<table>
<thead>
<tr>
<th>Subject Code</th>
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<th>Duration of Exam in Hours</th>
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<th>CREDITS</th>
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<tbody>
<tr>
<td></td>
<td>Lecture</td>
<td>Practical / FieldWork / Assignment/ Tutorials</td>
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<td>Exam</td>
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<tr>
<td>14MDE11</td>
<td>Applied Mathematics</td>
<td>4</td>
<td>2</td>
<td>3</td>
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<tr>
<td>14MTR12</td>
<td>Fluid Power Automation</td>
<td>4</td>
<td>2</td>
<td>3</td>
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<tr>
<td>14MTR13</td>
<td>Advanced Control Systems</td>
<td>4</td>
<td>2</td>
<td>3</td>
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<tr>
<td>14MTR14</td>
<td>Mechatronics System Design</td>
<td>4</td>
<td>2</td>
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<tr>
<td>Elective-I</td>
<td></td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>50</td>
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<tr>
<td>14MTR16</td>
<td>Mechatronics Engineering Fluid Power Automation Lab 1</td>
<td>--</td>
<td>3</td>
<td>3</td>
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<tr>
<td>14MTR17</td>
<td>Seminar</td>
<td>--</td>
<td>3</td>
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**ELECTIVE-I**

<table>
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<tr>
<th>Subject Code</th>
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<tbody>
<tr>
<td>14MTR 151</td>
<td>Automotive Electronics</td>
<td>14 MTR 153</td>
</tr>
<tr>
<td>14MTR 152</td>
<td>Micro and Smart Systems Technology</td>
<td>14MTR 154</td>
</tr>
</tbody>
</table>
## VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
### SCHEME OF TEACHING AND EXAMINATION FOR
M.TECH. Mechatronics (Tentative)

<table>
<thead>
<tr>
<th>II SEMESTER</th>
<th>Subject Code</th>
<th>Name of the Subject</th>
<th>Teaching hours/week</th>
<th>Duration of Of Exam in Hours</th>
<th>Marks for</th>
<th>Total Marks</th>
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</tr>
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<tr>
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<tr>
<td>14MTR21</td>
<td>Advanced Electronic Drives</td>
<td>4</td>
<td>2</td>
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<tr>
<td>14MTR22</td>
<td>Advanced Embedded Systems</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>50</td>
<td>100</td>
<td>150</td>
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<tr>
<td>14MTR23</td>
<td>Sensors and Signal Conditioning</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>50</td>
<td>100</td>
<td>150</td>
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<tr>
<td>14MST22</td>
<td>Smart Materials and Structures</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>50</td>
<td>100</td>
<td>150</td>
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<tr>
<td>14MTR26</td>
<td>Elective-II</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>50</td>
<td>100</td>
<td>150</td>
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<tr>
<td>14MTR27</td>
<td>Mechatronics Engineering Advanced Control System Lab -2</td>
<td>--</td>
<td>3</td>
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<td>Seminar</td>
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**PROJECT WORK PHASE-I COMMENCEMENT (6 WEEKS DURATION)**

| Total | 20 | 16 | 15 | 300 | 550 | 850 | 23 |

### ELECTIVE-I

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>Name of the Subject</th>
<th>Subject Code</th>
<th>Name of the Subject</th>
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<tbody>
<tr>
<td>14MTR251</td>
<td>Finite Element Methods</td>
<td>14 MTR 253</td>
<td>Product Design</td>
</tr>
<tr>
<td>14MTR 252</td>
<td>Simulation Modelling and Analysis</td>
<td>14MTR 254</td>
<td>Experimental Techniques</td>
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</table>

** Between the II Semester and III Semester, after availing a vacation of 2 weeks.
**III Semester: Internship**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Name of the Subject</th>
<th>Teaching hours/week</th>
<th>Duration of Exam in Hours</th>
<th>Marks for Total Marks</th>
<th>Credits</th>
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<td>Exam</td>
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<tr>
<td>14MTR31</td>
<td>SEMINAR/PRESENTATION ON INTERNSHIP (AFTER 8 WEEKS FROM THE DATE OF COMMENCEMENT)</td>
<td>-</td>
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<tr>
<td>14MTR32</td>
<td>REPORT ON INTERNSHIP</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>14MTR33</td>
<td>INTERNSHIP EVALUATION AND VIVA-VOCE</td>
<td>-</td>
<td>-</td>
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## IV SEMESTER

<table>
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<th>Subject Code</th>
<th>Name of the Subject</th>
<th>Teaching hours/week</th>
<th>Duration of Of Exam in Hours</th>
<th>Marks for</th>
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<th>CREDITS</th>
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<tr>
<td></td>
<td></td>
<td>Lecture</td>
<td>FieldWork / Assignment/ Tutorials</td>
<td></td>
<td>I.A.</td>
<td>Exam</td>
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<tr>
<td>14MTR41</td>
<td>Programmable Logic Controller</td>
<td>4</td>
<td>2</td>
<td>3</td>
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<td>Elective-IV</td>
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<tr>
<td>14MTR43</td>
<td>EVALUATION OF PROJECT WORK PHASE-II</td>
<td>-</td>
<td>2</td>
<td>25</td>
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<td>25</td>
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<tr>
<td>14MTR44</td>
<td>EVALUATION OF PROJECT WORK PHASE-III</td>
<td>-</td>
<td>3</td>
<td>25</td>
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<tr>
<td>14MTR45</td>
<td>EVALUATION OF PROJECT WORK AND VIVA-VOCE</td>
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## ELECTIVE-I

<table>
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<tr>
<th>Subject Code</th>
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<tbody>
<tr>
<td>14MTR 421</td>
<td>Artificial Intelligence and Neural Networks</td>
<td>14 MTR 423 Vibration Analysis</td>
</tr>
<tr>
<td>14MTR 422</td>
<td>Reliability and Failure Analysis</td>
<td>14MTR 424 Nano Technology</td>
</tr>
</tbody>
</table>
1) Project Phase - I: 6 weeks duration shall be carried out between II and III Semesters. Candidates in consultation with the guides shall carryout literature survey / visit to Industries to finalize the topic of dissertation.

2) Project Phase - II: 16 weeks duration. 3 days for project work in a week during III Semester. Evaluation shall be taken during the first two weeks of the IV Semester. Total Marks shall be 25.

3) Project Phase - III: 24 weeks duration in IV Semester. Evaluation shall be taken up during the middle of IV Semester. At the end of the Semester Project Work Evaluation and Viva-Voce Examinations shall be conducted. Total Marks shall be 250 (Phase I Evaluation: 25 Marks, Phase -II Evaluation: 25 Marks, Project Evaluation marks by Internal Examiner( guide): 50, Project Evaluation marks by External Examiner: 50, marks for external and 100 for viva-voce). Marks of Evaluation of Project: I.A. Marks of Project Phase - II & III shall be sent to the University along with Project Work report at the end of the Semester. During the final viva, students have to submit all the reports.

4) The Project Valuation and Viva-Voce will be conducted by a committee consisting of the following:
   a) Head of the Department (Chairman)
   b) Guide
   c) Two Examiners appointed by the university. (out of two external examiners at least one should be present).
The main objectives of the course are to enhance the knowledge of various methods in finding the roots of an algebraic, transcendental or simultaneous system of equations and also to evaluate integrals numerically and differentiation of complex functions with a greater accuracy. These concepts occur frequently in their subjects like finite element method and other design application oriented subjects.

Course Content:


5. Linear Transformation: Introduction to Linear Transformation, The matrix of Linear Transformation, Linear Models in Science and Engineering

**Text Books:**


**Reference Books:**


**Course Outcomes:**

The Student will be able to

1. Model some simple mathematical models of physical Applications.
2. Find the roots of polynomials in Science and Engineering problems.
3. Differentiate and integrate a function for a given set of tabulated data, for Engineering Applications
FLUID POWER AUTOMATION

Sub Code: 14MTR12    IA Marks: 50
Hrs/ Week: 04    Exam Hours: 03
Total Hrs.: 50    Exam Marks: 100

Course Objectives
1. Introduce the various aspects of FPA as applied to engineering problems.
2. Apply the fundamental concepts of fluid power and to obtaining solution to engineering problems.

Course Content:
   Control and regulation elements: Direction flow and pressure control valves-method of actuation, types, sizing of ports-pressure and temperature compensation, overlapped and under lapped spool valves-operating characteristics-electro hydraulic systems, electro hydraulic servo valves- different types characteristics and performance.

   12 Hours

2. Comparison of Hydraulics and Pneumatics: need for Automation, Hydraulic and Pneumatic comparison-ISO symbols for fluid power elements, Hydraulic, pneumatics-Selection criteria and examples related to selection criteria. Advanced Hydraulics: Types of proportional control devices-pressure relief, flow control, directional control, Hydraulic symbols, Spool configurations, electrical operation, Basic electrical circuit and operation, solenoid design, comparison between conventional and proportional valves.

   12 Hours

3. Method of control: Comparison between analogue and digital control, Proportional attributes, Ramp, Gain, dead band, Dither, Pulse width modulation, Amplifier cards, Principles of operation, Design and application, Analogue and digital, Closed loop, Internal and external feedback devices, Operation and application of closed loop system, Integrated electronics option frequency Response, Principles of operation, Bode diagrams and their use in manufacturer’s data, PID control, Practical exercises, Commissioning and set up procedures, open loop circuits, closed loop circuits, Interface to the control.

   8 Hours

4. Electrical Control of Fluid power: Electrical control of Hydraulics and Pneumatics, use of relays, Timers, counters, PLC ladder diagram for various circuits, motion controllers, use of field busses in circuits, Electronic circuits for various open loop control and closed loop (Servo) control of Hydraulics and Pneumatics.
   Circuit Design: Typical industrial hydraulic circuit design methodology- Ladder diagram-cascade, method-truth table- karnaugh map method-sequencing circuits- combinational and logic circuit.

   12 Hours

5. Application of Propositional and Servo Valves: Velocity control, Position control and Directional control and applications example: paper industry, process industry, printing sawmill, wood working, extrusion press, power metallurgical press, continuous casting, Food
and packaging, Injection moulding, Solar energy and automobile.

6 Hours

Text Books:
1. S.R.Majumdar-Pnematic System, TMH, 1995
3. R.Srinivasan, Hydraulic and Pneumatics control published by Vijay Nicole Imprints Private Ltd.

References:
5. Servo Pneumatics D Schilz A Zimmermann.

Course Outcome: The student will be able to understand hydraulic and pneumatic in the field of engineering and this will help him in his projects works.
**Course Objective:** This Syllabus addresses the need for a text that teaches advanced control system from a modern and intuitive perspective. The chosen topics, the order, and the depth and breadth so as to efficiently impart analysis and design principles of control systems that the students will find useful as they enter the industry or graduate school.

1: Mathematical models of Physical systems, Performance specification, Root locus analysis and design, frequency domain analysis and design.

**10 hours**

2: Sampled data control systems – Introduction to control systems, Sampling process; Sample and Hold circuit; Types of signals; Mathematical operation on discrete time signals; Z-transform; Properties of Z-transforms; Inverse Z-transform; Solving the differential equations using Z-transform; and its Applications.

**10 hours**

3: State space analysis- concepts of states; State space formulation; State model of linear system; State diagram and signal flow graph; State-space representation using physical variables-Electrical systems and mechanical translational system; State-space model of Mechanical translational systems and Rotational systems.

**10 hours**

4: Stability, Controllability and Observability- Linear discrete-time systems (LDS); Transfer function of LDS systems; Stability analysis of sampled data control systems using Jury’s stability test, Bilinear transformation and Root locus technique; Similarity transformation; Eigen values and Eigen vectors; Canonical form of state model; Controllability test and Observability test using Gilbert’s method of testing, Kalman’s test and Duality property.

**10 hours**

5: Nonlinear systems- Introduction to Nonlinear systems; common physical nonlinearities; Describing function; Derivation of describing function of dead-zone and saturation nonlinearity; Derivation of describing function of saturation nonlinearity; Derivation of describing function of dead-zone nonlinearity; Derivation of describing function of relay with dead-zone and hysteresis; Derivation of describing function of Backlash nonlinearity; Describing function analysis of nonlinear systems using polar plot and Nichols plot; Phase plane and phase trajectories; Singular points; Stability analysis of nonlinear systems using phase trajectories; Construction of phase trajectories by analytical method, Isocline method, delta method; Jump response; Liapunov’s stability criterion; Popov’s stability criterion.

**10 hours**

**Text Books:**


**REFERENCE BOOKS:**


**Course outcome:**

Students will be

1. Able to analyze various control systems.
2. Able to obtain transfer function of systems using signal flow graph and block diagram reduction.
3. Able to obtain stability of systems.
4. Able to make time domain analysis of control systems.
5. Able to make frequency domain analysis of control systems
MECHATRONICS SYSTEM DESIGN

(Common to MCM, MAR, IAE, MTR)

Sub Code : 14MTR14  IA Marks : 50
Hrs/ Week : 04  Exam Hours : 03
Total Hrs. : 50  Exam Marks : 100

Course Objectives
The course gives exposure to mechatronics system design and knowledge of MEMS and Microsystems

Course Content:

1. **Introduction**: Definition and Introduction to Mechatronic Systems, Measurement Systems, Control Systems, Microprocessors Based Controllers and Applications

   12 Hours

2. **Modeling for mechatronics system design** : Introduction, System, Mechanical System, Electrical System, Fluid system, Thermal System, Engineering system, Translational mechanical system with spring, damper and mass, Rotational mechanical system with spring, damper and mass, Modeling of electric motor, Chamber filled with fluid, Pneumatic actuator.

   10 Hours

MEMS and Microsystems:

 **Materials for MEMS and Microsystems**: Substrate and wafers, Active substrate material, Silicon, Silicon compound, Silicon Piezoresisters, Gallium Arsenide, Quartz, Piezoelectric crystals, Polymers.

   10 Hours


   10 Hours


   8 Hours

Text Books:

2. MEMS and Microsystems design and manufacture. HSU, TMH

Reference Books:

2. Mechatronics - Mahalik, TMH.
3. Mechatronics - HMT, TMH.

Course Outcome:
Students are able to acquaint themselves with the application of mechatronics systems in various engineering applications.
Mechatronics Engineering Fluid Power Automation Laboratory - Lab 1

Subject Code: 14MTR16   IA Marks : 25
Hours/Week : 6     Exam Hours : 03
Total Hours : 84    Exam Marks : 50

Note:
1) These are independent laboratory exercises
2) A student may be given one or two problems stated herein
3) Student must submit a comprehensive report on the problem solved and give a Presentation on the same for Internal Evaluation
4) Any one of the exercises done from the following list has to be asked in the Examination for evaluation.

Exercises:

1: Study of Hydraulic Pump and to draw characteristic curve of variable displacement pump.
2: Single rod cylinder with Pressure In-intensification (Use 4/2 DCV). Exercises on Meter-in Meter-out Circuit.
3: Application Involving 4/3 Direction Control Valve: Open Centre & Closed Center
4: Application Involving 4/3 Direction Control Valve Using motor.
5: Speed Control of Single Acting Cylinder. Slow speed Extension and Rapid Retraction by using pneumatic components.
6: Position Dependent Control of a Pneumatic Double Acting Cylinder with Mechanical Limit Switches.
7: Logical Control with Shuttle and Twin-Pressure Valves of pneumatic components.
8: Sequential Control of Two Double Acting Cylinders without Overlapping Signals.
AUTOMOTIVE ELECTRONICS

Sub code : 14MTR151    IA Marks : 50
Hrs. /Week : 04    Exam Hours : 03
Total Hrs. : 50    Exam Marks : 100

Course objective:
The subject gives deep insight regarding the automotives and the electro mechanical devices used in automobiles.

Course Contents:
1. **Automotive fundamentals overview** – four stroke cycle, engine control, ignition system, spark plug, spark pulse generation, ignition timing, drive train, transmission, brakes, steering system, starting system. **Actuators** – fuel metering actuators, fuel injector, ignition actuator

**Exhaust After – Treatment System** – AIR, catalytic converter, exhaust gas recirculation (EGR), Evaporative emission systems  

2. **Air/ fuel system** – fuel handling, air intake system, air/ fuel management

**Sensors**: Oxygen (O2/EGO) sensors, throttle position sensor (TPS), engine crankshaft angular position (CKP) sensor, magnetic reluctance position sensor, engine speed sensor, ignition timing sensor, hall effect position sensor, shield field sensor, optical crankshaft position sensor, manifold absolute pressure (MAP) sensor-strain gauge and capacitor capsule, Engine coolant temperature (ECT) sensor, intake air temperature (AIT) sensor, knock sensor, airflow rate sensor, throttle angle sensor  

3. **Electronic Engine Control** – engine parameters, variables, engine performance terms, electronic fuel control system, electronic ignition control, idle speed control, EGR control

**vehicle motion control** – cruise control, chassis, power brakes, antilock brake system (ABS), electronic steering control, power steering, traction control, electronically controlled suspension.  

4. **Communication**- serial data, communication systems, protection, body and chassis electrical systems, remote keyless entry, GPS

**Automotive Instrumentation**– sampling, measurement & signal conversion of various parameters. Radar warning system, low tire pressure warning system, radio navigation, advance driver information system  

5. **Integrated body**- climate control systems, electronic HVAC system, Safety systems- SIR, interior safety, lighting, entertainment systems

**Automotive diagnostics** – Timing light, engine analyser, on-board diagnostics, off- board diagnostics, expert systems.  

Reference Books:

Course outcome: Student shall demonstrate the knowledge associated with the automotive electronics.
MICRO AND SMART SYSTEMS TECHNOLOGY

Course Objective:

Knowledge of Micro and Smart system Technology is essential for Mechatronic students and the course aims at training students in smart Mechatronic systems, sensors etc.

Course Content:

1. Introduction:

Micro and smart devices and systems: principles and materials:
   a) Definitions and salient features of sensors, actuators and systems.
   b) Sensors: silicon capacitive accelerometer, piezo-resistive pressure sensor, blood analyser, conductometric gas sensor, fiber-optic gyroscope and surface acoustic – wave based wireless strain sensor.
   c) Actuators: silicon micro-mirror arrays, piezo-electric based inkjet print head, electrostatic com-drive and micromotor, magnetic micro relay, shape memory-alloy based actuator, electro-thermal actuator
   d) Systems: micro gas turbine, portable clinical analyser, active noise control in a helicopter cabin.

2. Micro-manufacturing and material processing:
   a) Silicon wafer processing, lithography, thin-film deposition, etching (wet and dry), wafer-bonding and metallization.
   b) Silicon micromachining: surface, bulk, moulding, bonding based process flows.
   c) Thick-film processing:
   d) Smart material processing:
   e) Processing of other materials: ceramics, polymers and metals
   f) Emerging trends

3. Modelling:
   a) Scaling issues.

Computer-aided simulation and design:

4. Electronics, circuits and control:
Carrier coentartions, semiconductor diodes, transistors, MOSFET amplifiers, operational amplifiers. Basic
Op-Amp circuits. Charge-measuring circuits. Examples from microsystems. Transfer function, state-space modelling, stability, PID controllers, and model order reduction. Examples from smart systems and micromachined accelerometer or a thermal cycler. **08 Hours**

5. **Integration and packing of microelectro mechanical systems:**

**Case studies:**
BEL pressure sensors, thermal cycler for DNA amplification and active vibration control of a beam. **10 Hours**

**Reference Books:**
2. **MEMS Microsystems:** Design and Manufacture, Tai-Ran Tsu, Tata Mc-Graw-Hill

**Course Outcome:**
Students will be able to develop expertise in Micro and smart systems, MEMS micro systems.

**Course Outcome:**
Students will be able to demonstrate their knowledge in Micro and Smart System Technology in Industrial applications.
INDUSTRIAL AUTOMATION

Sub Code:14MTR153  IA Marks:50
Hrs/ Week:04      Exam Hours:03
Total Hrs.:50     Exam Marks:100

Course Objective:

Student belonging to Mechanical as well as Electronics branches of Engineering are made to learn certain fundamental topics related to the Automation Production Systems and Computer Integrated Manufacturing so that they will have minimum understanding of Automation & Control Technologies, Material handling & Quality Control in Manufacturing Systems.

Course Content:


   **12 Hours**


   **10 Hours**


   **12 Hours**


   **8 Hours**


   **8 Hours**

**Text Books**

2. Computer Based Industrial Control, Krishna Kant, EEE-PHI

**References**
1. An Introduction to Automated Process Planning Systems, Tiess Chiu Chang & Richard A. Wysk
3. Principles of CIM by Vajpayee, PHI

**Course Outcome:** Student shall demonstrate the knowledge associated with the Automation in Production & Manufacturing Systems, Automated Assembly & Material handling Systems, Quality & Shop Floor Control Systems, Control Technologies in Automation, Computer Based Industrial Control systems.
MECHATRONIC SYSTEMS IN AUTOMOBILE ENGINEERING

Sub code : 14MTR154
Hrs/week : 04
Total Hrs. : 50
IA Marks : 50
Exam Hours : 03
Exam Marks : 100

Course Objective:

Knowledge of Automobile engineering is essential for Mechatronic students and the course aims at training students in Mechatronic systems in Automotive Industry.

Course Content:


7Hours


7Hours


12Hours

4: Transmission system – clutches-operation and fault finding of clutches, Fluid Flywheel, Gear-Box types, steering systems, chassis springs, suspension. Differential Dead and Live axles, Rims, Tyre etc. Brakes-Types, Construction and fault finding, CMV Rules- Brakes, Steering & Tyre.

12Hours

5: Lubrication systems- Types, components, Lubricating oil, Cooling system –Details of components, study of systems, Types. Miscellaneous- Special gadgets and accessories for fire fighting vehicles. Automobile accidents. CMV Rules regarding safety devices for drivers, passengers.

12Hours

References:

1) William H Crouse, Automobile chassis and body Construction, Operation and Maintenance.
2) William H Crouse, Automobile Machines –Principles and operations.
3) GBS Narang, Automobile Engineering
4) Kirpalsingh, Automobile Engineering.
6) P.L.Kohli Automotive Electrical Equipments.

Course Outcome:

Students will be able to develop expertise in Safety, security and Manufacturing of Mechatronic devices used in Automotive industry.
ADVANCED ELECTRONIC DRIVES

Sub Code: 14MTR21  IA Marks: 50
Hrs/Week: 04  Exam Hours: 03
Total Hours: 50 Exam Marks: 100

Course Objective:
➢ To understand the basics of an electrical drive system.
➢ To develop mathematical models of a drive (DC) system

Course Content:

1. **DC Motors** - Classification, Back EMF equation, Torque equation, Characteristics of shunt, series & compound motors, speed control by armature voltage control, field control, Ward Leonard method.

   **Synchronous machines** - Basic principle of operation, construction of salient & non-salient pole synchronous machines, generated EMF, effect of distribution of winding and use of chorded coils. Voltage regulation, Voltage regulation by EMF, MMF, ZPF & ASA.  

   **10 Hours**


   **10 Hours**


   **10 Hours**


   **10 Hours**

5. **Induction motor & synchronous motor drives**
Operation with unbalanced source voltage and single phasing, operation with unbalanced rotor impedances, Analysis of induction motor fed from non-sinusoidal voltage supply, starting braking, transient analysis, Operation from fixed frequency supply, synchronous motor, Variable speed drives, variable frequency control of multiple synchronous motors.  

   **10 Hours**

**TEXT BOOK:**
REFERENCE BOOKS:

COURSE OUTCOME:
The course will enable the student to describe the structure of a drive system and their role in any application.
Advanced Embedded Systems

Subject Code : 14MTR22
IA Marks : 50
No. of Lecture Hours /week : 04
Exam Hours : 03
Total no. of Lecture Hours : 50
Exam Marks : 100

Course Objective:
Students are made to learn certain fundamental topics related to Embedded Systems, Hardware-Software Design and Real Time operating systems along with the advancements in Embedded World

Course Outcome:

1. **Introduction to Embedded Systems:** Embedded systems Vs. General Computing Systems, Classifications, Major applications.
   
   **Typical Embedded System:** Core of the Embedded System, Memory, Sensors and Actuators, Communication Interface, Embedded Firmware, Other System Components.

   8 Hours


   10 Hours

3. **Embedded Firmware Design and Development:** Embedded Firmware Design Approaches, Embedded Firmware Development Languages (Ch.9.1,9.2)
   
   **The Embedded System Development Environment:** The Integrated Development Environment (IDE), Types of Files Generated on Cross compilation, Disassembler/ELD Compiler, Simulators, Emulators and Debugging, Target Hardware Debugging, Boundary Scan.

   10 Hours

4. **Real-Time Operating System (RTOS) based Embedded System Design:** Operating System Basics, Types of OS, Tasks, Process and Threads, Multiprocessing and Multitasking, Task Scheduling, Threads, Processes and Scheduling: Putting them altogether, Task Communication, Task Synchronization, Device Drivers, How to Choose an RTOS (Programming is limited to illustrative Codes only)

   12 Hours

5. **Introduction to ARM:** Advantages and applications of ARM CORTEX M processors, Software Development Flow, Compilation Flow. General Information about Cortex M3 & M4 Processors, Programmers Model, APSR(Ch 1.2, 1.3, 2.3,2.4,2.5,3.1,4.2,4.3)

   12 Hours

Course Outcome:

Students shall demonstrate the Knowledge associated with,

1. Fundamental components of Embedded Systems for Designing Embedded applications
2. Basics about the use of Real Time Operating systems in Embedded Systems
3. Fair Understanding of applications and Programming Embedded Systems using Keil Software
**Course Objective:** Students are exposed to various sensors and how the signals are measured.

**Course Content:**


2: **Resistive Sensors:** Potentiometers, Strain Gages, Resistive Temperature Detectors (RTDs), Thermistors, Magneto resistors, Light Dependent Resistors (LDRs), Resistive Hygrometers.  


5: **Signal Conditioning for Reactive Variation Sensors:** Problems and Alternatives, AC Bridges, Carrier Amplifiers, variable Oscillators, Resolver – to Digital and Digital-to- Resolvers Converters.


7: **Signal Conditioning for Self-Generating Sensors:** Chopper and Low-Drift Amplifiers, Electrometer Amplifiers, Charge Amplifiers, Noise in Amplifiers.

8: **Digital Sensors:** Position Encoders, Variable Frequency Sensors.

9: **Other Transduction Methods:** Sensors based on Semiconductors Junctions, Sensors based on MOSFET Transistors, Charge-Coupled Sensors, Ultrasonic- based Sensors, Fiber-Optic Sensors.

10: **Telemetry and Data Acquisition:** Data- Acquisition System Structure, Telemetry Systems, Amplitude Telemetry, Frequency Telemetry.


**Course Outcome:** Students get the expertise in various aspects of sensors and also the types of sensors and their signal conditioning, the knowledge can be later used in their project works.
Course Objective:

Knowledge of smart materials and structures is essential designing mechanical systems for advanced engineering applications, the course aims at training students in smart materials and structures application and analysis.

Course Content:

1. **Smart Structures**: Types of Smart Structures, Potential Feasibility of Smart Structures, Key Elements Of Smart Structures, Applications of Smart Structures. Piezoelectric materials, Properties, piezoelectric Constitutive Relations, Depoling and Coersive Field, field strain relation. Hysteresis, Creep and Strain Rate effects, Inchworm Linear Motor.

2. **Shape memory Alloy**: Experimental Phenomenology, Shape Memory Effect, Phase Transformation, Tanaka’s Constitutive Model, testing of SMA Wires, Vibration Control through SMA, Multiplexing. Applications Of SMA and Problems. 12 Hours

3. **ER and MR Fluids**: Mechanisms and properties, Fluid Composition and behavior, The Bingham Plastic and Related Models, Pre-Yield Response,Post-Yield flow applications in Clatches, Dampers and Others. 13 Hours

4. **Vibration Absorbers**: series and Parallel Damped Vibrations (OverView), Active Vibration Absorbers, Fiber Optics, Physical Phenomena, Characteristics, Sensors, Fiber Optics in Crack Detection, applications. 13 Hours

5. **Control of Structures**: Modeling, Control Strategies and Limitations, Active Structures in Practice. 13 Hours


7. **Devices**: Sensors and Actuators, Conductivity of Semiconductors, Crystal Planes and Orientation, (Stress and Strain Relations, Flexural Beam Bending Analysis Under Simple Loading Conditions), Polymers in MEMS, Optical MEMS Applications. 6 Hours

**TEXT BOOKS**:


REFERENCE BOOKS:


Course Outcome:
At the completion of this course, students will be able to:
1) Understand the behavior and applicability of various smart materials
2) Design simple models for smart structures & materials
3) Perform simulations of smart structures & materials application
4) Conduct experiments to verify the predictions
Mechatronics Engineering Advanced Control System Laboratory - Lab 2

Subject Code: 14MTR26 IA Marks : 25
Hours/Week : 6 Exam Hours : 03
Total Hours : 84 Exam Marks : 50

Note:

5) These are independent laboratory exercises
6) A student may be given one or two problems stated herein
7) Student must submit a comprehensive report on the problem solved and give a Presentation on the same for Internal Evaluation

8) Any one of the exercises done from the following list has to be asked in the Examination for evaluation.
9) Computer programme can be developed in ‘C’ or MATLAB.
10) MATLAB Simulink can be used wherever applicable.

1. Mathematical models of physical systems in the design and analysis of control systems.
2. To study the effect of P, PI, PID controllers using Matlab.
3. To analyse the stability of linear systems using Bode, Root locus, Nyquist plots.
4. To calculate an impulse response of a system described by difference equation
   \[ y[n]+0.7y[n-1]-0.45y[n-2]-0.6y[n-3] = 0.8x[n]-0.44x[n-1]+0.36x[n-2]+0.02x[n-3] \]
5. Question based on response of LTI systems to different inputs. A LTI system is defined by the difference equation \( y[n]=x[n]+x[n+1]+x[n+2] \).
   (a) determine the impulse response of the system and sketch it.
   (b) determine the output \( y[n] \) of the system when the input is \( x[n]=u[n] \).
   (c) Determine the output of the system when the input is a complex exponential (E.g. \( x[n]=2^\ast\exp(j0.26n) \)).
6. Comparison of DFT and DCT (in terms of energy compactness) Generate the sequence \( x[n]=(n-64) \) for \( n=0,...,127 \).
   (a) Let \( X[k]=\text{DFT}\{x[n]\} \). For various values of \( L \), set to zero "high frequency coefficients" \( X[64-1]=....X[64]=......X[64+L]=0 \) and take the inverse DFT. Plot the results.
   (b) Let \( \text{XDCT}[k]=\text{DCT}(X[n]) \). For the same values of \( L \), set to zero "high frequency coefficient" \( \text{XDCT}[127-L]=....\text{XDCT}[127] \). Take the inverse DCT for each case and compare the reconstruction with the previous case.
7. Develop programmes in C or MATLAB to solve \( \frac{\partial u}{\partial t} = \alpha \frac{\partial^2 u}{\partial x^2} \) and draw the characteristic curves for various boundary conditions. Use Lasooen Model.
8. Develop programmes in C or MATLAB to solve \( \frac{\partial u}{\partial t} = \alpha \frac{\partial^2 u}{\partial x^2} \) and draw the characteristic curves for various boundary conditions. Use Crank Nicholsen Model.
FINITE ELEMENT METHOD

(Common to MDE, MEA, MMD, CAE, MTR)

Sub Code : 14MTR251 IA Marks : 50
Hrs/ Week : 04 Exam Hours : 03
Total Hrs: 50 Exam Marks : 100

Course Objectives

1. To present the Finite element method (FEM) as a numerical method for engineering analysis of continua and structures
2. To present Finite element formulation using variational and weighted residual approaches
3. To present Finite elements for the analysis of bars & trusses, beams & frames, plane stress & plane strain problems and 3-D solids, for thermal and dynamics problems.

Course Content:

1. **Introduction to Finite Element Method:** Basic Steps in Finite Element Method to solve mechanical engineering (Solid, Fluid and Heat Transfer) problems: Functional approach and Galerkin approach, Displacement Approach: Admissible Functions, Convergence Criteria: Conforming and Non Conforming elements, \( C_0 \), \( C_1 \) and \( C_n \) Continuity Elements. Basic Equations, Element Characteristic Equations, Assembly Procedure, Boundary and Constraint Conditions.
   **10 Hours.**

2. **Solid Mechanics : One-Dimensional Finite Element Formulations and Analysis** – Bars- uniform, varying and stepped cross section- Basic (Linear) and Higher Order Elements Formulations for Axial, Torsional and Temperature Loads with problems. Beams- Basic (Linear) Element Formulation for uniform, varying and stepped cross section- for different loading and boundary conditions with problems. Trusses, Plane Frames and Space Frame Basic (Linear) Elements Formulations for different boundary condition - Axial, Bending, Torsional, and Temperature Loads with problems.
   **10 Hours.**

3. **Two Dimensional Finite Element Formulations for Solid Mechanics Problems:** Triangular Membrane (TRIA 3, TRIA 6, TRIA 10) Element, Four-Noded Quadrilateral Membrane (QUAD 4, QUAD 8) Element Formulations for in-plane loading with sample problems. Triangular and Quadrilateral Axi-symmetric basic and higher order Elements formulation for axi-symmetric loading only with sample problems
   **Three Dimensional Finite Element Formulations for Solid Mechanics Problems:** Finite Element Formulation of Tetrahedral Element (TET 4, TET 10), Hexahedral...
Element (HEXA 8, HEXA 20), for different loading conditions. Serendipity and Lagrange family Elements

4. **Finite Element Formulations for Structural Mechanics Problems:** Basics of plates and shell theories: Classical thin plate Theory, Shear deformation Theory and Thick Plate theory. Finite Element Formulations for triangular and quadrilateral Plate elements. Finite element formulation of flat, curved, cylindrical and conical Shell elements

5. **Dynamic Analysis:** Finite Element Formulation for point/lumped mass and distributed masses system, Finite Element Formulation of one dimensional dynamic analysis: bar, truss, frame and beam element. Finite Element Formulation of Two dimensional dynamic analysis: triangular membrane and axisymmetric element, quadrilateral membrane and axisymmetric element. Evaluation of eigen values and eigen vectors applicable to bars, shaft, beams, plane and space frame.

10 Hours.

**Text Books:**

**Reference Books:**

**Course Outcome:**

On completion of the course the student will be
1. Knowledgeable about the FEM as a numerical method for the solution of solid mechanics, structural mechanics and thermal problems
2. Developing skills required to use a commercial FEA software
## Course Objectives

1. Introduce the various aspects of simulation and modelling as applied to engineering problems.
2. Apply the fundamental concepts of simulation methods to solve simple problems.

## Course Content:

### 1. Introduction:
- Nature of Computer - modelling and simulation. Limitations of simulation, areas of applications.
- System and Environment: Components of a system – discrete and continuous systems, Models of a system – a variety of modelling approaches.

10 Hours

### 2. Discrete Event Simulation:
- Concepts in discrete event simulation, manual simulation using event scheduling, single channel queue, two server queue, simulation of inventory problem.
- Statistical Models in simulation: Discrete distributions, continuous distributions, Numericals.

12 Hours

### 3. Random Number Generation:

8 Hours

### 4. Random Variate Generation:
- Inversion transforms technique – exponential distribution.
- Uniform distribution, weibul distribution, continuous distribution, generating, approximate normal variates – Erlang distribution.

12 Hours

### 5. Design and Evaluation of Simulation Experiments:
- Variance reduction techniques – antithetic variables, variables – verification and validation of simulation models, simulation software and packages.

8 Hours

## Text Books:


## Reference Books:


## Course outcome:
Student will get expertise and will be able to write programme to simulate for the real problems in mechanical and electronics branch of engineering.
PRODUCT DESIGN

Sub Code   : 14MTR253     IA Marks      : 50
Hrs/ Week : 04      Exam Hours  : 03
Total Hrs   : 50      Exam Marks : 100

Course objective:
Student are trained regarding Process, planning and product development techniques practiced in Industries.

Course Content:
1 : DEVELOPMENT PROCESSES AND ORGANIZATION : Characteristics of successful product development, Design and development of product, Duration and cost of product development, the challenges of product development, A generic development process, concept development: the front-end process, adopting the generic product development process, the AMF development process, product development organization, the AMF organization. 06 Hours

2: PRODUCT PLANNING, IDENTIFYING CUSTOMER NEEDS AND PRODUCT SPECIFICATION: The product planning process, identifying opportunities, Evaluate and prioritize projects, allocate resources and plan timing, complete pre project planning, reflect all the results and process. Gather raw data from customers, interpret raw data in terms of customer needs, organize the needs into a hierarchy, establish the relative importance of the needs and reflect on the results and the process. What are specifications, when are specifications establishing target specifications, setting the final specifications. 08 Hours

3: CONCEPT GENERATION, SELECTION AND TESTING:
The activities of concept generation clarify the problem, search externally, search internally, explore systematically, reflect on the results and the process. Overview of concept selection methodology, concept screening, and concept scoring, Definition and the purpose of concept test, choose a survey population, choose a survey format, communication the concept, measure customer response, interpret the result, reflect on the results and the process.

PRODUCT ARCHITECTURE:
What is product Architecture, implications of the Architecture, Establishing the Architecture, Variety and supply chain considerations, platform planning, and related system level design issues. 12 Hours

4: INDUSTRIAL DESIGN: Assessing the need for industrial design, the impact of industrial design, industrial design process, managing the industrial design process, assessing the quality of industrial design.

DESIGN FOR MANUFACTURING AND PROTOTYPING: Definition, estimation of manufacturing cost, reducing the cost of components, assembly, supporting production
basics, principles of prototyping, technologies, planning for prototypes.

5: PRODUCT DEVELOPMENT: Elements of economic analysis, base case financial mode, sensitive analysis, project trade-offs, influence of qualitative factors on project success, qualitative analysis.

MANAGING PROJECTS: Understanding and representing task, baseline project planning, accelerating projects, project execution, postmortem project evaluation.

Reference Book:
Product Design and Development by Karl T Ulrich, Steven D Eppinger, Anita Goyal.

Course outcome:
Students get the expertise in various aspects of process planning, product development, managing projects and prototype manufacturing.
EXPERIMENTAL TECHNIQUES

Sub Code : 14MTR254   IA Marks : 50
Hrs/week : 04   Exam Hours : 03
Total Hrs. : 50   Exam Marks : 100

Course objective:
Student will learn the experimental technique, objectives, design and formulation of problems and its analysis.

Course Content:
1. Introduction – Multivariate analysis, the variate, measurement scales, measurement error and multivariate measurement, types of multivariate techniques, multiple regression, multivariate analysis of variance and covariance.

2. A structured approach to multivariate model building – define the research problem, objectives and multivariate technique to be used, develop the analysis plan, evaluate the assumptions underlying the technique, estimate the multivariate model and assess the model fit, interpret the variate, validate the model.
Examining the data – graphical examination of the data, Missing data, approaches to dealing with missing data.


4. Multiple Regression Analysis – Objectives of multiple regression, research design, assumptions, estimating the regression model, assessing fit, interpretation and validation.
Multiple Discriminant Analysis and Logistic Regression – Decision process for discriminant analysis, Objectives, Research design, assumptions, model estimation, interpretation and validation of results.

5. Interdependence Techniques – Cluster Analysis – Objectives, research design, assumptions, deriving clusters and assessing fit, interpretation and validation.
Multidimensional scaling – Objectives of MDS, Research design, assumptions, deriving the solution and assessing overall fit, interpreting and validating the results.

Text Books:
   Recommended software: SPSS, Systat 10.2

Course Outcome:
Student will get expertise in graphical examination of the data, Missing data, interpreting the factors and validation of factor analysis, Research design, assumptions, model estimation, interpretation and validation of results.
Programmable Logic Controllers (PLCs)

Subject Code: 14MTR41  
IA Marks: 50
No. of Lecture Hours /week: 04  
Exam Hours: 03
Total no. of Lecture Hours: 50  
Exam Marks: 100

Course Objectives:
The course aims at giving exposure to students on Industrial drives and Controls used in Automation.

Course Content:

2. Introduction To Logic: Equivalent ladder Diagram Of AND Gate, Equivalent ladder Diagram Of OR Gate, Equivalent ladder Diagram Of NOT Gate, Equivalent ladder Diagram Of XOR Gate, Equivalent ladder Diagram Of NAND Gate, Equivalent ladder Diagram Of NOR Gate. Equivalent ladder Diagram To Demonstrate De Morgan Theorem, Ladder Design. Timer And Its Classification: Characteristics Of PLC Timer, Functions In Timer, Resetting Retentive And Non-Retentive, Classification Of PLC Timer, Or Delay And Off Delay Timers Timer-On Delay, Timer Off Delay, Retentive And Non-Retentive Timers, Format of a Timer Instruction.

3. PLC Counter: Operation Of PLC Counter, Counter Parameters, Counter Instructions Overview Count Up (CTU) Count Down (CTD). Introduction to Comparison Instructions, Discussions On Comparison Instructions, “EQUAL.” or "EQU" Instruction, "NOT EQUAL" or "NEQ" Instruction, "LESS THAN" or "LES" Instruction, "LESS THAN OR EQUAL" or "LEQ" Instruction, GREATER THAN" or "GRT" Instruction, "GREATER THAN OR EQUAL TO" or "GRQ" Instruction, "MASKED COMPARISON FOR EQUAL" or "MEQ" Instruction, "LIMIT TEST" or "LIM" Instruction. Addressing Data Files: Format Of Logical Address. Addressing Format For Micrologic System.

5. INDUSTRIAL COMMUNICATION AND NETWORKING


Reference Books:
1. Cite Address : www.equinoxac.co.uk
2. 'Basic PLC Course (Programmable Logic Controller)’, MohdShafiekYaacob, Pearson, 2006.
3. Cite Address: PLCs, ELOSTZ.com

Course Outcome:

Student will get expertise in PLC & industrial applications, different PLC hardware/ software.
ARTIFICIAL INTELLIGENCE & NEURAL NETWORKS

Subject Code : 14MTR4511A Marks: 50
No. of Lecture Hours /week : 04 Exam Hours: 03
Total no. of Lecture Hours :50 Exam Marks : 100

Course Objectives

1. Introduce the various aspects of Neural network as applied to engineering problems.
2. Apply the fundamental concepts of Artificial intelligence and Neural network to mechanical and electronics problems

Course Content:

1: Introduction, history, structure and function of single neuron, neural network architectures, neural learning, use of neural networks. Supervised learning, single layer networks, perceptions, linear separability, perceptions training algorithm, guarantees of success, modifications. 10 Hours

2: Multiclass networks-I, multilevel discrimination, preliminaries, back propagation, setting parameter values, theoretical results. 10 Hours


4: Learning vector quantizing, counter propagation networks, adaptive resonance theorem, topologically organized networks, distance based learning, neo-cognition. 10 Hours

5: Associative models, hop field networks, brain state networks, Boltzmann machines, hetero associations. Optimization using hop filed networks, simulated annealing, randomsearch, evolutionary computation. 10 Hours

TEXTBOOK:

REFERENCE BOOKS:

Course Outcome:

Students will be able to

1. Define the problems in Mechatronics.
2. Apply Neural network to solve the problems.
3. Develop skill to develop models in artificial intelligence
Course Objectives:

The Student will learn reliability and failure concept that can be used in finding solutions to many engineering problems and in formulating models to represent engineering applications.

Course Content:

1. Reliability definition: introduction, definition, failure data, mean failure rate, mean time to failure, mean time between failure, graphical plots, four important points, MTTF in terms of failure density, generalization, reliability in terms of hazard rate and failure density, integral form, mean time to failure in integral form, reliability in other situations.
   7 Hours

2. Hazard models; constant hazard, linearly increasing hazard, the Weibull model, density function and distribution function, distribution function and reliability analysis, some important distributions, choice of distribution, expected value, standard deviation and variance, theorems concerning expectation and variance.
   7 Hours

3. Conditional probabilities and multiplication rule, independent events, venn diagrams-sample space, probability calculation by venn diagrams, system reliability, series configuration, parallel and mixed configuration, application to specific hazard models, anr-out-of-n structure, method of solving complex system, system not reducible to mixed configurations, mean time to failure of systems, logic diagrams, markov models, markov graphs, system subjected to probability laws.
   12 hours

4. Reliability improvement, improvement of components, redundancy, element redundancy, unit redundancy, stand by redundancy, optimization, reliability-cost trade-off, fault tree analysis and other techniques, fault free construction, calculation of reliability from fault tree, tie-set and cut-set, use of Boolean algebra, basic operations, truth tables, demorgan’s theorem, application to reliability analysis, probability calculations.
   12 Hours

5. Maintainability, availability(qualitative aspects) system down time, availability, reliability and maintainability trade-off, instantaneous repair rate, mean time to repair, reliability and availability functions, reliability allocation and applications, reliability allocation for a series system, applications, marine power plant, computer system, nuclear power plants, general complex systems, failure modes and effect analysis.
   12 Hours

Text Books:

Reference Books


Course Outcome:

Students will be able to formulate models to address real life issues in Industrial applications.
Course objectives:
The course aims at giving exposure to students on basic concepts of free vibration, degrees of freedom, damping, natural frequency, impulse excitation, arbitrary excitation, laplace transform etc.

Course Content:

2: Vibration Control: introduction, vibration isolation theory, vibration isolation theory for harmonic excitation, practical aspects of vibration analysis, shock isolation, dynamic vibration absorbers, vibration dampers. Vibration measurement and applications: introduction, transducers, vibration pickups, frequency measuring instruments, vibration exciters, signal analysis. 11 Hours


4: Random Vibrations: random phenomenon, time averaging and expected value, frequency response function, probability distribution, correlation, power spectrum and power spectral density, Fourier transforms, FTs and response. 06 Hours

5: Continuous System: vibrating string, longitudinal vibration of rods, torsional vibration of rods, suspension bridge as continuous system, Euler equation for beams, vibration of membrane. 10 Hours

Text Books:

Reference Book:

Course Outcome:
Students should be able to understand:

1. basics of vibration analysis, vibration control and measurement techniques
2. monitoring of machine condition and fault diagnosis techniques.
3. about nonlinear vibration and random vibrations and their causes.
NanoTechnology

Course Objective:
To provide exposure to principles of nanotechnology; characterization of nanostructured materials; and its applications

Course Content:

09 Hours

Unit 2: Effect of Nanometer Length Scale: changes to the system total energy. Changes to the system structure. How nanoscale dimensions affect properties. – Structural, thermal, chemical, mechanical, magnetic, optical and electrical. Semiconductor physics – to understand inorganic semiconductor structures: what is a semiconductor? Doping, the concept of effective mass, carrier transport, mobility and electrical conductivity, optical property of semiconductors, excitations, the pn junction, phonons, types of semiconductors, quantum confinement in semiconductor nanostructures, in two dimensions: quantum wires. Quantum confinement in three dimensions: quantum dots, superlattices, band offsets.

07 Hours


16 Hours

10Hours

Unit 5: Nanotribology Composition and Structure of Surface Natural Condition: oxide and hydrocarbon films surface segregation and reaction with environments, thermodynamics structure of surfaces, atomistic simulations methods to study composition and structure of surfaces, decomposition – auger electron spectroscopy, x-ray photoelectron spectroscopy, structure, LEED, STM/AFM XRD, HREM. Chemical interactions on surfaces, adsorption and deposition on surfaces (physisorption and chemisorption), Langmuir adsorption isothenn, desorption from surfaces: electronic properties and surface reactions relevant to tribology, density functional studies analysis of structure sensitivity lubricant degradation. Nanomechanical properties: determination of surface mechanical properties (AFM/nanoindentation) simple friction theories effects of surface composition and structure on friction, environmental and temperature effects, relationship with surface chemistry, mixed and boundary lubrication, failure mechanisms.

10Hours

TEXT BOOKS

REFERENCE BOOKS:

Course Outcome:
Students will be able to demonstrate their understanding of basics of nanoscience and technology and the concept nanoscale and nanostructure.