model
2.1 Necessity of mathematical modeling, principles of mathematical modeling
2.2 Dimensional analysis, scale | 10 |
3.0 | Approximating and validating models
3.1 Taylor’s formula, algebraic approximations, Numerical approximations
3.2 Validating models | 10 |
4.0 | Analysis and control of the systems
4.1 Solution Techniques for Ordinary Differential Equations, Free Response and Eigenvalues
4.2 State-space Equations: Converting to state space, simulating the models using any simulation | 08 |
5.0 | Examples of System Models
5.1 Exponential growth and decay – radioactive decay, capacitor charging-discharging
5.2 Freely vibrating pendulum, spring-mass oscillator | 08 |
6.0 | System Simulation
6.1 Techniques of simulations, The Monte-Carlo Method
6.2 Types of system Simulation
6.3 Continuous System Simulation: Analog and Hybrid method
6.4 Probability concepts in simulation | 10 |
Internal Assessment:
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems.

Theory Examination:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

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

References:
5. Fundamentals of Process Control Theory, Paul Murrill, ISA
Pre-requisite:
1. MTC405 Application of Integrated Circuit
2. MTC605 Instrumentation and Controller Design

Objectives:
1. To teach the significance of biomedical signal and the challenges in picking the signal
2. To educate students the different mechanism to measure and monitor different biomedical parameters
3. To identify different types of biomedical units such as pathological, diagnostic, therapeutic and prosthetic devices.
4. To help students in enhancing their knowledge about different imaging techniques
5. Mechanical design of the electrodes, prosthetic devices and the miniature as well as EMI /RFI protected cabinet is a major challenge to be looked into by this course.

Outcomes: Learner will be able to …
1. Select proper electrodes and electrolyte for different measurement of parameters
2. Explain the principle and working of any biomedical equipment
3. Design suitable orthotic and prosthetic devices and applications
4. Explain the working of different imaging techniques in Biomedical Engineering
5. Demonstrate the significance of safety, telemetry and hospital information system in biomedical Instrumentation

<table>
<thead>
<tr>
<th>Module</th>
<th>Topics</th>
<th>Hrs.</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Sources of Bioelectric potential, Electrodes and Transducers</td>
<td>08</td>
</tr>
<tr>
<td></td>
<td>1.1 Understand generation of electrical signal in human cell, Resting and Action potential</td>
<td></td>
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<tr>
<td></td>
<td>1.2 Different types of Electrodes, Electrolytes and their significance, Biosensors</td>
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<tr>
<td></td>
<td>1.3 Classification of Biomedical Instruments</td>
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<tr>
<td>2</td>
<td>Biopotential Amplifiers and recorders</td>
<td>08</td>
</tr>
<tr>
<td></td>
<td>2.1 The origin of bio-potential, ECG, ENG, EMG, EEG, MEG, ERG etc. The signal conditioners and amplifiers</td>
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<tr>
<td></td>
<td>2.2 Recording systems for the bio-potential listed above and patient monitoring system, Foetal heart rate monitor</td>
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<tr>
<td>3</td>
<td>Measurement and analysis techniques</td>
<td>08</td>
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<tr>
<td></td>
<td>3.1 Blood flowmeters, Cardiac output measurement, pulmonary function analysers</td>
<td></td>
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<td></td>
<td>3.2 Blood gas analysers, oximeters, Blood cell counters, Audiometers</td>
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<tr>
<td>4</td>
<td>Therapeutic and Prosthetic Equipments</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>4.1 Cardiac Pacemakers, Cardiac defibrillators, Hemodialysis machine, Electrosurgical unit, Ventilators, Infant incubator, drug delivery devices,</td>
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<tr>
<td></td>
<td>4.2 Orthotic and Prosthetic devices Definition, Need and Classification, Normal Human Locomotion . Gait Cycle, Biomaterials: Definition, Need and Classification, Biological Testing and Biocompatibility, Upper and Lower limb Prosthetic devices. Upper and Lower limb Orthotic devices, Study of various biomaterials and applications</td>
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</tr>
</tbody>
</table>

University of Mumbai, Mechatronics Engineering (Second, Third and Final Year) New Course (N-2015)
### Fundamentals of medical imaging

5.1 X-ray computed Tomography, Spiral or Helical C T: Slip Ring Technology, C T Angiography. Clinical use & Biological effects and safety, Magnetic resonance imaging Biological effects and safety. Nuclear medical imaging Biological effects and safety, Infrared imaging, Liquid crystal thermography. Microwave thermography.

5.2 Endoscopy, gastroscope, bronchoscope, cystoscope, colonoscope, Enteroscope Lithotripsy.

### Electrical safety, Telementry and Hospital Information system

6.1 Macroshocks and microshocks hazards, electrical safety and EMI/RFI interference and its testing

6.2 Biomedical telemetry, wireless and multi patient telemetry

6.3 Hospital Information system: Role of database in HIS. Need of Networking in HIS. Overview of Networking, topologies and its configuration. Structuring medical record to carry out functions like admissions, discharges, treatment history etc. Computerization in pharmacy & billing. Automated clinical laboratory systems & radiology information system.

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**Internal Assessment:**

Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems.

**Theory Examination:**

1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

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

**References:**

6. John G. Webster, Bioinstrumentation John Wiley and sons, 2004
CLASS: BE (Mechatronics)  
Subject Code: MTE8042  
Semester:-VIII

SUBJECT: Robotics and Machine Vision  
Credit-4

<table>
<thead>
<tr>
<th>Periods per week: 1 Period of 60 min.</th>
<th>Lecture</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutorial</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td><strong>Hours</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Marks</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Evaluation System

<table>
<thead>
<tr>
<th>Theory Examination</th>
<th>3</th>
<th>80</th>
<th><strong>Hours</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal Assessment</td>
<td>20</td>
<td></td>
<td><strong>Marks</strong></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>100</td>
<td></td>
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</tr>
</tbody>
</table>

Pre-requisites:
1. MTC603: Dynamics of Machinery
2. MTC503: Sensors and Actuators
3. MTC504: Control Systems

Objectives:
1. To familiarize the students with the significance of robotic system in agile and automated manufacturing processes.
2. To prepare the students to be conversant with robotic elements/ peripherals, their selection and interface with manufacturing equipment’s.
3. To familiarize the students with the basics of robot kinematics.

Outcomes: Learner will be able to..
1. Acquire the skills in understanding robot language and programming.
2. Acquire the skill in robot task planning for problem solving.
3. Develop skills in understanding various sensors, robot peripherals and their use.
4. Develop skills in identifying areas in manufacturing, where robotics can be deployed for enhancing productivity.

<table>
<thead>
<tr>
<th>Modules</th>
<th>Details</th>
<th>Hrs</th>
</tr>
</thead>
</table>
| 1       | **Introduction:** Automation & robotics, Robotic System & Anatomy Classification, Future Prospects  
**Robotic Application in Manufacturing:** Material transfer, Machine loading & unloading, Processing operations, Assembly & Inspectors  
**Drives:** Control Loops, Basic Control System Concepts & Models, Control System Analysis, Robot Activation & Feedback Components, Position & Velocity Sensors, Actuators, Power Transmission Systems. | 8 |
| 2       | **Robot Kinematics:** Coordinate Frames, Rotations, Homogeneous Coordinates, Arm Equation of Planer Robot, Four axis SCARA Robot, TCV, Inverse Kinematics of Planer Robot, Four Axis SCARA Robot. | 10 |
| 3       | **Trajectory Planning & Robot Dynamics:** Manipulator Path Control- Linear, Quadratic and Cubic Interpolation, Work Space Analysis, Robot Dynamics –Langrangian Dynamics of one and two link robot arm | 8 |
| 4       | **Programming For Robots:** Methods, Robot programme as a path in space, Motion interpolation, level & task level languages, Robot languages; Programming in suitable languages Characteristics of robot | 8 |
**5**  
**Machine Vision:** Introduction, Low level & High level vision, Sensing & Digitising, Template Matching, Image processing & analysis, Segmentation, Edge detection, Object description & recognition, Interpretation, Noises in Image, Applications.

**6**  
**Robot Intelligence & Task Planning:** Introduction, State space search, Problem reduction, Use of predictive logic, Means - Ends Analysis, Problem solving, Robot Learning, Robot task planning, Robot Vision

**Social Issues and Economics of robotics**

**Internal Assessment:**
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on Programming & Manipulating an Industrial Manipulator along with Machine Vision

**Theory Examination:**
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

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

**References:**
1. 1.YoremKoren, “Robotics for Engineers”
2. J. F. Engelberger, “Robotics in Practice”
5. Mark Spong, “Robot Dynamics and Control”, Wiley India
6. John Craig, “Robotics”
8. Groover and Simmers, “Industrial Robotics”
10. Beckwith and Lewisbuck, “Mechanical Measurements”
11. K. Ogata, “Modern Control Engineering”, PHI
12. Benjamin Kuo, “Automatic Control Systems”, Wiley India
## Subject: Microfabrication Processes

<table>
<thead>
<tr>
<th>Module</th>
<th>Details</th>
<th>Hrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Introduction to microfabrication processes, Additive and subtractive type microfabrication processes. Advantages and disadvantages of additive and subtractive microfabrication. Applications and scope, Microfabrication process and its CAD compatibility.</td>
<td>08</td>
</tr>
<tr>
<td>02</td>
<td>Diffusion, Ion Implantation, Chemical–Mechanical Polishing (CMP). Bonding. Glass Micro processing. Surface Micromachining, dimensional uncertainties, sealing processes in surface micromachining, IC compatibility, poly-Si surface micromachining, hinged polysilicon, thick polysilicon, CVD silicon dioxides.</td>
<td>10</td>
</tr>
<tr>
<td>03</td>
<td>Photolithography overview, masks, spinning resist and soft baking, exposure and post exposure treatment, development, post baking, resist, wafer priming, resist stripping, critical dimensions, line width, overall resolution, resist profile, overview of profile type, lift-off technique, Extreme UV lithography, Pattern Generation, Micro stereo lithography (types: scanning, projection, Integral Hardening, (IH), multi-resist, constraint surface), bulk lithography</td>
<td>10</td>
</tr>
<tr>
<td>04</td>
<td>Working Principles of Electro-discharge Machining (EDM), Reverse Micro-EDM, Wire cut EDM, laser micromachining, Electro-chemical machining.</td>
<td>08</td>
</tr>
<tr>
<td>05</td>
<td>Dry Etching, Sputtering or Ion Etching, Plasma etching, reaction mechanism, Ion energy vs Pressure relationship in a plasma. Chemical Etching, Energy driven anisotropy, Dopant driven anisotropy, Deep Reactive Ion Etching, Comparing dry and wet etching, combining dry and wet etching.</td>
<td>08</td>
</tr>
</tbody>
</table>
| 06 | LIGA and Micromolding:  
Synchrotron orbital Radiation (SOR), X-ray masks, resist requirement,  
exposure, development, metal deposition, molding, demolding, sacrificial layers |
|----|------------------------------------------------------------------|

**Internal Assessment:**
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems.

**Theory Examination:**
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

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

**References:**
3. Yi Qin, Micromanufacturing Engineering and Technology, Micro and Nanotechnology series, Elsevier.
### Subject Details

**CLASS: BE (Mechatronics)** | **Subject Code: MTE8044** | **Semester:-VIII**

**SUBJECT: Machine Interface Design**

| Periods per week: 1Period of 60 min. | Lecture | 4 |
| | Tutorial | -- |
| **Evaluation System** | **Theory Examination** | 3 | 80 |
| | **Internal Assessment** | 2 | 20 |
| **TOTAL** | **Marks** | **100** |

#### Pre-requisites:
1. MTL307: Object Oriented Programming Laboratory.

#### Objectives:
1. To stress the importance of a good interface design.
2. To understand the importance of human psychology in designing good interfaces.
3. To motivate students to apply HMI in industrial application.
4. To bring out the creativity in each student – build innovative applications that are user friendly.
5. To encourage students to indulge into research in Machine Interface Design.

#### Outcomes:
Learner will be able to..
1. Design innovative and user friendly interfaces for industrial application.
2. Criticize existing interface designs, and improve them.
3. Design application for social and technical task with safety concern.

#### Module Detailed Contents

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hours</th>
</tr>
</thead>
</table>
| 1      | **1.1 Introduction:** Introduction to Human Machine Interface, Hardware, software and operating environment to use HMI in various fields.  
1.2 The psychopathology of everyday things – complexity of modern devices; human-centered design; fundamental principles of interaction;  
1.3 Psychology of everyday actions- how people do things; the seven stages of action and three levels of processing; human error; | 10 |
| 2      | **2.1 GUI** – benefits of a good UI; popularity of graphics; concept of direct manipulation; advantages and disadvantages; characteristics of GUI; characteristics of Web UI; General design principles.  
2.2 User Interface Design Process: Steps in UI design | 10 |
| 3      | 3.1 Graphical screen design: graphical design concepts, components of visible language, graphical design by grids  
3.2 Beyond screen design: characteristics of good representations, information visualization, Tufte’s guidelines, visual variables, metaphors, direct manipulation | 04 |
| 4      | **4.1 Interaction styles and communication** – menus; windows; device based controls, screen based controls, feedback and guidance, icons, colors.  
**4.2 Societal and Individual Impact of User Interfaces:** Future Interfaces, Ten Plagues of the Information Age, Overcoming the Obstacle of Animism | 08 |
| 5      | 5.1 Design principles and usability heuristics: design principles, principles to support usability, golden rules and heuristics, Human Computer Interaction (HCI) patterns  
5.2 HCI design standards: process-oriented standards, product-oriented standards, strengths and limitations of HCI Standards | 04 |
Case studies:
Designing and evaluating Human-Machine Interface (HMI) for
1. Process control application.
2. Flight control system
3. Robotics Welding
4. Air-conditioning system
5. Smart phones
6. Medical Devices

Internal Assessment:
Assessment consists of two tests out of which; one should be compulsory class test (on
minimum 40% of curriculum) and the other is either a class test (on minimum 70% of
curriculum) or assignment on live problems.

Theory Examination:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part
   (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

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

References:
3. Ben Shneiderman and Catherine Plaisant, Desinging the user Interface:,Pearson,Addison Wesley.
<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.1 Introduction to Product Design: product definition, specifications of product, product life cycle. 1.2 Concurrent engineering &amp; Sequential engineering 1.3 Modern product development process. 1.4 Morphology of design.</td>
<td>08</td>
</tr>
<tr>
<td>2</td>
<td>2.1 Conceptual Design: generation, selection &amp; embodiment of concepts. 2.2 Product architecture. 2.3 Industrial design: process, need. 2.4 Design Optimization</td>
<td>08</td>
</tr>
<tr>
<td>3</td>
<td>3.1 Design for Manufacturing (DFM) and Design for Assembly (DFA). 3.2 Designs for Maintainability. 3.3 Designs for Environment. 3.4 Design for Robustness: Taguchi Designs &amp; Design of Experiments (DOE).</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>4.1 Process selection: Important types of manufacturing process and their classification. 4.2 Process and material selection Methods : AHP and fuzzy approach. 4.4 Ergonomics approach</td>
<td>08</td>
</tr>
<tr>
<td>5</td>
<td>5.1 Value Engineering / Value Analysis: : definition, methodology-FAST 5.2 Case studies. 5.3 Design and Process Failure Mode Effect Analysis (FMEA) 5.4 Economic analysis: Qualitative &amp; Quantitative.</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>6.1 Rapid prototyping: Viz. Stereo lithography. FDM, SLS etc. 6.2 Quality function deployment (QFD) 6.3 Case studies. 6.4 Legal and social issues 6.5 Patents and IP acts</td>
<td>08</td>
</tr>
</tbody>
</table>
Internal Assessment:
Assessment consists of two tests out of which; one should be compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Theory Examination:
1. Question paper will comprise of 6 questions, each carrying 20 marks.
2. Question number 1 will be compulsory and based on maximum contents of the syllabus
3. Remaining questions will be mixed in nature (for example, if Q.2 has part (a) from module 3 then part (b) will be from other than module 3)
4. Total four questions need to be solved.

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

References:
3. L D Miles “Value Engineering.”
Pre-requisite:
1. MTC504 Control Systems,
2. MTC605 Instrumentation and Controller Design

Objectives:
1. To teach the significance of modeling
2. To highlight the importance of simulation

Outcomes: Learner will be able to:
1. Design a system and process as per needs/specifications.
2. Work in multi-disciplinary task.
3. Use modern Engineering tools to solve engineering problems.

List of Experiments:
It is advisable to use required application software for simulation based experiments. Objective is students should get extensive experience in using the most popular modern simulation tools used worldwide. Use of open source software should be encouraged. This will give them confidence in coupling theory with practice and make them aware of trends in design and simulation of both research and industry. Instructors are requested to use their own ideas to help students excel in use of these simulation tools. Followings are the recommendations:
1. Circuit Design with Circuit simulation tools
2. Tools used in control system and instrumentation like Labview
3. Programming with Embedded tools
4. FPGA/CPLD programming tools
5. Modeling with autocard tools
6. Mathematical modeling tools like Scilab/Matlab
7. Tools for implementation of Real Time Operating System
8. Tools used for communication

Also mini-project based on any of the above tools is expected.

Term Work:
Term work shall consist of exercises done on simulation platforms and mini project.

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

1. Exercises : 25 Marks
2. Mini Project : 20 Marks
3. Attendance (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.

Practical / Oral Examination:
Practical exam will be based on the performance on the design task given.

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

Practical Examination……. 15 mark
Oral …… 10 Marks

1. Evaluation of practical examination to be done based on the performance of design task.
2. Students work along with evaluation report to be preserved till the next examination.

University of Mumbai, Mechatronics Engineering (Second, Third and Final Year) New Course (N-2015)
Pre-requisites:
1. MTC503: Sensors and Actuators
2. MTC504: Control Systems
3. MTC502: Machine Design
4. MTC505: Embedded Systems

Objectives:
1. To present architecture of the mechatronics system
2. Method of experimental identification of the control system
3. To study interfacing of the electromechanical devices.

Outcome: Learner will be able to…
1. Identify the suitable sensor and actuator for a control system
2. Indigenously design and develop a mechatronic system

<table>
<thead>
<tr>
<th>Expt. No.</th>
<th>Aim of the Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Experiment based on waveform generation, interfacing and control of motors etc.</td>
</tr>
<tr>
<td>02</td>
<td>System identification of any one of the actuator</td>
</tr>
<tr>
<td>03</td>
<td>Experimental characterization of any one of the sensor.</td>
</tr>
<tr>
<td>04</td>
<td>Experimental Identification by frequency response approach of Mechanical, Electrical, Chemical system</td>
</tr>
<tr>
<td>05</td>
<td>Development of transfer function based on experimentally identified data, Stability analysis of predicted transfer function, and PID tuning and implementation on experimental setup.</td>
</tr>
<tr>
<td>06</td>
<td>Experimental identification of mechanisms such as flexural based systems etc.</td>
</tr>
<tr>
<td>07</td>
<td>Experiment on image based navigation and control of robot.</td>
</tr>
<tr>
<td>08</td>
<td>Experiment on control of non-linear systems.</td>
</tr>
<tr>
<td>09</td>
<td>Experiment on control of inverted pendulum</td>
</tr>
<tr>
<td>10</td>
<td>Experiment on system identification and control of scanning mechanism</td>
</tr>
</tbody>
</table>

Term Work:
Term work shall consist of exercises from the above list.

The distribution of marks for term work shall be as follows:
1. Exercises : 45 Marks
2. Attendance (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.

Practical / Oral Examination:
Practical examination of 2 hours duration based on any one of the experiments mentioned in the list above.
The distribution of marks for oral-practical examination shall be as follows:
Practical Examination ...... 15 marks
Oral ...... 10 Marks
1. Evaluation of practical examination to be done based on the performance of design task.
2. Students work along with evaluation report to be preserved till the next examination.

University of Mumbai, Mechatronics Engineering (Second, Third and Final Year) New Course (N-2015)