# Autonomous Program Structure of Third Year B. Tech. Sixth Semester (Mechanical Engineering)  
**Academic Year: 2022-2023 Onwards**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Teaching Scheme Hours /Week</th>
<th>Examination Scheme</th>
<th>Total Marks</th>
<th>Credit</th>
</tr>
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<tbody>
<tr>
<td>20ME601</td>
<td>Robotics and Control Systems (RCS)</td>
<td>3 0 0 50 50 0 0 100</td>
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<tr>
<td>20ME602</td>
<td>Applied Thermodynamics (AT)</td>
<td>2 1 0 50 50 0 0 100</td>
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<td>20ME603</td>
<td>System Dynamics - Modeling and Simulation (SDMS)</td>
<td>2 1 0 50 50 0 0 100</td>
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<tr>
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<td>2 1 0 50 50 0 0 100</td>
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<tr>
<td>20OEHS601</td>
<td>Industrial Engineering and Operation Research (IIOR)</td>
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<tr>
<td>1</td>
<td>20OE601A</td>
<td>Automation and Control Engineering</td>
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<td>Automotive Electronics</td>
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<td>Avionics</td>
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<td>4</td>
<td>20OE601D</td>
<td>Bioinformatics</td>
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<td>5</td>
<td>20OE601E</td>
<td>Computer Vision</td>
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<td>6</td>
<td>20OE601F</td>
<td>Design Thinking</td>
<td>Y</td>
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<td>7</td>
<td>20OE601G</td>
<td>e-Business</td>
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<td>8</td>
<td>20OE601H</td>
<td>Electric Vehicles</td>
<td>Y</td>
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<tr>
<td>9</td>
<td>20OE601I</td>
<td>Gamification</td>
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<td>10</td>
<td>20OE601J</td>
<td>Geographical Information Systems</td>
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<td>Y</td>
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<tr>
<td>11</td>
<td>20OE601K</td>
<td>Multimedia Systems</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>
Course Name: Robotics and Control Systems

Course Code: 20ME601

Prerequisite: Basic Mathematics, Engineering Mechanics, Elements of Electrical and Electronics Engineering

Course Objectives:

To familiarize the students

1. Basics of Robotics
2. Robotic control and Actuation
3. Control Technology
4. System Modelling, Stability and Control actions.

Course Outcomes:

At the end of the course, student will be able to

1. Identification of the basic Robotic systems components and performance parameters
2. Understand the fundamentals of Robotic sensory and actuation systems
3. Analyze the robotic kinematics
4. Identify the basic control systems and its classifications
5. Prepare the system model and can perform the stability analysis of the model
6. Analyze the different control modes and perform the frequency domain analysis

Unit 1
Introduction to Robotics
4 hours
CO : 1
Basic concepts, Laws of Robotics, Classification, Structure of Robots, Point to point and continuous path control system, Robot performance measurement characteristics- accuracy, resolution, repeatability, precision, dexterity, Industrial Applications.

Unit 2
Robotic Sensors & Actuation
6 hours
CO : 2
Classification, Selection and application, Need for sensors and vision system is robotic control.

Sensors: Light, Sound, Temperature, Contact, Proximity, Distance, Pressure, Tilt, Navigation, Acceleration
GPS, IMU, Vision, PVDF Tactile (Construction, working and selection)

Actuation: Selection of Drives, Actuators and transmission system of manipulator.

Machine Vision System: Vision system devices, image acquisition, Masking, Sampling and Quantization, Image processing techniques, Noise reduction, Edge detection, Segmentation.
## Unit 3: Robot Kinematics

**6 hours | CO : 3**

Transformation matrices, link and joint, Denavit-Hartenberg (D-H) parameters, kinematics redundancy, kinematics calibration, inverse kinematics

Static force and velocity in manipulators, Motion of the manipulator links, Jacobians, Singularities, static forces, Jacobian in force domain.

## Unit 4: Control System

**6 hours | CO : 4**

Definition, Classification- open loop and closed loop control system, case studies, Feedback and Feed Forward Control System, Transfer Function, Block diagram reduction techniques, Signal flow Graphs-Mason's Gain Formula

## Unit 5: System Modelling and Stability

**7 hours | CO : 5**

Basic system Models: Thermal, Fluid, Hydraulic, Mechanical: Spring-Mass-Damper system equations


Time domain Response analysis.

## Unit 6: Controllers and Frequency Response Analysis

**6 hours | CO : 6**

**Frequency domain specifications**, Bode plot diagrams-Determination of Phase margin and Gain margin, Stability analysis from Bode plots, Polar plots.

| Total Lecture hours: | 36 hours |

### Text Books:

3. Ogata K., “Modern Control Engineering” Prentice Hall of India

### Reference Books:

2. Handbook of design, manufacturing and Automation: R.C. Dorf, John Wiley and Sons
## Course Name

**Applied Thermodynamics**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>20ME602</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-requisite</td>
<td>Engineering Thermodynamics, Fluid Mechanics, Heat Transfer</td>
</tr>
</tbody>
</table>

### Course Objectives:

To make students

1. understand performance parameters of reciprocating air compressor.
2. understand and analyze refrigeration cycles
3. understand various psychrometric processes
4. understand performance parameters of gas turbines.

### Course Outcomes:

**Students will be able to**

After successful completion of the course, student will be able to

1. Evaluate isothermal and volumetric efficiency of reciprocating compressor.
2. Analyze refrigeration cycles and calculate COP.
3. Plot psychrometric processes and perform air conditioning load calculations.
4. Calculate the efficiency and power developed for a gas turbine

### Unit/Module: 1 Reciprocating Air Compressors

- Computation of work done, Isothermal efficiency, Volumetric efficiency, Multi staging of compressor, Capacity control of compressor

### Unit/Module: 2 Refrigeration

- Vapor compression cycle, Multistage refrigeration, Vapor absorption cycle

### Unit/Module: 3 Psychrometry

- Basic concepts and definitions, Psychrometric chart, Analysis of various psychrometric processes

### Unit/Module: 4 Gas Turbines

- 6 hours
- CO: 4
Working of Brayton Cycle, Thermal Efficiency, Work ratio, maximum & optimum pressure ratio, Actual cycle, Effect of operating variables on thermal efficiency, Inter-cooling, Reheating, and
Regeneration cycle

<table>
<thead>
<tr>
<th>Text Books:</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Manohar Prasad, Refrigeration and Air Conditioning, Wiley Eastern Ltd</td>
</tr>
<tr>
<td>4. V. Ganeshan, Gas Turbines, Tata Mcgraw Hill</td>
</tr>
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<table>
<thead>
<tr>
<th>Total Course hours:</th>
<th>hours</th>
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<tr>
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<td>24</td>
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</tbody>
</table>
Course Name: System Dynamics – Modeling and Simulation

Course Code: 20ME603

Pre-requisite: Analysis and Synthesis of Mechanisms, Machine Design, Power Train Design

Course Objectives:

1. To understand the methods to find natural frequency of system subjected to undamped free vibrations
2. To analyze the system subjected to vibrations with viscous/coulomb damping
3. To calculate the amplitude and phase difference for various cases of forced vibrations
4. To determine natural frequencies and mode shapes of multiple degree of freedom system
5. To explain the features and applications of various dynamic modeling techniques

Course Outcomes:

Upon completion of this course, the student will be able to,

1. evaluate the natural frequency of system subjected to undamped free vibrations
2. analyze the system subjected to vibrations with viscous/coulomb damping
3. calculate the amplitude and phase difference for various cases of forced vibrations
4. determine natural frequencies and mode shapes of multiple degree of freedom system
5. understand features and applications of various dynamic modeling techniques

Unit 1  | Fundamentals of Dynamic System | 4 hours | CO: 1
--- | --- | --- | ---
Elements of a vibratory system, S.H.M., degrees of freedom, modeling of a system, concept of linear and non-linear systems, equivalent spring, linear and torsional systems. Matrix Algebra

Unit 2  | Single Degree of Freedom Systems – Free and Forced Vibrations | 6 hours | CO: 2
--- | --- | --- | ---
Natural frequency by equilibrium and energy methods for longitudinal and torsional vibrations.

Forced vibrations of longitudinal and torsional systems, simple harmonic excitation, excitation due to reciprocating and rotating unbalance, base excitation, magnification factor and phase difference, force and motion transmissibility

Different types of damping, free vibrations with viscous damping - over damped, critically damped and under damped systems, dry friction damping.
<table>
<thead>
<tr>
<th>Unit 3</th>
<th>Multiple Degree of Freedom Systems - Undamped Vibrations</th>
<th>6 hours</th>
<th>CO: 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Free vibration of spring coupled systems – longitudinal and torsional, natural frequency and mode shapes. Eigen value and Eigen vector by Matrix method, Geared systems.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Unit 4</th>
<th>Frequency Response and Vibration</th>
<th>6 hours</th>
<th>CO: 4</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Digital and Fast Fourier Transform, Frequency Response of first and second order Systems, Vibration Isolator and Vibration Absorption, Response to General Periodic Inputs</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Unit 5</th>
<th>Dynamic Modeling and Simulation</th>
<th>6 hours</th>
<th>CO: 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Introduction to Laplace Method for Step input, impulse input to SDOF, Laplace Transform, Response for First Order Models, State Space system, Simulations using MATLAB and SIMULINK, Base Excitation, Rotating Imbalance</td>
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<td></td>
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</tbody>
</table>

| Total Lecture hours: | 28 hours |

**Text Books:**


**Reference Books:**


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<table>
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<tr>
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</table>
## Course Name: Turbo Machines

<table>
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<tr>
<th>Course Name</th>
<th>L</th>
<th>T</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Turbo Machines</td>
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</tbody>
</table>

| Course Code | 20ME604 | 3 | 1 | - |

<table>
<thead>
<tr>
<th>Pre-requisite</th>
<th>Syllabus Version</th>
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<tbody>
<tr>
<td>Physics, Calculus, Fluid Mechanics</td>
<td>V:1.1</td>
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</table>

### Course Objectives:

**Course prepares students to**

1. differentiate between impulse and reaction turbine
2. illustrate inlet and outlet conditions of a turbomachine with the help of velocity triangles
3. calculate the head requirement and efficiency of a centrifugal pump
4. determine the slip and efficiency of a centrifugal compressor

### Course Outcomes:

**Students will be able to**

1. differentiate between impulse and reaction turbine
2. illustrate inlet and outlet conditions with the help of velocity triangles and Calculate the efficiency and power developed for a hydraulic turbine
3. illustrate inlet and outlet conditions with the help of velocity triangles Calculate the efficiency and power developed for a steam turbine
4. draw the inlet and outlet velocity triangle for centrifugal pump and calculate its efficiency
5. Determine the efficiency and power developed by compressor based on the given inlet and outlet conditions

### Unit/Module: 1 Introduction

<table>
<thead>
<tr>
<th>Introduction</th>
<th>4 hours</th>
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</thead>
</table>

Turbo machines (Hydraulic & Thermal), Classification of Turbo machines, Comparison with positive displacement machines, Fundamental equation governing turbo machines, Concepts of Velocity triangle and impact of jet on curved vanes

### Unit/Module: 2 Hydraulic Turbines

<table>
<thead>
<tr>
<th>Hydraulic Turbines</th>
<th>8 hours</th>
<th>CO: 2</th>
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</thead>
</table>

Pelton wheel- Construction, principle of working, velocity diagrams and analysis, design aspects,
Reaction Water Turbines : Classifications, Francis, Propeller, Kaplan Turbines, construction features, velocity diagrams and analysis, degree of reaction,
<table>
<thead>
<tr>
<th>Unit/Module: 3</th>
<th>Steam Turbine</th>
<th>8 hours</th>
<th>CO: 3</th>
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<tr>
<td>Steam Turbines: Classifications (Axial and Radial), construction details, compounding of steam turbines, velocity diagrams and analysis of Impulse and reaction turbines (single stage), governing of steam turbines</td>
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<thead>
<tr>
<th>Unit/Module: 4</th>
<th>Centrifugal Pump</th>
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<tr>
<td>Classification of rotodynamic pumps, components of centrifugal pump, types of heads, velocity triangles and their analysis, effect of outlet blade angle, cavitation, NPSH, specific speed, performance characteristics of centrifugal pump, Cavitation, open, semi open impeller pumps</td>
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<table>
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<tr>
<th>Unit/Module: 5</th>
<th>Centrifugal Compressor</th>
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<tr>
<td>Classification of rotodynamic compressors, blowers, fans. Centrifugal compressor: Construction, flow process on T-S Diagram, velocity diagram and Euler’s work, slip factor and its effect on work input, actual work input, dimension parameters, surging, choking, stalling.</td>
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<table>
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<th>Total Lecture hours:</th>
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**Text Books:**

1. Jagdish Lal, Hydraulic Machines, Metropolitan Book Company
6. R. K. Rajput Hydraulic Machines, S. Chand
7. V. Ganeshan, Gas Turbines, Tata Mcgraw Hill
### Course Name

**Industrial Engineering and Operations Research [IEOR - OEHS]**

<table>
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<th>Course Code</th>
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<tbody>
<tr>
<td>Pre-requisite</td>
<td>Manufacturing Process, Industrial Inspection, Quality Control</td>
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</table>

**Syllabus Version**

V:1.1

### Course Objectives:

**Course prepares students to**

1. Effectively explain production planning and Control functions.
3. Develop mathematical skills to analyse Project Scheduling arising from a wide range of applications.
4. Understand procedure for Replacement and Queuing System analysis.

### Course Outcomes:

**Students will be able to**

1. Analyze different types of production planning functions viz. productivity analysis, Aggregate and Capacity production planning, forecasting, inventory control.
2. Apply method study and work measurements technique to solve industrial problem.
3. Analyze the given Project for optimum schedule and sequence.
4. Analyze the given industrial situation to optimize replacement decision and queuing problem.

### Unit/Module: 1  
**Industrial Engineering, Productivity and PPC**

- **Industrial Engineering**: Objectives, Functions & Tools; Production Systems and Organisation structures: Types, Strategies & Principles
- **Productivity Analysis**: Definition, Factors Affecting the Productivity, Productivity models and index (numerical);
- **Production Planning and Control**: Functions of PPC, Aggregate production planning; Capacity Planning, ERP

### Unit/Module: 2  
**Production Forecasting and Facility Planning**

- **Forecasting Techniques**: Qualitative and Quantitative Methods: Causal and time series models, moving average, exponential smoothing, trend and seasonality (Numerical)
- **Facility Layout Planning**: Factors Influencing, Material Flow Patterns, Tools & Techniques
- **Inventory Control**: Inventory costs, Types of inventory models - Deterministic and Probabilistic, Concept of EOQ, purchase model without shortages (Numerical); ABC and VED Analysis (Numerical).

<table>
<thead>
<tr>
<th>Unit/Module: 3</th>
<th>Method Study and Work Measurements</th>
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<tr>
<td><strong>Method Study</strong>: Definition, objective and procedural steps; activity recording tools, Human factors considerations; Value Engineering</td>
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<tr>
<td><strong>Work measurement</strong>: Definition, objectives and techniques: Time study &amp; Work sampling, (numerical); Synthetic motion studies: PMTS and MTM, MOST</td>
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<th>Unit/Module: 4</th>
<th>Project Scheduling</th>
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<tr>
<td><strong>Critical Path Method (CPM)</strong>: Network Diagram;</td>
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<tr>
<td><strong>Program Evaluation and Review Technique (PERT)</strong>: Problems, Time Cost Trade Off (Crashing),</td>
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<tr>
<td><strong>Jobs Sequencing</strong>: „N” Jobs &amp; 2 / 3 Machines</td>
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<tr>
<td><strong>Jobs Assignment</strong>:</td>
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<table>
<thead>
<tr>
<th>Unit/Module: 5</th>
<th>Replacement and Queuing System analysis</th>
<th>8 hours</th>
<th>CO: 4</th>
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<tbody>
<tr>
<td><strong>Replacement analysis</strong>: Maintenance cost increases with time and the value of money remains same / increases during the period; replacement of items that fail completely and suddenly.</td>
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<tr>
<td><strong>Queuing System analysis</strong>: M / M / 1 / (□/ FIFO); (FCFS/□): (Birth – Death process)</td>
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**Total Lecture hours**: 36 hours

**Text Books:**

3. Industrial engineering and management by O. P. Khanna, Dhanpatrai publication
4. Industrial Engineering , Martend Telsang, S. Chand Publication
5. Industrial Organisation & Engineering Economics by Banga and Sharma, Khanna publication.

**Reference Books:**

<table>
<thead>
<tr>
<th>Course Name</th>
<th>Robotics and Controls Lab</th>
<th>L</th>
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<td>2</td>
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<tr>
<td>Pre-requisite</td>
<td>Engineering Mechanics, Elements of Electrical and Electronics Engineering</td>
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</table>

### Course Objectives:

To familiarize the students with the

1. Basics of robots and robotic manipulator components
2. Control system and controller actions
3. Industrial application of robotics

### Course Outcomes:

Students will be able to

After successful completion of the course, student will be able to

1. Identify the elements of robotics and apply the knowledge to design simple control system.
2. Perform forward and Inverse kinematic analysis of robotic system.
3. Integrate different types of sensors and control the basic robotic motion.
4. Identify and Apply the knowledge of basic concepts of robotic system and its components.

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<table>
<thead>
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<tbody>
<tr>
<td>1</td>
<td>Study components of an industrial robot (PUMA, KUKA, FANUC, MTAB, UR, Etc) and its DH parameters.</td>
</tr>
<tr>
<td>2</td>
<td>Forward kinematics and validation using suitable software (Robo Analyser/ MatLab or any other free software tool).</td>
</tr>
<tr>
<td>3</td>
<td>Inverse kinematics of an industrial robot and validation using any open source software</td>
</tr>
<tr>
<td>4</td>
<td>Integration of assorted sensors (IR, Potentiometer, strain gages etc.), micro controllers in a robotic system. (Free software, Matlab)</td>
</tr>
<tr>
<td>5</td>
<td>Control experiment using available hardware or software. (Open source or Matlab).</td>
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<tr>
<td>6</td>
<td>Tunning of PID Controller for suitable application.</td>
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<tr>
<td>7</td>
<td>Small group project work relevant to Industrial automation.</td>
</tr>
<tr>
<td>8</td>
<td>Industrial visit to any Robotic assembly line or Robot assisted manufacturing.</td>
</tr>
<tr>
<td></td>
<td>Total Lab hours:</td>
</tr>
</tbody>
</table>

**Textbooks:**

1. *Introduction to Robotics*: J. Craig, Pearson
Course Name: Applied Thermodynamics Lab

<table>
<thead>
<tr>
<th>Course Code</th>
<th>20ME602 L</th>
<th>L</th>
<th>T</th>
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<tbody>
<tr>
<td>Prerequisite</td>
<td>Engineering Thermodynamics, Fluid Mechanics, Heat Transfer</td>
<td>Syllabus Version</td>
<td>V:1.1</td>
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</tbody>
</table>

Course Objectives:

1. To study performance parameters of I C Engines.
2. To conduct trial and do performance calculations for reciprocating air compressor
3. To evaluate performance of refrigeration cycles
4. To analyze various psychrometric processes

Course Outcomes:

After successful completion of the course, students will be able to

1. Conduct trial on IC engines and calculate performance parameters.
2. Conduct trial on reciprocating air compressor to ascertain volumetric and isothermal efficiency.
3. Compute performance parameters of vapor compression refrigeration system
4. Perform a trial on air conditioning tutor to understand different psychrometric processes.

Lab Work:

1. Study and trial on petrol engine.
2. Study and trial on Diesel engine
3. Morse Test on multi cylinder petrol/Diesel engine for determination of friction power.
4. Trial on vapor compression test rig.
5. Trial on ice plant test rig.
6. Trial on air conditioning test rig.
7. Trial on two stage reciprocating air compressor.
8. Visit to the air conditioning plant.

Text Books/References:

1. V. Ganesan, Internal Combustion Engines, Tata McGraw Hill
2. M.L. Mathur and R.P. Sharma, A course in Internal Combustion Engines, Dhanpat Rai
<table>
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Course Name | System Dynamics – Modeling and Simulation Lab | L | T | P
---|---|---|---|---
Course Code | 20ME603L | - | - | 2
Prerequisite | 1. Analysis and Synthesis of Mechanisms  
2. Machine Design  
3. Power Train Design | Syllabus Version
Co-requisites: | System Dynamics - Modeling and Simulation | V:1.1

**Course Objectives:**

1. To understand the methods to find natural frequency of system subjected to undamped free vibrations
2. To determine natural frequencies and mode shapes of multiple degree of freedom system
3. To understand the implications of rotating imbalance
4. To explain the features and applications of various dynamic modeling techniques

**Course Outcomes:**

Upon completion of this course, the student will be able to,

1. evaluate the natural frequency of system subjected to un-damped free vibrations
2. determine natural frequencies and mode shapes of multiple degree of freedom system
3. perform experiment of rotating imbalance
4. understand features and applications of various dynamic modeling techniques

**Text Books/References:**


**List of Experiments:**

1. MATLAB and some Functions
2. Data Acquisition Basics + SDOF Undamped
3. Cantilever Beam (SDOF System)
4. SDOF Simulation - MATLAB/SIMULIN - Underdamped Free Vibration
5. SIMULINK Examples and Numerical Methods
6. Air Track SDOF and 2DOF Free Vibration
7. Eigenvalue in MATLAB/Simulation of 2 DOF system
8. Rotating Imbalance
Course Name: Turbo Machines Lab

Course Code: 20ME604L

Pre-requisite: Fluid dynamics

Course Objectives:

To make students

1. To conduct experiments involving various parameters of different turbo machines
2. To calculate hydraulic and overall efficiency of a given hydraulic turbine
3. To Illustrate the characteristics in the graphical form
4. To Compare the results with available characteristic curves and deduce the conclusion from it

Course Outcomes:

Students will be able to

After successful completion of the course, student will be able to

1. conduct experiments involving various parameters of different turbo machines
2. calculate hydraulic and overall efficiency of a given hydraulic turbine
3. Illustrate the characteristics in the graphical form
4. Compare the results with available characteristic curves and deduce the conclusion from it

1. Verification of impulse moment principle using impact of jet on curved vane
2. Study and constant speed trial on impulse water turbine (Pelton wheel) and plotting of main and operating characteristics
3. Study and constant head trial on impulse water turbine (Pelton wheel) and plotting of main and operating characteristics
4. Study and constant speed trial on any hydraulic reaction turbine and plotting of main and operating characteristics
5. Study and constant head trial on any hydraulic reaction turbine and plotting of main and operating characteristics
6. Study and trial on centrifugal pump and plotting operating characteristics Study and trial of rotary compressors.
7. Visit to hydro/steam power plant and report to be submitted.
8. Performance Test on Gear (Oil) Pump Test Rig

Total Lab hours: 20