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 brain storming 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 stake holders.

Dr. S. M. Khot
Chairman, Board of Studies in Mechanical Engineering, University of Mumbai
### Program Structure for B E Mechatronics Engineering

**T. E. Mechatronics - (Semester V)**

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Subject Name</th>
<th>Teaching Scheme (Contact Hours)</th>
<th>Credits Assigned</th>
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<td>Theory</td>
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<td>MTC501</td>
<td>Manufacturing Processes</td>
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Total - 22 12 22 6 28

* Theory for entire class to be conducted, ³ Common for all Engineering Program
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CLASS: TE (Mechatronics)  
Subject Code: MTC501  
Semester: V

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<tr>
<th>SUBJECT: Manufacturing Processes</th>
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Lecture | 4  
Tutorial | --  
| Hours | Marks |
| Evaluation System | Theory Examination | 3 | 80 |
| | Internal Assessment | 20 |  
| TOTAL | 100 |

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.

<table>
<thead>
<tr>
<th>Modules</th>
<th>Details</th>
<th>Hrs.</th>
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</thead>
</table>
| 01      | **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 & 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. | 07 |
| 02      | **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. | 08 |
| 03      | **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. | 12 |
### 3.2 Machine Tools (Construction and Operations):

### 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.

### 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.

### 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.

#### 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

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<th>Periods per week: 1Period of 60 min.</th>
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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.

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<tr>
<th>Module</th>
<th>Details</th>
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<tbody>
<tr>
<td>1</td>
<td>Design Considerations</td>
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<td>2</td>
<td>Joints:</td>
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<td></td>
<td>Cotter Joint, Knuckle Joint, Turn Buckle, Bolted and welded joints for direct and eccentric loading.</td>
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<td>3</td>
<td>Springs;</td>
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<td>Design of Helical Springs under static and variable axial loading. Design of Leaf Springs.</td>
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<td>4</td>
<td>Shafts and Couplings:</td>
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<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>
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</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:**
6. Recommended Data Books - PSG, K. Mahadevan
7. Machine Design - Reshetov - Mir Publication
11. Design of Machine Elements - V.M. Faires
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 actuators.

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

Module | Detailed Contents | Hrs.
--- | --- | ---
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  
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. | 10
02 | 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
03 | | 08
### Electrical Actuating systems

**DC motors:** Review of DC motor, Modeling of DC motor behavior, Heat dissipation in DC motor, Velocity Profile Optimization, Inertia matching, Servo Amplifier, DC motor drive.

**Stepper Motors:** Characteristics of a Stepper motor, Classification of a Stepper motor, Principle of Operation, Step Angle, Electrical model of energized coil, Drive method, Stepper motor performance

**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

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### Internal Assessment

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### 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
CLASS: TE (Mechatronics)  |  Subject Code: MTC504  |  Semester:- V

SUBJECT: Control Systems  |  Credit-4

Periods per week: 1Period of 60 min.

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<tr>
<td>Tutorial</td>
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Evaluation System

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<tr>
<th>Evaluation System</th>
<th>Theory Examination</th>
<th>3</th>
<th>80</th>
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<td></td>
<td>Internal Assessment</td>
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<td>20</td>
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<td><strong>TOTAL</strong></td>
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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 | 10

**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.

2.0     | Time –Domain Analysis and Response         | 10

**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                          | 07

4.0 Frequency Response Analysis
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.

5.0 Stability & Compensation Techniques


6.0 Analog and Digital Control
Analog and Digital Control:
Introduction to Digital control systems, comparison with analog control systems, Case study of analog control system design with practical approach- Temperature Control system.

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

**SUBJECT: Embedded Systems**  Credit-4

<table>
<thead>
<tr>
<th>Periods per week: 1 Period of 60 min.</th>
<th>Lecture</th>
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<td>Tutorial</td>
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<table>
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<tr>
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<tr>
<td><strong>TOTAL</strong></td>
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<td>100</td>
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</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>
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<tbody>
<tr>
<td>1.0</td>
<td><strong>General Concepts</strong></td>
<td></td>
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<tr>
<td></td>
<td>1.1 <strong>Basic Concepts:</strong> Microprocessor and Microcontroller, Von Neumman and Harward, Intel 8085 microprocessor architecture (only)</td>
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<tr>
<td></td>
<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>
</tr>
<tr>
<td>2.0</td>
<td><strong>8051 Microcontroller</strong></td>
<td></td>
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<tr>
<td></td>
<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>
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<td></td>
<td>2.2 <strong>8051 Assembly Language Programming:</strong> Instruction set, Addressing mode, Assembler directives and programs</td>
<td></td>
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<td></td>
<td>2.3 <strong>8051 Interfacing:</strong> LED, LCD, seven segment display, keyboard, ADC, DAC, Stepper Motor, Relay and Serial Communication</td>
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<tr>
<td>3.0</td>
<td><strong>ARM7: A 32-bit Microcontroller</strong></td>
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<tr>
<td></td>
<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>
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<tr>
<td></td>
<td>3.2 <strong>ARM7 Programming:</strong> Instruction set, Addressing mode and programs</td>
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<tr>
<td>4.0</td>
<td><strong>Embedded Software Development</strong></td>
<td></td>
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<td></td>
<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>
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<tr>
<td></td>
<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>
</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

<table>
<thead>
<tr>
<th>SUBJECT: Operating System</th>
<th>Credit-2</th>
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<tbody>
<tr>
<td>Periods per week: 1Period of 60 min.</td>
<td>Lecture 2</td>
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<td>Tutorial --</td>
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<tr>
<td>Evaluation System</td>
<td>Theory Examination 2 40</td>
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<td></td>
<td>Internal Assessment 10</td>
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<td>TOTAL 50</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>
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</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”
CLASS: TE (Mechatronics)  Subject Code: MTL507  Semester: V

SUBJECT: Business Communication & Ethics

<table>
<thead>
<tr>
<th>Practical to be conducted for batch of students</th>
<th>*Theory for entire class to be conducted</th>
<th>*Theory</th>
</tr>
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<tbody>
<tr>
<td>Practical</td>
<td>*02 hours Theory for entire class per week + 02 hours practicals per batch per week</td>
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</table>

& Common with All Engineering Programs

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.

<table>
<thead>
<tr>
<th>Module</th>
<th>Unit No.</th>
<th>Topics</th>
<th>Hrs</th>
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<tbody>
<tr>
<td>1.0</td>
<td>1.0</td>
<td>Report Writing</td>
<td>07</td>
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<tr>
<td></td>
<td>1.1</td>
<td>Objectives of report writing</td>
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<td>1.2</td>
<td>Language and Style in a report</td>
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<td>1.3</td>
<td>Types of reports</td>
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<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>
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<td></td>
<td>2.1</td>
<td>Objective of technical proposals</td>
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<td>2.2</td>
<td>Parts of proposal</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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<td></td>
<td>3.1</td>
<td>Emotional Intelligence</td>
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<td>3.2</td>
<td>Leadership</td>
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<td>3.3</td>
<td>Team Building</td>
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<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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University of Mumbai, Mechatronics Engineering (Second, Third and Final Year) New Course (N-2015)
4.0  Meetings and Documentation  02
  4.1 Strategies for conducting effective meetings
  4.2 Notice
  4.3 Agenda
  4.4 Minutes of the meeting

5.0  Introduction to Corporate Ethics and etiquettes  02
  5.1 Business Meeting etiquettes, Interview etiquettes, Professional and work etiquettes, Social skills.
  5.2 Greetings and Art of Conversation
  5.3 Dressing and Grooming
  5.4 Dinning etiquette
  5.5 Ethical codes of conduct in business and corporate activities (Personal ethics, conflicting values, choosing a moral response, the process of making ethical decisions)

6.0  Employment Skills  06
  6.1 Cover letter
  6.2 Resume
  6.3 Group Discussion
  6.4 Presentation Skills
  6.5 Interview Skills

Total  26

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:

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>
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<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>
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</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).
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.
### SUBJECT: CNC Technology

**Subject Code:** MTC601  
**Credit:** 4  
**Semester:** VI

<table>
<thead>
<tr>
<th>Periods per week: 1 Period of 60 min.</th>
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<tr>
<td><strong>TOTAL</strong></td>
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</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>
</tr>
</thead>
</table>
| 1          | **Numerical Control of Machines**  
1 Introduction-NC Machine, CNC Machines, DNC, Advantages and Disadvantages of CNC Machines, Applications of CNC  
2 Components of Numerical Control System-Basic Components, Programme of Instructions  
3 Classification of Numerical Control Machines  
4 Engineering Analysis of NC Positioning Systems | 06 |
| 2          | **CNC Control System**  
CNC motion controller, Linear, circular, parabolic, cubic, helical interpolator, Positioning and contouring control loops, MCU **Output Transducers**  
Introduction, positional transducers, optical gratings, encoders, Inductosyns, Magnescales. | 07 |
| 3          | **Tooling for CNC machines**  
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. | 08 |


5 | **Computer-aided Part Programming** – Introduction, Computer-aided Part Programming Languages, APT, MACROS, Milling Machine Programs | 10

6 | Adaptive control – ACO and ACC systems, Maintenance of CNC Machines, Economics of manufacturing using CNC machines, CNC Machine and Automation | 09

**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:**
### SUBJECT: Metrology and Quality Engineering

- **Credit:** 4

<table>
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<tr>
<th>Periods per week: 1 Period of 60 min.</th>
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<td><strong>TOTAL</strong></td>
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**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.

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<thead>
<tr>
<th>Module</th>
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<th>Hrs.</th>
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<tbody>
<tr>
<td><strong>01</strong></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><strong>02</strong></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><strong>03</strong></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><strong>04</strong></td>
<td><strong>Quality Control</strong>  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>
05  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.

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

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. Practical Engineering Metrology, K.W.B.Sharp, Pitman Publication
2. Engineering Metrology, K.J.Hume, Kalyani publication
7. Statistical Quality control, R.C. Gupta
CLASS: TE (Mechatronics)  
Subject Code: MTC603  
Semester:-VI

SUBJECT: Dynamics of Machinery  
Credit-4

<table>
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<th>Periods per week: 1 Period of 60 min.</th>
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<td>Internal Assessment</td>
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</table>

TOTAL 100

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>
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</table>
| 1       | Controlling Mechanisms – Governors:  
3.1. Governors: Types, centrifugal governors, inertia governors,  
3.2. Force analysis of gravity loaded governors - Watt, Proell, Performance characteristics of governors - stability, sensibility, isochronisms, Hunting, governor effort and governor power, coefficient of insensitiveness. | 06 |
| 2       | 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. | 06 |
| 3       | 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. | 10 |
| 4       | 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; | 10 |
| 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  
CLASS: TE (Mechatronics)  |  Subject Code: MTC604  |  Semester: VI

**SUBJECT: Power Electronics and Drives**  |  Credit: 4

<table>
<thead>
<tr>
<th>Periods per week: 1 Period of 60 min.</th>
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**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.

<table>
<thead>
<tr>
<th>Module</th>
<th>Topics</th>
<th>Hrs</th>
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<tbody>
<tr>
<td>1.0</td>
<td>Power Semiconductor Switches</td>
<td>10</td>
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<tr>
<td></td>
<td>1.1 SCR: Principle of operation, static and dynamic characteristics, gate characteristics, turn-on and turn-off methods, protection.</td>
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<td>1.2 Principle of operation and characteristics of: TRIAC, power BJT, power MOSFET, IGBT.</td>
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<tr>
<td>2.0</td>
<td>AC-DC Converters</td>
<td>08</td>
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<td>2.2 Switched-mode rectifiers: Principle of operation.</td>
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<tr>
<td>3.0</td>
<td>DC-DC converters: Basic principle of step up and step down choppers. Buck, Boost, Buck-Boost, Cuk regulators.</td>
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<td>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.</td>
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<tr>
<td>4.0</td>
<td>AC-AC Converters</td>
<td>06</td>
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<td>4.1 AC voltage Controllers: Single phase AC voltage controller – on – off control and phase control.</td>
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<td>4.2 Cycloconverters: principle of operation of single phase step-up and step-down cycloconverters.</td>
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<td>5.0</td>
<td>DC Drives</td>
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<td>5.1 DC Drive Operation: Introduction to Four quadrant operation – Motoring, Plugging, Dynamic and Regenerative Braking.</td>
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<td>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.</td>
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<td>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.</td>
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</tbody>
</table>
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.
CLASS: TE (Mechatronics)  Subject Code: MTC605  Semester: VI

SUBJECT: Instrumentation and Control

Credit-4

Periods per week: 1 Period of 60 min.

<table>
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Evaluation System

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TOTAL 100

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

1.0 Fundamentals of process and control

1.1 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 & Pressure to Current converter.


2.0 Transmitters:

2.1 Need of transmitter (concept of field area & control room area), Need for standardization of signals, Current, voltage, and pneumatic signal standards, Concept of live & dead zero

2.2 Types of transmitters: Two and four wire transmitters, Electronic and Pneumatic transmitters Electronic Differential Pressure Transmitter

3.0 Actuators

3.1 Control valve: Necessity, comparison with other final control elements, Control valve Characteristics (Inherent & 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 & applications of Globe: Single, double, 3way, angle, Gate, Needle, Diaphragm, Rotary valves, Ball, Butterfly.

3.2 Types of actuators: Construction, Advantages, Disadvantages & applications: Spring Diaphragm & Smart actuators. Control valve accessories: Positioners:
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,

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:**
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 Details:

**CLASS:** TE (Mechatronics)  
**Subject Code:** MTC606  
**Semester:** VI  
**Subject:** APPLIED HYDRAULICS AND PNEUMATICS  
**Credit:** 4

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### 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:
1. Design the pneumatic and electro-pneumatic system.
2. Design hydraulic and electro-hydraulic system.
3. Design PLC for various applications.

### Module Details:

<table>
<thead>
<tr>
<th>Module</th>
<th>Detailed Contents</th>
<th>Hours</th>
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</table>
| 1      | **Fluid Power Systems and Fundamentals**  
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. | 06    |
| 2      | **Hydraulic System & Components**  
| 3      | **Design of Hydraulic Circuits**  
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. | 10    |
| 4      | **Pneumatic Systems and Components**  
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, | 08    |
| 5      | **Design of Pneumatic Circuits**  
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. | 10    |
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:
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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. 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.
SUBJECT: CNC Technology Laboratory
Credit: 1

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.

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<tr>
<th>Modules</th>
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<tbody>
<tr>
<td>1</td>
<td>Study and operation of CNC Lathe</td>
<td>01</td>
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<tr>
<td>2</td>
<td>Study and operation of CNC Milling Center</td>
<td>01</td>
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<td>3</td>
<td>Manufacturing Simulation using Software like Master CAM</td>
<td>02</td>
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<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>
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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.
SUBJECT: Instrumentation and Control Laboratory

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).