Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

### Group-1

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>SUBJECT CODE</th>
<th>SUBJECT TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16MDE11</td>
<td>Applied Mathematics</td>
</tr>
<tr>
<td>2</td>
<td>16MCM12</td>
<td>Automation &amp; Comp. Integrated Manufacturing</td>
</tr>
<tr>
<td>3</td>
<td>16MCM13</td>
<td>Computer Aided Design</td>
</tr>
<tr>
<td>4</td>
<td>16MCM151</td>
<td>Finite Element Method</td>
</tr>
<tr>
<td>5</td>
<td>16MCM152</td>
<td>Artificial Intelligence &amp; Expert Systems</td>
</tr>
<tr>
<td>6</td>
<td>16MDE152</td>
<td>Computer Applications in Design</td>
</tr>
<tr>
<td>7</td>
<td>16MDE153</td>
<td>Mechatronics System Design</td>
</tr>
<tr>
<td>8</td>
<td>16MAR21a</td>
<td>Robotics for Industrial Automation</td>
</tr>
<tr>
<td>9</td>
<td>16MST424</td>
<td>Experimental Methods in Engineering</td>
</tr>
<tr>
<td>10</td>
<td>16MCS24</td>
<td>Modeling &amp; Simulation</td>
</tr>
<tr>
<td>11</td>
<td>16MTR153</td>
<td>Industrial Automation</td>
</tr>
<tr>
<td>12</td>
<td>16MTR22</td>
<td>Advanced Embedded System</td>
</tr>
<tr>
<td>13</td>
<td>16MTR41</td>
<td>Programmable Logic Controller</td>
</tr>
<tr>
<td>14</td>
<td>16MTR12</td>
<td>Fluid Power Automation</td>
</tr>
</tbody>
</table>

### Group-2

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>SUBJECT CODE</th>
<th>SUBJECT TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16MCS11</td>
<td>Advanced Mathematics</td>
</tr>
<tr>
<td>2</td>
<td>16MDE12</td>
<td>Finite Element Method</td>
</tr>
<tr>
<td>3</td>
<td>16CAE13</td>
<td>Continuum Mechanics</td>
</tr>
<tr>
<td>4</td>
<td>16CAE14</td>
<td>Experimental Mechanics</td>
</tr>
<tr>
<td>5</td>
<td>16MDE151</td>
<td>Computer Graphics</td>
</tr>
<tr>
<td>6</td>
<td>16MST22</td>
<td>Smart Materials &amp; Structures</td>
</tr>
<tr>
<td>7</td>
<td>16MAR156</td>
<td>Modern Control Engineering</td>
</tr>
<tr>
<td>8</td>
<td>16CAE421</td>
<td>Fracture Mechanics</td>
</tr>
<tr>
<td>9</td>
<td>16MDE22</td>
<td>Advanced Machine Design</td>
</tr>
<tr>
<td>10</td>
<td>16MCM422</td>
<td>Dynamics &amp; Mechanism Design</td>
</tr>
<tr>
<td>11</td>
<td>16MMD41</td>
<td>Tribology and Bearing Design</td>
</tr>
<tr>
<td>12</td>
<td>16MDE24</td>
<td>Advanced Theory of Vibrations</td>
</tr>
<tr>
<td>13</td>
<td>16MDE254</td>
<td>Rotor Dynamics</td>
</tr>
<tr>
<td>14</td>
<td>16MTR254</td>
<td>Experimental Techniques</td>
</tr>
</tbody>
</table>
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>SUBJECT CODE</th>
<th>SUBJECT TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16MTP13</td>
<td>Advanced Fluid Mechanics</td>
</tr>
<tr>
<td>2</td>
<td>16MTP14</td>
<td>Thermodynamics &amp; Combustion Engineering</td>
</tr>
<tr>
<td>3</td>
<td>16MTP151</td>
<td>Nonconventional Energy System</td>
</tr>
<tr>
<td>4</td>
<td>16MTP154</td>
<td>Refrigeration and Air Conditioning</td>
</tr>
<tr>
<td>5</td>
<td>16MTP41</td>
<td>Design of heat Transfer Equipment for Thermal Power production</td>
</tr>
<tr>
<td>6</td>
<td>16MCS154</td>
<td>Solar Energy Engineering</td>
</tr>
<tr>
<td>7</td>
<td>16MTP252</td>
<td>Alternate Fuels for IC Engines</td>
</tr>
<tr>
<td>8</td>
<td>16MTP421</td>
<td>Convective Heat and Mass Transfer</td>
</tr>
<tr>
<td>9</td>
<td>16MTP422</td>
<td>Engine Flow &amp; Combustion</td>
</tr>
<tr>
<td>10</td>
<td>16MTP423</td>
<td>Design &amp; Analysis of Thermal Systems</td>
</tr>
<tr>
<td>11</td>
<td>16MTP424</td>
<td>Experimental Methods in Thermal Power Engineering</td>
</tr>
<tr>
<td>12</td>
<td>16MTP21</td>
<td>Advanced Heat Transfer</td>
</tr>
<tr>
<td>13</td>
<td>16MCS421</td>
<td>Wind Energy Engineering</td>
</tr>
<tr>
<td>14</td>
<td>16MTP23</td>
<td>Advanced Power Plant Cycles</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>SUBJECT CODE</th>
<th>SUBJECT TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16MST14</td>
<td>Nano Science and Nano Materials</td>
</tr>
<tr>
<td>2</td>
<td>16MST151</td>
<td>Advances in Materials and Processing</td>
</tr>
<tr>
<td>3</td>
<td>16MST152</td>
<td>Advanced Foundry Technology</td>
</tr>
<tr>
<td>4</td>
<td>16MST21</td>
<td>Composite Materials Technology</td>
</tr>
<tr>
<td>5</td>
<td>16MST41</td>
<td>Plastic Processing</td>
</tr>
<tr>
<td>6</td>
<td>16MST13</td>
<td>Materials for Cryogenic &amp; High Temperature</td>
</tr>
<tr>
<td>7</td>
<td>16MST23</td>
<td>Testing of Materials</td>
</tr>
<tr>
<td>8</td>
<td>16MCS254</td>
<td>Nano Technology</td>
</tr>
<tr>
<td>9</td>
<td>16MCS423</td>
<td>Analysis &amp; Design of Composites</td>
</tr>
<tr>
<td>10</td>
<td>16MST153</td>
<td>Non Destructive Testing</td>
</tr>
<tr>
<td>11</td>
<td>16MST422</td>
<td>Bio Materials &amp; Technology</td>
</tr>
<tr>
<td>12</td>
<td>16MST423</td>
<td>Mechanical Behavior of Materials</td>
</tr>
<tr>
<td>13</td>
<td>16MST251</td>
<td>Surface Treatment And Finishing</td>
</tr>
<tr>
<td>14</td>
<td>16MST154</td>
<td>Selection of Materials in Engineering</td>
</tr>
</tbody>
</table>
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>Group-5</th>
<th>Sl. No.</th>
<th>SUBJECT CODE</th>
<th>SUBJECT TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>16MTR423</td>
<td>Vibration Analysis</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>16MTR13</td>
<td>Advanced Control Systems</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>16MTR154</td>
<td>Mechatronics System in Automobile</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>16MTR151</td>
<td>Automotive Electronics</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>16MTR251</td>
<td>Finite Element Methods</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>16MAR424</td>
<td>Concurrent Engineering for Manufacturing</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>16MEA 424</td>
<td>Computational Fluid Dynamics</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>16MTR152</td>
<td>Micro and Smart Systems Technology</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>16MCM22</td>
<td>Flexible Manufacturing Systems</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>16MST421</td>
<td>Modeling, Simulation &amp; Analysis of</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>16CAE251</td>
<td>Design Optimization</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>16MTR421</td>
<td>Artificial Intelligence and Neural Networks</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>16MTR21</td>
<td>Advanced Electronic Drives</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>16MTR23</td>
<td>Sensor and Signal Conditioning</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group-6</th>
<th>Sl. No.</th>
<th>SUBJECT CODE</th>
<th>SUBJECT TITLE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>16MCM153</td>
<td>Rapid Prototyping</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>16MCM154</td>
<td>Agile Manufacturing</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>16MAR155</td>
<td>Modeling of Management Information Systems</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>16MTR253</td>
<td>Product Design</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>16MCS253</td>
<td>Projects Analysis and Management</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>16MDE154</td>
<td>Design for Manufacture</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>16MTR422</td>
<td>Reliability and Failure Analysis</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>16MTP152</td>
<td>Nuclear Energy Conservation</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>16MCM252</td>
<td>Concurrent Engineering &amp; Product Life Cycle</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>16MAR23a</td>
<td>Computer Control of Manufacturing Systems</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>16MCS13</td>
<td>Optimization Techniques</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>16MAR423</td>
<td>Tooling for Manufacture in Automation</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>16MAR14a</td>
<td>Automation in Manufacturing Systems</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>16MAR421</td>
<td>Production Planning and Control</td>
</tr>
</tbody>
</table>
# APPLIED MATHEMATICS

<table>
<thead>
<tr>
<th>Exam Hours:03</th>
<th>Exam Marks:100</th>
</tr>
</thead>
</table>

## Modules


## Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

## Text Books:

## Reference Books:
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>02</th>
<th>16MCM12</th>
<th>Group-1</th>
<th>AUTOMATION AND COMPUTER INTEGRATED MANUFACTURING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Exam Hours:03   Exam Marks:100</td>
</tr>
</tbody>
</table>

**MODULE 1**

**MODULE 2**
Detroit Type of Automation: Flow lines, Different Transfer Mechanisms, work pattern transfer, Different methods.

**MODULE 3**
Analysis of Automated flow lines: Analysis of transfer lines without storage, with storage buffer, single stage, Double stage, Multistage with problems, Automated assembly systems, Design for automated assembly, parts feeding devices.
Computer Process Monitoring: Process control methods, direct digital control, supervisory computer control, steady state optimal control, on line search strategies, adaptive control.

**MODULE 4**
Automated Material Handling and Storage: Material functions, types of material handling equipment, analysis of material handling systems, design of system, conveyor system, automated guided vehicle systems, automated storage/retrieval systems, caroused storage systems, work in process storage, interfacing handling & storage with manufacturing.

**MODULE 5**
Robotics in Material Handling
General considerations in robot material handling – material transfer application – pick &place operations – machine loading & unloading – characteristics of robot application.
Computer Aided Quality Control: The computer in Q.C, automated inspection principles and methods, Contact inspection methods, non-contact inspection methods, machine vision system, optical inspection method, sensors, coordinate measuring machine.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**
1. CAD/CAM – Zimmers& Grover, PHI.
2. CAD/CAM/CIM – P. Radhakrishna, New Age Internationa l.

**REFERENCE BOOKS:**
1. CAD/CAM – Zeid, Mc-Graw Hill
2. CAD/Cam, P. N. Rao.
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>03</th>
<th>16MCM13</th>
<th>Group-1</th>
<th>COMPUTER AIDED DESIGN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Exam Hours:03 Exam Marks:100</td>
</tr>
</tbody>
</table>

**MODULE 1**

**MODULE 2**
Transformations-Translation, Scaling, Reflection or Mirror, Rotation, Concatenations, Homogeneous Transformation, 3D Transformations-Translation, Scaling, Rotation about, X, Y and Z axes, Mathematics of Projections- Orthographic and Isometric Projections. Clipping, Hidden Line or Surface removal, Color and Shading.

**MODULE 3**
GEOMETRIC MODELING: Requirements of Geometric Modeling, Geometric Models, Geometric Construction Methods, Constraint- Based Modeling.

**MODULE 4**

**MODULE 5**
VIRTUAL AND RAPID PROTOTYPING: Introduction to Virtual modeling, Rapid prototyping, RP data formats and Information workflow, Classifications of RP, Process involving Liquid, discrete particle and solid sheet of standard methods of each, Technical characteristics of standard methods. Applications of RP.

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**
2. Ibrahim Zeid & R.Shivasubramanian, CAD/CAM Theory & Practice, 2nd Ed., TMH Education Pvt Ltd., New Delhi (Chapter 2.)
3. Piegel, Mathematical Elements for Computer Graphics,

**REFERENCE:**
<table>
<thead>
<tr>
<th>Group-1</th>
<th>FINITE ELEMENT METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>16MCM151</td>
<td></td>
</tr>
<tr>
<td><strong>Exam Hours:</strong></td>
<td><strong>Exam Marks:</strong></td>
</tr>
<tr>
<td>03</td>
<td>100</td>
</tr>
</tbody>
</table>

**Finite Element Modeling and Analysis:** Introduction, Basic Concepts, Engineering Applications, Features, steps in FEM, Discretisation of domain, discussion on various 1D, 2D and 3D Elements

**Discretisation and Shape Functions:** Discretisation Process, various consideration for discretisation Process. Derivation of shape function for 1D and 2D element. Comparison of 1D linear, 1D quadratic and 1D cubic element. Convergence requirements


**Analysis of Structures:** Truss Elements, Analysis of Truss Problems by Direct Stiffness Methods, Analysis of Frames and Different Problems, Different Axi-Symmetric Truss Problems.


**Transformation and Manipulation of Objects:** Introduction, Transformation Matrix, 2D transformation, Arbitrary Rotation about the origin, Rotation by different angles, Concatenation, 2D transformation, Projection on to a 2D plane, Overall scaling, Rotation about an Arbitrary Point, 2D Reflection, 3D Transformation, 3D scaling, 3D Rotation of Objects, 3D Rotation about an arbitrary Axis, 3D Visualisation.

**Geometric Modeling:** Line Fitting, Non Linear Curve Fitting with a Power Function, Curve Fitting with a High Order Polynomial, Cubic Splines, Parabolic Cubic Splines, Non Parametric Cubic Spline, Boundary Conditions, Bezier Curves, Differentiation of Bezier Curve Equations, B-Spline Curve, Non Uniform Rational B-Spline(NURBS), Surface creation, Plane Surface, Ruled Surface, Rectangular Surface, Surface of Revolution, Application Software. Introduction, Construction Techniques, Representation Schemes, and Application of Solid Modeling.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
**ARTIFICIAL INTELLIGENCE & EXPERT SYSTEMS**

<table>
<thead>
<tr>
<th>Exam Hours:03</th>
<th>Exam Marks:100</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Module 1. Human and Machine Intelligence:</strong> Concepts of fifth generation computing, programming AI environment, developing artificial intelligence system, definition of Expert systems, Natural Language processing, neural networks.</td>
<td></td>
</tr>
<tr>
<td><strong>Tools for Machine Thinking:</strong> Forward chaining, Backward chaining, use of probability and fuzzy logic.</td>
<td></td>
</tr>
<tr>
<td><strong>Module 2. Expert System Development:</strong> Choice of Domain, collection of knowledge base, selection of inference mechanism, case studies of expert system development in design and manufacturing.</td>
<td></td>
</tr>
<tr>
<td><strong>Advanced Programming Techniques:</strong> Fundamentals of object oriented programming, creating structure and object, object operations, involving procedures, programming applications, object oriented expert system.</td>
<td></td>
</tr>
<tr>
<td><strong>Module 3. Advanced knowledge representation for smart systems:</strong> semantic nets-structure and objects, ruled systems for semantic nets; certainly factors, Automated learning.</td>
<td></td>
</tr>
<tr>
<td><strong>Languages in AI:</strong> Using PROLOG to design expert systems, converting Rules to PROLOG, Conceptual example, introduction to LISP, Function evaluation, Lists, Predicates, Rule creation.</td>
<td></td>
</tr>
<tr>
<td><strong>Module 4. Expert System Tools:</strong> General structure of an expert system shell, examples of creation of an expert system using an expert system tool.</td>
<td></td>
</tr>
<tr>
<td><strong>Module 5. Industrial Application of AI and Expert systems:</strong> Robotic vision systems, Image processing techniques, application to object recognition and inspection, automatic speech recognition.</td>
<td></td>
</tr>
</tbody>
</table>

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**
<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module 4.</td>
<td><strong>B-Spline Curve:</strong> Evaluating of a B-Spline Curve, Composition of B-Spline Curves, Differentiation of a B-Spline Curve, Non uniform Rational B-Spline (NURBS) Curve, Evaluating of a NURBS Curve, Differentiation of a NURBS Curve, Interpolation Curves, Interpolation Using a Hermite Curve, Interpolation Using a B-Spline Curve, Intersection of Curves.</td>
</tr>
</tbody>
</table>

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
**Visvesvaraya Technological University, Belagavi.**  
**PhD Coursework Courses – 2018 (Mechanical Engineering)**  
**As per 2017 Regulation**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Group</th>
<th>Course Title</th>
<th>Exam Hours</th>
<th>Exam Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>16MDE153</td>
<td>Group-1</td>
<td>MECHATRONICS SYSTEM DESIGN</td>
<td>03</td>
<td>100</td>
</tr>
</tbody>
</table>

**Modules**

- **Introduction:** Definition and Introduction to Mechatronic Systems. Modeling & Simulation of Physical systems. Overview of Mechatronic Products and their functioning, measurement systems. Control Systems, simple Controllers. Study of Sensors and Transducers:
  - Pneumatic and Hydraulic Systems, Mechanical Actuation System, Electrical Actual Systems, Real time interfacing and Hardware components for Mechatronics.
- **Electrical Actuation Systems:** Electrical systems, Mechanical switches, Solid state switches, solenoids, DC & AC motors, Stepper motors.
- **System Models:** Mathematical models:- mechanical system building blocks, electrical system building blocks, thermal system building blocks, electromechanical systems, hydro-mechanical systems, pneumatic systems.
- **Signal Conditioning:** Signal conditioning, the operational amplifier, Protection, Filtering, Wheatstone Bridge, Digital signals, Multiplexers, Data Acquisition, Introduction to digital system processing, pulse-modulation.
- **Data Presentation Systems:** Basic System Models, System Models, Dynamic Responses of System

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

2. HSU “MEMS and Microsystems design and manufacture”- Tata McGraw-Hill Education, 2002

**Reference Books:**

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>08</th>
<th>16MAR21</th>
<th>Group-1</th>
<th>ROBOTICS FOR INDUSTRIAL AUTOMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


**Module 2. End Effectors And Robot Controls:** Mechanical grippers-Slider crank mechanism, Screw type, Rotary actuators, cam type-Magnetic grippers-Vacuum grippers-Air operated grippers-Gripper force analysis-Gripper design-Simple problems-Robot controls-Point to point control, Continuous path control, Intelligent robot-Control system for robot joint-Control actions-Feedback devices-Encoder, Resolver, LVDT-Motion Interpolations-Adaptive control.

**Module 3. Time and Motion:** Trajectories, Smooth One-Dimensional Trajectories, Multi Dimensional Case, Multi-Segment Trajectories, Interpolation of Orientation in 3D, Cartesian Motion, Time Varying Coordinate Frames, Rotating Coordinate Frame, Incremental Motion, Inertial Navigation Systems. Mobile Robot Vehicles, Mobility, Car-like Mobile Robots, Moving to a Point, Following a Line, Following a Path, Moving to a Pose. SLE: Flying Robots.

**Module 4. Robot Arm Kinematics:** Describing a Robot Arm, Forward Kinematics, A 2-Link Robot, A 6-Axis Robot, Inverse Kinematics, Closed-Form Solution, Numerical Solution, Under Actuated Manipulator, Redundant Manipulator, Trajectories, Joint-Space Motion, Cartesian Motion, Motion through a Singularity.


**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books**
Module 1. Introduction: Basic concepts of measurement methods, single and multipoint measurement Min space and time. Processing of experimental data, curve fitting and regression analysis. Data Acquisition systems: Fundamentals of digital signals and their transmission, A/D-and D/A converters, Basic components of data acquisition system. Computer interfacing of digital instrument and data acquisition systems; Digital multiplexes, Data acquisition board (DAQ), Digital image processing fundamentals.

Module 2. Design and Construction of Experimental facilities: wind tunnel, general test rigs, Test cells for flow visualization and temperature mapping.


Module 3. Temperature Measurement: Measurement Design, Construction and Analysis of liquid and gas thermometers, resistance thermometer with wheat stone bridge, Thermo-electric effect, Construction, testing and calibration of thermocouples and thermopiles, Analysis of effect of bead size and shielding on time constant and frequency response, characteristics of thermocouple, pyrometers, radiation thermometers.

Interferometry & Humidity measurement: interferometers, Humidity measurement: Conventional methods, electrical transducers, Dunmox humidity and microprocessor based dew point instrument, Calibration of humidity sensors.


Module 5. Measurement of Pressure, Force, and Torque: Analysis of liquid manometer, dynamics of variable area and inclined manometer, Pressure transducers, Speed and torque measurement, speed and torque measurement of rotating system.

Air Pollution sampling and measurement: Units for pollution measurement, gas sampling techniques, particulate sampling technique, gas chromatography.

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

REFERENCE BOOKS:
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>Module 1. Introduction and Overview: Concept of System, System environment, element of system, system modeling, types of models, Monte Carlo method, system simulation, simulation-management laboratory, advantages limitations of system, simulation, continuous and discrete systems.</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Module 2. Simulation of Continuous Systems: Characteristics of a continuous system, comparison of numerical integration with continuous simulation system, Simulation of an integration formula.</td>
<td></td>
</tr>
<tr>
<td>Module 3. Simulation of Queuing Systems: Concept of queuing theory, characteristics of queues, stationary and time dependent queues, queue discipline, time series analysis, measure of system performance, Kendall ’s notation, auto covariance and auto-correlation function and effects in queuing systems, simulation of single server queues, multi server queues, queues involving complex arrivals and service times with blanking reneging.</td>
<td></td>
</tr>
<tr>
<td>Module 4. Simulation of Inventory systems: Rudiments of inventory theory, MRP, in process inventory, Necessity of simulation in inventory problems, forecasting and regression analysis, forecasting through simulation, generation of Poisson and Erlang variates, simulation of complex inventory situations.</td>
<td></td>
</tr>
<tr>
<td>Module 5. Design of Simulation Experiments: Length of run, elimination of initial bias. Variance reduction techniques, stratified sampling, antipathetic sampling, common random numbers, time series analysis, spectral analysis, model validation, optimization procedures, search methods, single variable deterministic case search, single variable non-deterministic case search, regenerative techniques.</td>
<td></td>
</tr>
<tr>
<td>Simulation of PERT: Simulation of maintenance and replacement problems, capacity planning production system, reliability problems, computer time sharing problem, the elevator system.</td>
<td></td>
</tr>
</tbody>
</table>

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**
2. Dr.D.S.Hira S.Chand &Co: “System Simulation”

**REFERENCE BOOKS:**
2. Gordon:“System Simulation”- Prentice Hall of India.
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>Group-1</th>
<th>INDUSTRIAL AUTOMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours: 03</td>
<td>Exam Marks: 100</td>
</tr>
</tbody>
</table>


**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**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 Vaipayee, PHI
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>12</th>
<th>16MTR22</th>
<th>Group-1</th>
<th>ADVANCED EMBEDDED SYSTEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours: 03</td>
<td>Exam Marks: 100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Module 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.


Module 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.

Module 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)


**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Book:**

**Reference Books:**
3. ARM System on Chip Architecture by Steve Furber, Pearson Education
Visvesvaraya Technological University, Belagavi.  
PhD Coursework Courses – 2018 (Mechanical Engineering)  
As per 2017 Regulation

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module 1.</td>
<td>Technical Definition Of PLC. What Are Its Advantages, Characteristic Functions Of A PLC, Chronological Evolution Of PLC, Types Of PLC, Unitary PLC, Modular PLC. Small PLC, Medium PLC, Large PLC, Block Diagram Of PLC: Input / Output (VO) Section, Processor Section, Power Supply, Memory. Central Processing Unit: Processor Software/Executive Software, Multitasking, Languages, Ladder Language. Input And Output Contact Program Symbols, Numbering System Of Inputs And Outputs, Program Format</td>
</tr>
<tr>
<td>Module 2.</td>
<td>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</td>
</tr>
<tr>
<td>Module 3.</td>
<td>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 “GRTQ” Instruction, MASKED COMPARISON FOR EQUAL” or “MEQ” Instruction, “LIMIT TEST” of “LIM” Instruction, Addressing Data Files- Format Of Logical Address, Addressing Format For Micrologic System</td>
</tr>
</tbody>
</table>

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

**Text Book:**
"PLC and Industrial Applications", Madhuchhandan Gupts and Samarjit Sen Gupta,

**Reference Books:**
1. Cite Address : www.equinoxac.co.uk
3. Cite Address: PLCs, ELOSTZ.com
### Module 1
**Fluid Power Generating/Utilizing Elements:** Hydraulic pumps and motor gears, vane, piston pumps-motors-selection and specification-drive characteristics-Linear actuator- Types, mounting details,cushioning-power packs-construction,reservoir capacity, heat dissipation, accumulators-standard circuit symbols, circuit (flow) analysis.

**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.

### Module 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

### Module 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.

### Module 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.

### Module 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.
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

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.
**Visvesvaraya Technological University, Belagavi.**

**PhD Coursework Courses – 2018 (Mechanical Engineering)**

As per 2017 Regulation

**01 16MCS11 Group-2 ADVANCED MATHEMATICS**

<table>
<thead>
<tr>
<th>Exam Hours:03</th>
<th>Exam Marks:100</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduction:</strong> Numerical Analysis, Approximation errors-absolute and relative, round-off errors, round-off errors in arithmetical operations, Error in numerical method, Recursive Computation.</td>
<td></td>
</tr>
<tr>
<td><strong>Interpolation:</strong> Problem of interpolation, Remainder or error in interpolation, Linear operators, Differences, difference table, Propagation of errors, Newton’s forward interpolation formula, Newton’s backward interpolation formula, Central interpolation, Stirling’s interpolation formula, Bessel’s interpolation formula, Everett’s interpolation formula, Steffensen’s interpolation formula, Different interpolation zones, Error estimation, Working rules for use of different interpolation formulae, Sub-tabulation, Lagrange’s interpolation formula, Aitken’s interpolation method, Divided difference, Divided differences interpolation formula, Some important relations, Deductions from divided difference formula, Inverse interpolation, Estimate of remainder.</td>
<td></td>
</tr>
<tr>
<td><strong>Numerical Differentiation:</strong> problem of numerical differentiation, Error term, Differentiation formulae for equidistant nodes, lagrange’s differentiations formula.</td>
<td></td>
</tr>
<tr>
<td><strong>Numerical Integration:</strong> Problem of numerical integration, A general formula, Some basic concepts, Newton-Cotes formula (closed type), Some lemmas, error in Newton-Cotes formula (closed type), Newton-Cotes formula (open type), Some useful quadrature rules, Richardson extrapolation, Central- difference quadrature rules, Gaussian quadrature theory. Remarks on the use of different quadrature.</td>
<td></td>
</tr>
<tr>
<td><strong>Euler-Maclaurin Sum Formula:</strong> Bernoulli polynomials, Euler-Maclaurin sum formula, Deductions of quadrature rules, Gregory- Newton quadrature formula, Romberg integration.</td>
<td></td>
</tr>
<tr>
<td><strong>Numerical Solution of Linear Equations:</strong> The problem and methods of solution, Gauss’s elimination method, Iterative methods-preliminary concepts, Gauss-Jacobi iteration, Gauss-Seidel iteration, Ill- Conditioned equations.</td>
<td></td>
</tr>
</tbody>
</table>

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

**REFERENCE BOOKS:**
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>Module</th>
<th>FINITE ELEMENT METHOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours: 03</td>
<td>Exam Marks: 100</td>
</tr>
</tbody>
</table>

**Module 1. Introduction to Finite Element Method:** Basic Steps in Finite Element Method to solve mechanical engineering (Solid, Fluid and HeatTransfer) 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**

**Module 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**

**Module 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. **10 Hours**


**Module 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**

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
### Visvesvaraya Technological University, Belagavi.

**PhD Coursework Courses – 2018 (Mechanical Engineering)**

**As per 2017 Regulation**

<table>
<thead>
<tr>
<th>03</th>
<th>16CAE13</th>
<th>Group-2</th>
<th>CONTINUUM MECHANICS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exam Hours:</strong></td>
<td>03</td>
<td><strong>Exam Marks:</strong></td>
<td>100</td>
</tr>
</tbody>
</table>

#### Module 1. Analysis of Stress:
- Definition and Notation for forces and stresses: body force, surface force Components of stresses, equations of Equilibrium, Specification of stress at a point. Principal stresses, maximum and minimum shear stress, Mohr’s diagram in three dimensions. Boundary conditions. Stress components on an arbitrary plane, Stress invariants, Octahedral stresses, Decomposition of state of stress, deviator and spherical stress tensors, Stress transformation.

#### Module 2. Deformation and Strain:
- Deformation, Strain Displacement relations, Strain components. The state of strain at a point. Principal strain, strain invariants, Strain transformation, Compatibility equations, Cubical dilatation, spherical and deviator strains, plane strain, Mohr’s circle, and compatibility equation

#### Relations and the General Equations of Elasticity:
- Generalized Hooke's law in terms of engineering constants.

#### Module 3. Two Dimensional Problems in Cartesian Co-Ordinates:

#### Module 4. Two Dimensional Problems in Polar Co-Ordinates:
- General equations, stress distribution symmetrical about an axis, Strain components in polar co-ordinates, Rotating disk and cylinder, Concentrated force on semi-infinite plane, Stress concentration around a circular hole in an infinite plate.

#### Thermal Stresses:
- Introduction, Thermo-elastic stress-strain relations, thin circular disc, long circular cylinder

#### Module 5. Torsion of Prismatic Bars:
- Introduction, Torsion of Circular cross section bars, Torsion of elliptical cross section bars, Soap film analogy, Membrane analogy, Torsion of thin walled open tubes.

#### Elastic Stability:
- Axial compression of prismatic bars, Elastic stability, buckling load for column with constant cross section.

#### Viscoelasticity:
- Linear viscoelastic behavior. Simple viscoelastic models-generalized models, linear differential operator equation. Creep and Relaxation- creep function, relaxation function, hereditary integrals, Complex moduli and compliances. (Note: No numerical)

### Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

### Text Books:

### References:
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>04</th>
<th>16CAE14</th>
<th>Group-2</th>
<th>EXPERIMENTAL MECHANICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Module 1. Introduction:** Definition of terms, calibration, standards, dimension and units, generalized measurement system, Basic concepts in dynamic measurements, system response, distortion, impedance matching, experiment planning.

**Analysis of Experimental Data:** Cause and types of experimental errors, error analysis. Statistical analysis of experimental data- Probability distribution, gaussian, normal distribution. Chi-square test, Method of least square, correlation coefficient, multivariable regression, standard deviation of mean, graphical analysis and curve fitting, general consideration in data analysis.

**Module 2. Data Acquisition and Processing:** General data acquisition system, signal conditioning revisited, data transmission, Analog-to-Digital and Digital-to-Analog conversion, Basic components (storage and display) of data acquisition system. Computer program as a substitute for wired logic.

**Force, Torque and Strain Measurement:** Mass balance measurement, Elastic Element for force measurement, torque measurement. Strain Gages -Strain sensitivity of gage metals, M gage construction, Gage sensitivity and gage factor, Performance characteristics, Environmental effects Strain, gage circuits, Potentiometer, Wheat Stone's bridges, Constant current circuits. Strain Analysis Methods-Two element and three element, rectangular and delta rosettes, Correction for transverse strains effects, stress gage - plane shear gage, Stress intensity factor gage


**Module 4. Three Dimensional Photo elasticity:** Stress freezing method. General slice, Effective stresses, Stresses separation. Shear deference method, Oblique incidence method Secondary principals stresses, Scattered light photo elasticity, Principals, Polari scope and stress data analyses.


**Holography:** Introduction, Equation for plane waves and spherical waves, Intensity, Coherence, Spherical radiator as an object (record process), Hurter, Driffel curves, Reconstruction process, Holographicinterferometry, Realtime. and double exposure methods, Displacement measurement, Isopachics.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
**Visvesvaraya Technological University, Belagavi.**  
**PhD Coursework Courses – 2018 (Mechanical Engineering)**  
**As per 2017 Regulation**

<table>
<thead>
<tr>
<th>05</th>
<th>16MDE151</th>
<th>Group-2</th>
<th>COMPUTER GRAPHICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours: 03</td>
<td>Exam Marks: 100</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Module 1. Transformations</strong></td>
<td></td>
<td></td>
<td>Representation of points, Transformations: Rotation, Reflection, Scaling, Shearing, Combined Transformations, Translations and Homogeneous Coordinates, A geometric interpretation of homogeneous coordinates, Over all scaling, Points at infinity, Rotation about an arbitrary point, Reflection through an arbitrary line, Rotation about an axis parallel to coordinate axis, Rotation about an arbitrary axis in space, Reflection through an arbitrary plane.</td>
</tr>
<tr>
<td><strong>Module 2. Types and Mathematical Representation of Curves</strong></td>
<td></td>
<td></td>
<td>Curve representation, Explicit, Implicit and parametric representation. Nonparametric and parametric representation of Lines, Circles, Ellipse, Parabola, Hyperbola, Conics. Parametric representation of synthetic curve, Hermite cubic splines, Bezier curves: Blending function, Properties, generation, B-spline curves- Cox-deBoor recursive formula, Properties, Open uniform basis functions, Non-uniform basis functions, Periodic B-spline curve.</td>
</tr>
<tr>
<td><strong>Types and Mathematical Representation of Surfaces</strong></td>
<td></td>
<td></td>
<td>Surface entities and parametric representation- Plane, Ruled, surface of revolution, Offset surface, Coons patch, Bezier surface, B-spline surface.</td>
</tr>
<tr>
<td><strong>Module 3. Types and Mathematical Representation of Solids</strong></td>
<td></td>
<td></td>
<td>Solid entities: Block, Cylinder, Cone, Sphere, Wedge, Torus, Solid representation, Fundamentals of solid modeling, Set theory, Regularized set operations, Set membership classification, Half spaces, Basic elements, Building operations, Boundary representation and Constructive solid geometry, Basic elements, Building operations.</td>
</tr>
<tr>
<td><strong>Scan Conversion and Clipping</strong></td>
<td></td>
<td></td>
<td>Representation of points, lines, Drawing Algorithms: DDA algorithm, Bresenham's integer line algorithm, Bresenham's circle algorithm, Polygon filling algorithms: Scan conversion, Seed filling, Scan line algorithm. Viewing transformation, Clipping - Points, lines, Text, Polygon, Cohen-Sutherland line clipping, Sutherland-Hogdmen algorithm</td>
</tr>
<tr>
<td><strong>Module 5. Applications</strong></td>
<td></td>
<td></td>
<td>Colouring- RGB, CMY, HSV, HSL colour models, Data Exchange: Evolution of Data exchange, IGES, PDES, Animation: Conventional animation-key frame, Inbetweening, Line testing, Painting, Filming, Computer animation, Entertainment and Engineering Animation, Animation system hardware, Software architecture, Animation types, Frame buffer, Colour table, Zoom-pan-scroll, Cross bar, Real time play back, Animation techniques-key frame, Skelton. Path of motion and p-curves.</td>
</tr>
<tr>
<td><strong>Question paper pattern:</strong></td>
<td></td>
<td></td>
<td>The question paper will have ten questions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Each full question consists of 20 marks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>There will be 2 full questions (with a maximum of four sub questions) from each module.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Each full question will have sub questions covering all the topics under a module.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The students will have to answer 5 full questions, selecting one full question from each module.</td>
</tr>
</tbody>
</table>
### Module 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.

**Beam Modeling:** Beam Modeling with induced strain Rate effects, Inchworm Linear Motor Beam Modeling with induced strain Actuation-single Actuators, dual Actuators, Pure Extension, Pure Bending harmonic excitation, Bernoulli-Euler beam Model, problems, Piezoelectrical Applications.

### Module 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.

**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 Clutches, Dampers and Others.

### Module 3. Vibration Absorbers
series and Parallel Damped Vibrations (Overview), Active Vibration Absorbers, Fiber Optics, Physical Phenomena, Characteristics, Sensors, Fiber Optics in Crack Detection, applications.

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

### Module 4. MEMS

### Module 5. 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.

#### Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

### TEXT BOOKS:

### REFERENCE BOOKS:
### MODERN CONTROL ENGINEERING

<table>
<thead>
<tr>
<th></th>
<th>16MAR156</th>
<th>Group-2</th>
<th>MODERN CONTROL ENGINEERING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:</td>
<td>03</td>
<td>Exam Marks:</td>
<td>100</td>
</tr>
</tbody>
</table>

#### MODULE 1
**Introduction to Automatic Controls:** Representation of Control Components, Representation of Control Systems, Characteristic functions, Steady-State Operation, Laplace Transforms, Basic Control Actions and Industrial Automatic Controllers. 10 Hours

#### MODULE 2
**The Root-Locus Method:** Introduction, Root Locus Plots, Illustrations, General rules for Constructing Root Loci, Root Locus Analysis of Control Systems, Transport Lag and Root contour Plots. 10 Hours

#### MODULE 3
**Frequency Response Methods:** Introduction, Frequency Response, Logarithmic Representation, Evaluating the Gain K, Equivalent Unity-Feedback Systems. Polar Plots, M And Circles, Correlation between Transient and Frequency Response. 10 Hours

#### MODULE 4
**System Compensation:** Nyquist Stability Criterion, Gain Margin and Phase Margin, Lead Compensation, Lag Compensation, Lag-Lead Compensation.
**State-Space Methods:** Introduction, Basic materials in State-Space Analysis, Transfer Matrices, Controllability, Observability, System Representation, Signal Flow Graphs, Solution of State-Space Equations. 10 Hours

#### MODULE 5
**Control Action and System Compensation:** Concept of proportional, integral, proportional integral, proportional-integral-differential controllers, series and feedback compensation, Physical devices for system compensation.
**Introduction to State Variable Techniques:** Introduction to state concepts, state equation of linear continuous data system. Matrix representation of state equations, controllability and observability, Kalman and Gilberts test. 10 Hours

#### Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

#### Text Books:
2. Modern Control Engineering - K. Ogata, PHI.

#### Reference Books:
3. Feed Back Control System - Schaum’s Series, McGraw Hill.
**Visvesvaraya Technological University, Belagavi.**  
**PhD Coursework Courses – 2018 (Mechanical Engineering)**  
**As per 2017 Regulation**

<table>
<thead>
<tr>
<th>08</th>
<th>16CAE421</th>
<th>Group-2</th>
<th>FRACTURE MECHANICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**MODULE 1**  

**MODULE 2**  

**MODULE 3**  

**MODULE 4**  

**MODULE 5**  
**Fatigue crack propagation and applications of fracture mechanics:** Crack growth and the stress intensity factor. Factors affecting crack propagation. Variable amplitude service loading. Means to provide fail-safety, required information for fracture mechanics approach, Mixed mode (combined) loading and design criteria.

**Question paper pattern:**  
- The question paper will have ten questions.  
- Each full question consists of 20 marks.  
- There will be 2 full questions (with a maximum of four sub questions) from each module.  
- Each full question will have sub questions covering all the topics under a module.  
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>09</th>
<th>16MDE22</th>
<th>Group-2</th>
<th>ADVANCED MACHINE DESIGN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Module 1. Introduction:** Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr’s theory and modified Mohr’s theory. Numerical examples.

**Fatigue of Materials:** Introductory concepts, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Test methods and standard test specimens, Fatigue fracture surfaces and macroscopic features, Fatigue mechanisms and microscopic features.

**Module 2. Stress-Life (S-N) Approach:** S-N curves, Statistical nature of fatigue test data, General S-N behavior, Mean stress effects, Different factors influencing S-N behaviour, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using S-N approach.

**Strain-Life (ε-N) approach:** Monotonic stress-strain behavior, Strain controlled test methods, Cyclic stress-strain behavior, Strain based approach to life estimation, Determination of strain life fatigue properties, Mean stress effects, Effect of surface finish, Life estimation by ε-N approach.

**Module 3. LEFM Approach:** LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation.

**Notches and their effects:** Concentrations and gradients in stress and strain, S-N approach for notched membranes, mean Stress effects and Haigh diagrams, Numerical examples.

**Module 4. Fatigue from Variable Amplitude Loading:** Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle counting methods, Life estimation using stress life approach. Numerical examples.

**Notch strain analysis:** Strain – life approach, Neuber’s rule, Glinka’s rule, applications of fracture mechanics to crack growth at notches. Numerical examples.

**Module 5. Surface Failure:** Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear.

**Surface fatigue:** Spherical contact, Cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength, Surface fatigue failure modes, Design to avoid Surface failures.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
Module 1
Geometry of Motion: Introduction, analysis and synthesis, Mechanism terminology, planar, Spherical and spatial mechanisms, mobility, Grashoff's law, Equivalent mechanisms, Unique mechanisms, Kinematic analysis of plane mechanisms: Auxiliary point method using rotated velocity vector, Hall - Ault auxiliary point method, Goodman's indirect method.

Module 2

Module 3
System Dynamics: Gyroscopic action in machines, Euler's equation of motion, Phase Plane representation, Phase plane Analysis, Response of Linear Systems to transient disturbances. Synthesis of Linkages: Type, number, and dimensional synthesis, Function generation, Path generation and Body guidance, Precision positions, Structural error, Chebychev spacing, Two position synthesis of slider crank mechanisms, Crank-rocker mechanisms with optimum transmission angle Motion Generation.

Module 4
Graphical Methods of Dimensional Synthesis: Two position synthesis of crank and rocker mechanisms, Three position synthesis, Four position synthesis (point precision reduction) Overlay method, Coupler curve synthesis, Cognate linkages. Analytical Methods of Dimensional Synthesis: Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples.


Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

References Books:
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>11</th>
<th>16MMD41</th>
<th>Group-2</th>
<th>TRIBOLOGY AND BEARING DESIGN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Module 1


Module 2 Hydrodynamic Lubrications:


Module 3 Hydrostatic Bearings:

Hydrostatic thrust bearings, hydrostatic circular pad, annular pad, rectangular pad bearings, types of flow restricters, expression for discharge, load carrying capacity and condition for minimum power loss, numerical problems, and hydrostatic journal bearings. EHL Contacts: Introduction to Elasto - hydrodynamic lubricated bearings. Introduction to 'EHL' constant, Grubin type solution.

Module 4 Antifriction bearings:


Module 5

**Magnetic Bearings:** Introduction to magnetic bearings, Active magnetic bearings. Different equations used in magnetic bearings and working principal. Advantages and disadvantages of magnetic bearings, Electrical analogy, Magneto-hydrodynamic bearings.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books**


**Reference Books**

Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>12</th>
<th>16MDE24</th>
<th>Group-2</th>
<th>ADVANCED THEORY OF VIBRATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Exam Hours:03</td>
</tr>
<tr>
<td><strong>Module 1. Review of Mechanical Vibrations:</strong> Basic concepts; free vibration of single degree of freedom systems with and without damping, forced vibration of single DOF-systems, Natural frequency.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vibration Control:</strong> Introduction, Vibration isolation theory, Vibration isolation and motion isolation for harmonic excitation, practical aspects of vibration analysis, vibration isolation, Dynamic vibration absorbers, and Vibration dampers.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Module 2. Vibration Measurement and applications:</strong> Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Vibration exciters, Signal analysis.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Modal analysis &amp; Condition Monitoring:</strong> Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine Condition monitoring and diagnosis.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Module 3. Transient Vibration of single Degree-of freedom systems:</strong> Impulse excitation, arbitrary excitation, Laplace transforms formulation, Pulse excitation and rise time, Shock response spectrum, Shock isolation.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Random Vibrations:</strong> Random phenomena Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms and response.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Module 5. Continuous Systems:</strong> Vibration of string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books**

**Reference Books**
**Visvesvaraya Technological University, Belagavi.**

**PhD Coursework Courses – 2018 (Mechanical Engineering)**

**As per 2017 Regulation**

<table>
<thead>
<tr>
<th>Module</th>
<th>Exam Hours:03</th>
<th>Exam Marks:100</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fluid Film Lubrication:</strong> Basic theory of fluid film lubrication, Derivation of generalized Reynolds equations, Boundary conditions, Fluid film stiffness and Damping coefficients, Stability and dynamic response for hydrodynamic journal bearing, Two lobe journal bearings.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Stability of Flexible Shafts:</strong> Introduction, equation of motion of a flexible shaft with rigid support, Radial elastic friction forces, Rotary friction, friction Independent of velocity, friction dependent on frequency, Different shaft stiffness Constant, gyroscopic effects, Nonlinear problems of large deformation applied forces, instability of rotors in magnetic field.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Critical Speed:</strong> Dunkerley's method, Rayleigh's method, Stodola's method. Rotor Bearing System: Instability of rotors due to the effect of hydrodynamic oil layer in the bearings, support flexibility, Simple model with one concentrated mass at the center</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Turborotor System Stability by Transfer Matrix Formulation:</strong> General turborotor system, development of element transfer matrices, the matrix differential equation, effect of shear and rotary inertia, the elastic rotors supported in bearings, numerical solutions.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Turborotor System Stability by Finite Element Formulation:</strong> General turborotor system, generalized forces and co-ordinates system assembly element matrices, Consistent mass matrix formulation, Lumped mass model, linearised model for journal bearings, System dynamic equations Fix stability analysis non dimensional stability analysis, unbalance response and Transient analysis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Blade Vibration:</strong> Centrifugal effect, Transfer matrix and Finite element, approaches.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Reference Books:**
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>14</th>
<th>16MTR254</th>
<th>Group-2</th>
<th>EXPERIMENTAL TECHNIQUES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Exam Hours:03 Exam Marks:100</td>
</tr>
</tbody>
</table>

Module 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.

Module 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.


Module 4. Multiple Regression Analysis – Objectives of multiple regressions, 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.

Module 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.

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:
Recommended software: SPSS, Systat 10.2
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>01</th>
<th>16MTP13</th>
<th>Group-3</th>
<th>ADVANCED FLUID MECHANICS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
</tr>
<tr>
<td>Module 1. Introduction and Kinematics of Fluids: Concepts of continuum rarefied gas dynamics, magnetofluid mechanics regimes in mechanics of fluids; fluid properties. Kinematics of Fluids- Methods of describing fluid motion - Lagrangian method, Eulerian method; translation, rotation and rate of deformation; stream lines, path lines and streak line; material derivative and acceleration; vorticity.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Governing Equations for Fluid Flow: Nature of stress; transformation of stresses - nature of strains; transformation of the rate of strain; relation between stress and rate of strain; Conservation equations for mass, momentum and energy - differential and integral forms; Euler’s equations of motion, integration along the stream line; integration of steady irrotational motion; integration for two dimensional unsteady flow.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Module 2. Mechanics of Laminar Flow: Introduction; Laminar and turbulent flows; viscous flow at different Reynolds number – wake frequency; laminar plane Poiseuille flow; stokes flow; flow through a concentric annulus.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanics of Turbulent Flow: Structure and origin of turbulent flow - Reynolds, average concept, Reynolds equation of motion; zero equationmodel for fully turbulent flows; k-l, k- and other turbulence models; turbulent flow through pipes; losses in bends, valves etc; analysis of pipe network - Hard cross method.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Module 3. Exact and Approximate solutions of N-S Equations: Introduction; Parallel flow past a sphere; Oseen’s approximation; hydrodynamic theory of lubrication; Hele-Shaw Flow.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boundary Layer Theory: Introduction; Boundary layer equations; displacement and momentum thickness, shape factor; flow over a flat plate – similarity transformation, integral equation for momentum and energy ; skin friction coefficient and Nusselt number; separation of boundary layer; critical Reynolds number; control of boundary layer separation.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Module 4. Flow Around bodies: Introduction; flow past a circular cylinder; drag on a sphere; stream lined body, lift and drag on airfoil; Drag and lift on road vehicles.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Module 5. Experimental Techniques: Introduction; improved modeling through experiments; design of fluid flow experiments; error sources during measurement; pressure transducers; hot wire anemometer; laser - Doppler velocity meter; methods of measuring turbulence fluctuations - flow visualization techniques; wind tunnel; analysis of experimental uncertainty - types of error, estimation of uncertainty.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question paper pattern:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• The question paper will have ten questions.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Each full question consists of 20 marks.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• There will be 2 full questions (with a maximum of four sub questions) from each module.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Each full question will have sub questions covering all the topics under a module.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• The students will have to answer 5 full questions, selecting one full question from each module.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Text Books:

Reference Books:
### module 1
Work and heat interaction, first law of thermodynamics, steady and unsteady flows with energy transaction. Second law of thermodynamics, reversibility, corollaries of the second law and entropy. Available energy, availability analysis of open and closed systems.

### module 2
Properties of pure substances, properties of gases and gas mixtures, combined first and second laws of thermodynamics. Phase and reaction equilibrium, equilibrium constants, calculation of equilibrium composition of multicomponent gaseous mixtures.

### module 3
Equation of state and calculation of thermodynamics and transport properties of substances. Reaction rates and first, second and higher order reaction, in gaseous, liquid and solid phases.

### module 4
Combustion and flame velocities, laminar and turbulent flames, premixed and diffusion flames, their properties and structures.

### module 5

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
**Visvesvaraya Technological University, Belagavi.**  
**PhD Coursework Courses – 2018 (Mechanical Engineering)**  
**As per 2017 Regulation**

| Module 1. Global and National Energy Scenario: |  
| Module 4. Biogas: | Properties of biogas (Calorific value and composition) - Biogas plant technology and status – Bio energy system - Design and constructional features – Biomass resources and their classification – Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification – pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion – Biomass energy programme in India |
| Module 5. Ocean Energy: | Ocean wave energy conversion - Principle of Ocean Thermal Energy Conversion (OTEC) - Ocean thermal power plants - Tidal energy conversion - Tidal and wave energy its scope and development - Scheme of development of tidal energy. |
| Geothermal power plants: | Various types - Hot springs and steam ejection. |
| Fuel cells: | Introduction, applications, classification, different types of fuel cells such as phosphoric acid fuel cell, alkaline fuel cell, PEM fuel cell, MC fuel cell. Development and performance fuel cells. |

**Question paper pattern:**  
- The question paper will have ten questions.  
- Each full question consists of 20 marks.  
- There will be 2 full questions (with a maximum of four sub questions) from each module.  
- Each full question will have sub questions covering all the topics under a module.  
- The students will have to answer 5 full questions, selecting one full question from each module.

**READING:**  
### Visvesvaraya Technological University, Belagavi.

**PhD Coursework Courses – 2018 (Mechanical Engineering)**

**As per 2017 Regulation**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Exam Hours</th>
<th>Exam Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>16MTP154</td>
<td>REFRIGERATION AND AIR CONDITIONING</td>
<td>03</td>
<td>100</td>
</tr>
</tbody>
</table>


**Main system components:** Compressor- Types, performance, Characteristics of Reciprocating Compressors, Capacity Control, Types of Evaporators & Condensers and their functional aspects, Expansion Devices and their Behaviour with fluctuating load.


**Other refrigeration cycles:** Vapor Absorption Systems-Aqua Ammonia & LiBr Systems, Steam Jet Refrigeration Thermo Electric Refrigeration, Air Refrigeration cycles.


**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Reference Books:**
9. Refrigeration and Air Conditioning (3/e) - Langley Billy C., Engie wood Cliffs (N.J) PHI.
### Module 1

### Module 2

### Module 3
**CONDENSATION OF SINGLE VAPOURS:** Calculation of horizontal condenser, Vertical condenser, De-Super heater condenser, Vertical condenser-sub-Cooler, Horizontal Condenser-Sub cooler, Vertical reflux type condenser. Condensation of steam.

### Module 4
**VAPORIZERS, EVAPORATORS AND REBOILERS:** Vaporizing processes, Forced circulation vaporizing exchanger, Natural circulation vaporizing exchangers, Calculations of a reboiler. Extended Surfaces: Longitudinal fins. Weighted fin efficiency curve, Calculation of a Double pipe fin efficiency curve. Calculation of a double pipe finned exchanger, Calculation of a longitudinal fin shell and tube exchanger.

### Module 5
**DIRECT CONTACT HEAT EXCHANGER:** Cooling towers, relation between wet bulb & dew point temperatures. The Lewis number and Classification of cooling towers, Cooling tower internals and the roll of fill, Heat Balance. Heat Transfer by simultaneous diffusion and convection, Analysis of cooling tower requirements, Design of cooling towers, Determination of the number of diffusion units, Calculation of cooling tower performance.

### Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

### READING
6. Heat exchanger design- Press and N. Ozisik.
**Visvesvaraya Technological University, Belagavi.**

**PhD Coursework Courses – 2018 (Mechanical Engineering)**

**As per 2017 Regulation**

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MODULE 2</strong></td>
<td><strong>Liquid Flat Plate Collectors:</strong> Performance analysis, Transmissivity of cover system, Transmissivity-absrpvtivity product, Overall loss coefficient and heat transfer correlations, Collector efficiency factor, collector heat-removal factor. A numerical example, Effects of various parameters on performance. Analysis of collectors similar to the conventional collector, Transient analysis, testing procedures, Alternatives to the conventional collector. <strong>Solar Air Heaters:</strong> Performance analysis of a conventional air heater, other types of air heaters, Testing procedures. <strong>Concentrating Collectors:</strong> Flat-plate collectors with plane reflectors, cylindrical parabolic collector, Compound Parabolic collector (CPC), Paraboloid dish collector, central receiver collector.</td>
</tr>
<tr>
<td><strong>MODULE 3</strong></td>
<td><strong>Solar Air Heaters:</strong> Performance analysis of a conventional air heater, other types of air heaters, Testing procedures. <strong>Concentrating Collectors:</strong> Flat-plate collectors with plane reflectors, cylindrical parabolic collector, Compound Parabolic collector (CPC), Paraboloid dish collector, central receiver collector.</td>
</tr>
<tr>
<td><strong>MODULE 4</strong></td>
<td><strong>Thermal Energy Storage:</strong> Sensible heat storage, Latent heat storage, Thermo chemical storage. Solar Pond, Description, Performance analysis, Experimental studies Operational problems, Other solar pond concepts.</td>
</tr>
<tr>
<td><strong>MODULE 5</strong></td>
<td><strong>Economic Analysis:</strong> Initial and annual costs, Definitions, Present worth calculation, Repayment of loan in equal annual instalments, Annual Solar savings, Cumulative solar savings and life cycle savings, Payback period, Concluding remarks. <strong>Other Methods for Solar Energy Utilization:</strong> Photovoltaic conversion, Wind energy, Energy from biomass, Wave energy, Ocean thermal energy conversion, Geothermal Energy.</td>
</tr>
</tbody>
</table>

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>07</th>
<th>16MTP252</th>
<th>Group-3</th>
<th>Alternate Fuels for IC Engines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Module 1**

**Conventional Fuels:** Introduction, Current fuel scenario and consumption, per capita consumption Indian scenario, Structure of petroleum, Refining process, Products of refining process, Fuels for spark ignition, Knock rating of SI engine fuels, Octane number requirement, Diesel fuels.

**Properties of petroleum products:** Specific gravity, Density, Molecular weight, Vapour pressure, Viscosity, Flash point, Fire point, Cloudpoint, Pour point, Freezing point, Smoke point & Char value, Aniline point, Octane Number, Performance Number, Cetane Number, Emulsification, Oxidation Stability, Acid Value/Number, Distillation Range, and Sulphur content.

**Module 2**

**Alternative fuels for I.C. engines:** Need for alternative fuels such as Ethanol, Methanol, LPG, CNG, Hydrogen, Biogas and Producer gas and their methods of manufacturing.

**Single Fuel Engines:** Properties of alternative fuels, Use of alternative fuels in SI engines, Engine modifications required, Performance and emission characteristics of alternative fuels in SI mode of operation v/s gasoline operation.

**Module 3**

**Dual fuel Engine:** Need and advantages, The working principle, Combustion in dual fuel engines, Factors affecting combustion in dual fuel engine, Use of alcohols, LPG, CNG, Hydrogen, Biogas and Producer gas in CI engines in dual fuel mode. Engine modifications required. Performance and emission characteristics of alternative fuels (mentioned above) in Dual Fuel mode of operation v/s Diesel operation.

**Module 4**

**Bio-diesels:** What are bio-diesels Need of bio-diesels, Properties of bio-diesels v/s petro-diesel, Performance and emission characteristics of bio-diesels v/s Petro diesel operation.

**Availability:** Suitability & Future prospects of these gaseous fuels in Indian context.

**Module 5**

**Environmental pollution:** with conventional and alternate fuels, Pollution control methods and packages, Euro norms, Engine emissions, Emission control methods, EPA, Air quality emission standards

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

The students will have to answer 5 full questions, selecting one full question from each module.

**Reference Books:**
- Elements of Fuels, Furnaces & Refractories - O.P. Gupta, Khanna Publishers
### CONVECTIVE HEAT AND MASS TRANSFER

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Module 4</strong></td>
<td>COMBINED CONVECTION: Governing parameters &amp; equations – laminar boundary layer flow over an isothermal vertical plate – combined convection over a horizontal plate – correlations for mixed convection – effect of boundary forces on turbulent flows – internal flows – internal mixed convective flows – Fully developed mixed convective flow in a vertical plane channel &amp; in a horizontal duct.</td>
</tr>
</tbody>
</table>

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.

**READING:**
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>Exam Hours: 03</th>
<th>Exam Marks: 100</th>
</tr>
</thead>
</table>

### Module 1
**Gas exchange process:** Inlet & exhaust processes in four stroke cycle, volumetric efficiency, flow through valves, residual gas fraction, exhaust gas flow rate and temperature variation, super charging, turbo charging. Intake jet flow, mean velocity turbulence characteristics, swirl, squish, pre chamber engine flows, crevice flow and blow by, flows generated by piston cylinder wall interaction.

### Module 2
**Combustion in IC Engines:** Combustion in SI engines: Ignition, flame velocity, Normal and abnormal combustion, knocking, pre-ignition, effect of engine variables on knocking, features and design consideration of combustion chambers, concept of lean burn engines, Combustion in CI engines: Air motion: Swirl and squish, spray formation and vaporization, Stages of combustion, physical and chemical delay, diesel knock, effect of engine variables on diesel knock, combustion chambers: design features, Combustion characteristics of Diesel and Biodiesel blends, Low NOx diesel combustion: homogeneous charge compression ignition engine (HCCI- combustion), p HCCI, and EGR techniques.

### Module 3
**Combustion Models:** Fuel spray: Factors influencing fuel spray atomization, Spray equation models, penetration and dispersion of fuel, fuel line hydraulics, fuel pumps and injectors, Zerodimensional modeling, quasi dimensional modeling, combustion systems: efficiency and its applications, Single zone models, multi zone models, Premixed and diffusive models, Heat transfer coefficients, and specific heat relations, Weibes function analysis, two zone models, heat transfer in IC engines, heat transfer correlations, data logging and acquisition, cylinder pressure measurement and Gross and net release rate calculations.

### Module 4
**Engine Emissions and Air-Pollution:** Emissions and its Formation: Gaseous emissions: CO, CO2, HC, NOx (NO & NO2), SOx (SO2 & SO3); particulate matter (PM), Sources of emission formation; Emissions formation mechanisms of PM and NOx; volatile organic compounds (VOCs), poly aromatic hydrocarbons (PAH), soluble organic fraction (SOF); Mechanism of air pollution: Ozone depletion, Greenhouse effect, Photochemical smog, acid rain, Effect of air pollution on health and environment, Emission norms (passenger and commercial vehicles): National and International emission standards: BS-III and BS-IV & Euro III, IV, and V.

### Module 5
**Emission Control Technologies and Emission Measurements:** PM reduction technologies: Diesel oxidation catalysts (DOCs), Diesel particulate filters (DPFs), closed crankcase ventilation (CCV); NOx reduction technologies: Exhaust gas recirculation (EGR), Selective catalytic reduction (SCR), Lean NOx catalysts (LNCs), Lean NOx traps (LNTs), NOx adsorber catalysts, Exhaust gas recirculation (EGR), Diesel exhaust after treatment: diesel oxidation catalyst (DOC), diesel particulate filter (DPF), Soot suppression by fuel additives, relationship: soot, combustion chamber and swirl ratio, catalytic converters: constructional features and types: 2-way and 3-way catalytic converters. Measurement of gaseous emissions using thermal, chemical, magnetic and optical gas analyzers: infrared gas analyzer, chemiluminescent analyzer, gas chromatography, smoke (soot) measurement, application of microprocessor in emission control. Trends of emission reduction.

### Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

### BOOKS:
2. Thermodynamic Analysis of Combustion Engines, by Ashley S Campbell, John Wiley and Sons, 1980
**Visvesvaraya Technological University, Belagavi.**  
**PhD Coursework Courses – 2018 (Mechanical Engineering)**  
**As per 2017 Regulation**

<table>
<thead>
<tr>
<th>10</th>
<th>16MTP423</th>
<th>Group-3</th>
<th>DESIGN &amp; ANALYSIS OF THERMAL SYSTEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Module 1**  
**Thermal Systems:** Characteristics- formulation of design problem - Steps in the design process - Modeling of thermal systems – importance - Types of models – Mathematical Modeling, Exponential forms- Method of least squares - Counter flow heat exchanger, Evaporators and Condensers, Effectiveness, NTU, Pressure drop and pumping power

**Module 2**  
**Design of piping and pump systems:**- Head loss representation ;Piping networks ; Hardy – Cross method Generalized Hardy – Crossanalysis ; Pump testing methods ; Cavitation considerations ; Dimensional analysis of pumps ; piping system design practice.

**Module 3**  
**Unconstrained Optimization Techniques:** Univariate, Conjugate Gradient Method and Variable Metric Method.  
**Constrained Optimization Techniques:** Characteristics of a constrained problem; Direct Method of feasible directions; Indirect Method of interior and exterior penalty functions

**Module 4**  
**Thermo-economic analysis and evaluation:**- Fundamentals of thermo-economics, Thermo-economic variables for component evaluation ; thermo-economic evaluation ; additional costing considerations.

**Module 5**  
**Thermo-economic optimization:**- Introduction ; optimization of heat exchanger networks ; analytical and numerical optimization techniques ;design optimization for the co-generation system- a case study ; thermo-economic optimization of complex systems

**Question paper pattern:**  
- The question paper will have ten questions.  
- Each full question consists of 20 marks.  
- There will be 2 full questions (with a maximum of four sub questions) from each module.  
- Each full question will have sub questions covering all the topics under a module.  
- The students will have to answer 5 full questions, selecting one full question from each module.

**READING**

### Visvesvaraya Technological University, Belagavi.
#### PhD Coursework Courses – 2018 (Mechanical Engineering)
#### As per 2017 Regulation

<table>
<thead>
<tr>
<th>Module 1</th>
<th>Group-3 Experimental Methods in Thermal Power Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours: 03</td>
<td>Exam Marks: 100</td>
</tr>
</tbody>
</table>

**Module 1**
- **Basics of Measurements**: Introduction, General measurement system, Signal flow diagram of measurement system, Inputs and their methods of correction
- **Pressure measurement**: Different pressure measurement instruments and their comparison, Transient response of pressure transducers, dead-weight tester, low-pressure measurement.

**Module 2**
- **Thermometry**: Overview of thermometry, temperature measurement by mechanical, electrical and radiation effects. Pyrometer, Thermocouple compensation, effect of heat transfer.
- **Thermal and transport property measurement**: Measurement of thermal conductivity, diffusivity, viscosity, humidity, gas composition, pH, heat flux, calorimetry, etc.

**Module 3**
- **Flow Measurement**: Flow obstruction methods, Magnetic flow meters, Interferometer, LDA, flow measurement by drag effects, pressure probes, other methods.
- **Nuclear, thermal radiation measurement**: Measurement of reflectivity, transmissivity, emissivity, nuclear radiation, neutron detection, etc. Other measurements: Basics in measurement of torque, strain.

**Module 4**
- **Analysis of experimental data**: Causes and types of errors in measurement, Propagation of errors, Uncertainty analysis, Regression analysis, Statistical analysis of Experimental data.
- **Sensing Devices**: Transducers-LVDT, Capacitive, piezoelectric, photoelectric, photovoltaic, Ionization, Photoconductive, Hall-effect transducers, etc.

**Module 5**
- **Air-Pollution**: Air-Pollution standards, general air-sampling techniques, opacity measurement, sulphur dioxide measurement, particulate sampling technique, combustion products measurement.
- **Advanced topics**: Issues in measuring thermo physical properties of micro and Nano fluids. Design of Experiments: Basic ideas of designing experiments, Experimental design protocols with some examples and DAS

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module. The students will have to answer 5 full questions, selecting one full question from each module.

**READING**
1. Modern Electronic Instrumentation and Measurement Techniques; Albert D Helfrick and William D Cooper, 2004, PHI
4. Transducers and Instrumentation; DVS Murthy, 2003, PHI
5. Instrumentation Devices and Systems; CS Rangan, GR Sarma, and VSV Mani; 2 ed, Tata McGraw-Hill
14. Modern Control Engineering, Katsuhiko Ogata, Prentice Hall
<table>
<thead>
<tr>
<th>12</th>
<th>16MTP21</th>
<th>Group-3</th>
<th>ADVANCED HEAT TRANSFER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exam Hours:</strong></td>
<td><strong>Exam Marks:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Module 1. Introduction and one-dimensional heat transfer:
The differential equation of heat conduction, heat generation, two dimensional steady state heat conduction, unsteady state processes, extended surfaces- fins of uniform cross section and non uniform cross sections, Thermal resistance networks and applications.

### Numerical heat Transfer:
Numerical techniques for solving heat conduction problems, the finite difference method for steady state situations, the finite difference method for unsteady state situations, Controlling Numerical Errors, problems.

### Module 2. Thermal radiation:
Basic concepts and laws of thermal radiation, the shape factor, Eradiant heat exchange in enclosures ,black and Grey surfaces ,radiation shields and Radiation Effect on temperature measurements. Radiation properties of participating Medium, Emissivity and absorbivity of Gases and Gas Mixtures, Heat transfer from the Human Body problems.

### Module 3. Analysis of Convection Heat Transfer:
Boundary layer fundamentals evaluation of convection heat transfer coefficient, Analytical solution for laminar boundary layer flow over a flat plate ,Approximate integral boundary layer analysis, Analogy between momentum and heat transfer in turbulent flow over a flat surface, Reynold's Analogy for Turbulent Flow Over Plane Surfaces, Mixed Boundary Layer, Special Boundary Conditions and High-Speed Flow

### Module 4. Natural convection:
Introduction, Similarity Parameters for Natural Convection, Empirical Correlation for Various Shapes, Rotating Cylinders, Disks, and Spheres, Finned Surfaces

### Heat transfer by forced convection:

### Module 5. Heat exchangers:
Basic concepts, types of heat exchangers, Analysis of heat exchangers, Counter-Flow Heat Exchangers, Multi-pass and Cross-Flow Heat Exchangers, Use of a Correction Factor , Selection of Heat Exchangers such as Heat Transfer Rate ,Cost ,Pumping Power, Size and Weight ,Type, Materials, Other Considerations, Compact Heat Exchangers. Heat Exchangers for multi phase flow.

### Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

### Reference Books:
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>13</th>
<th>16MCS421</th>
<th>Group-3</th>
<th>WIND ENERGY ENGINEERING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours: 03</td>
<td>Exam Marks: 100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**MODULE 1**
**Introduction:** Historical uses of wind, history of wind electric generation, horizontal axis, wind turbine, Innovative wind turbines.

**Wind Characteristics:** Metrology of wind, world distribution of wind, Atmospheric stability, Wind speed, variation with height, wind speed statistics, Weibull statistics, determining Weibull parameters, Rayleigh & normal distributions.

**MODULE 2**
**Wind Measurements:** Eolian features, biological indicators, rotational anemometers, other anemometers, wind direction, wind measurements with balloons.

**Wind Turbine Power, Energy & Torque:** power output from an ideal turbine, aerodynamics, power output from practical turbines, transmission & generator efficiencies, energy production & capacity factor, torque at constant speeds, turbine shaft power and torque at variable speeds.

**MODULE 3**
**Wind Turbine Connected To Electrical Network:** Methods of generating synchronous power, AC circuits, the synchronous generator, the induction machine, power calculation, motor starting, features of electrical network.

**Wind Turbines With a Synchronous Electrical Generators:** Asynchronous systems, DC shunt generator life battery head permanent magnet generator, AC generators, self excitation of induction generator, single phase operation of induction generator, field mounted generator, Rosel generator.

**MODULE 4**
**Asynchronous Head:** Piston water pumps, Centrifugal pumps, paddle wheel heaters, batteries, hydrogen economy & electrolysis cells.

**MODULE 5**
**Economics Of Wind Systems:** Capital costs, economic concepts, revenue requirements, value of wind generated electricity, hidden costs & non economic factors in industrialized nations, economic & non economic factors in developing nations, break even points, tariff calculations.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

**REFERENCE BOOKS:**
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>Course Code: 16MTP23</th>
<th>Group: 3</th>
<th>Module: ADVANCED POWER PLANT CYCLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours: 03</td>
<td>Exam Marks: 100</td>
<td></td>
</tr>
</tbody>
</table>

1. **Analysis of Steam cycles**: Rankine cycle, Carnot cycle, mean temperature of heat addition, effect of variation of steam condition on thermalefficiency of steam power plant, reheating of steam, regeneration, regenerative feed water heating, feed water heaters, carnitization of Rankine cycle, optimum degree of regeneration, Super critical pressure cycle, steam power plant appraisal, Deaerator, typical layout of steam power plant, efficiencies in a steam power plant, Cogeneration of Power and Process Heat, Numerical Problems.

**Combined cycle power generation**: Flaws of steam as working fluid in Power Cycle, Characteristics of ideal working fluid in vapor power cycle, Binary vapor cycles, coupled cycles, combined cycle plants, gas turbine-steam turbine power plant, MHD-steam power plant, Thermonic- Steam power plant.

2. **Fuels and combustion**: Coal, fuel oil, natural and petroleum gas, emulsion firing, coal – oil and coal – water mixtures, synthetic fuels, bio-mass, combustion reactions, heat of combustion and enthalpy of combustion, theoretical flame temperature, free energy of formation, equilibrium constant, effect of dissociation.

**Combustion Mechanisms**: Kinetics of combustion, mechanisms of solid fuel combustion, kinetic and diffusion control, pulverized coal firing system, fuel-bed combustion, fluidized bed combustion, coal gasifiers, combustion of fuel oil, combustion of gas, combined gas fuel oil burners, Requirements for efficient combustion, Recent trends in furnace/combustion chamber.

3. **Steam Generators**: Basic type of steam generators, fire tube boilers, water tube boilers. Economizers, superheaters, reheaters, steam generator control, air preheater, fluidized bed boilers, electrostatic precipitator, fabric filters and bag houses, ash handling system, feed water treatment, de-aeration, evaporation, internal treatment, boiler blow down, steam purity, Numerical problems.

**Condenser, feed water and circulating water systems**: Need of condenser, direct contact condensers, feed water heaters, circulating water system, cooling towers, calculations, Numerical Problems.

4. **Nuclear Power Plants**: Chemical and nuclear reactions, nuclear stability and binding energy, radioactive decay and half life, nuclear fission, chain reaction, neutron energies. Neutron flux and reaction rates, moderating power and moderating ratio, variation of neutron cross sections with neutron energy, neutron life cycle. Reflectors, Types of Reactor, PWR, BWR, gas cooled reactors. Liquid metal fast breeder reactor, heavy water and Fusion Power reactors.

5. **Hydro Electric Power Plant**: Introduction, advantages and disadvantages of water power, optimization of hydro – thermal mix, hydrological cycles, storage and pondage.

**Power plant Economics**: Definitions, Principles, Location of power plant, cost analysis selection of type of generation, selection of power plant equipments.

**Question paper pattern**:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Reference Books**:
## NANO SCIENCE AND NANOMATERIALS

| Exam Hours: | 03 | Exam Marks: | 100 |

### 1. Introduction To Nanoscience And Nanotechnology

- History, background scope and interdisciplinary nature of nanoscience and nanotechnology, scientific revolutions, nano sized effects surface to volume ratio, atomic structure, molecules and phases, energy at the nanoscale molecular and atomic size, quantum effects, types of nanotechnology and nano machines.

### 2. Properties Of Nanomaterials

- Mechanical properties-Thermo physical properties - Electrical properties Electric properties – Electro chemical properties Magnetic properties - optical properties-Catalytic property – properties of gas permeation and separation membranes.

### 3. Nanostructure Design

- Functionality of nanostructures and their characteristics evaluation, size effect in semiconductor nanoparticles – particle size, shape density – Melting point, surface energy – specific surface area and pore – Assembly of nanoparticles and functionalization – nanoparticles arranged structure as nanocomposites – Structure control of nanoparticle collectives by sintering and binding – Self-assembly.

### 3. Melting Point And Phase Transition Processes


### Surface Modification Of Nanoparticles


### 4. Application Of Quantum Dots For Bio-Medical Engineering


### 5. Smart Materials And Systems

- Thermoresponsive materials, piezoelectric materials, electrostrictive and magnetostrictive materials, ferrofluids, ER and MR fluids, biomimetic materials, smart gel, shape memory alloys and polymers, actuation methods, measurements.
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

**REFERENCEBOOKS:**
**Visvesvaraya Technological University, Belagavi.**

**PhD Coursework Courses – 2018 (Mechanical Engineering)**

**As per 2017 Regulation**

<table>
<thead>
<tr>
<th>Exam Hours:03</th>
<th>Exam Marks:100</th>
</tr>
</thead>
</table>

### Module 1

**Classification and Characteristics:** Metals, Non ferrous Metals and Ferrous Metals, classification of Ferrous Metals and Non Ferrous Metals, Types of Ceramics, Polymers and composites and classification of composites.

**General Properties and Structure:** Atoms, molecules bonds in solids, Crystalline - Defects in Metallic structure, Dislocations and plastic deformation - Strengthening mechanism - grain size, dislocation - Cold work, precipitation hardening, dispersion hardening - phase reactions, fatigue and Creep behaviour.

### Ferrous Alloys:
- iron carbon equilibrium diagrams - Steels and cast irons - properties, structure, composition and applications transformation hardening in steels - TTT diagrams - Heat treatment processes - Effect of alloying elements - High alloy steels, Stainless steel types, tool Steels, Manganese steels, heat resistant steels, HSLA, Managing steels.

### Non Ferrous Alloys:
- Alloys of copper, Aluminium, nickel, magnesium, titanium, lead, tin, Zinc - composition, heat treatment, structure, properties and application.

### Module 3

**Polymers and Polymerizations:** Structure and properties of thermoplastics and thermo sets – Engineering Applications - property modifications - Mechanical and thermal behaviour – processing methods

**Ceramics:** Nature and structure of Ceramics - Refractory Abrasives glasses - glass ceramics - Advanced ceramics processing methods.

### Module 4

**Composites:** Definition - classification and characteristics of composite materials - Volume fraction - laminated composites particulate composites, fibrous composites - Types of reinforcements, their shape and size - production and properties of fiber reinforced plastics, Metal Matrix composites and ceramic matrix composites - Applications.

### Module 5

**Processing of Polymers:** composites, ceramics - thermal spraying - Ion beam machining diamond coating techniques-tribological applications.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**
1. Engineering Metallurgy - Raymond and Higgens - ELBS/EA

**REFERENCE BOOKS:**
5. Material science and metallurgy - by Calliester, John Willey & Sons.
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>03</th>
<th>16MST152</th>
<th>Group-4</th>
<th>ADVANCED FOUNDRY TECHNOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Module-1 Solidification of Casting:** Concept of solidification of metals. Homogenous and heterogeneous nucleation. Growth mechanism. Solidification of pure metals and alloys. Mechanism of columnar and dendritic growth. Coring or Segregation. Solidification time and Chvorinov's rule. Concept of progressive and directional solidifications.


**Module-2 Design of Casting and Quality Control:** Factors to be considered in casting design. Design consideration in pattern making, moulding techniques and core making and assembly. Cooling stresses and hot spots in casting and modification in casting geometry to overcome them. Casting defects and factors responsible for them. Different inspection and testing methods to evaluate the casting. Quality control activities in a foundry. Salvaging methods of defective casting.

**Furnace Technology:** Study of various furnaces used in foundry, construction and operation of crucible and hearth furnaces. Resistance, Arc and Induction furnaces-their construction. Operation and application. Heat treatment furnaces and drying ovens used in foundry.


**Module-4 Aluminium Foundry Practice:** Composition, properties and application of common aluminum alloy casting. Melting and casting of Al-alloys. Gating and risering of Al-alloy casting.

**Copper Alloy Foundry Practice:** General characteristics of common cast copper alloys. Melting and casting of copper alloys. Gating and risering of cu-alloy castings


**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

**REFERENCE BOOKS:**
2. Foundry Technology - Beelely, P.R. – Butterworth.
Visvesvaraya Technological University, Belagavi.  
PhD Coursework Courses – 2018 (Mechanical Engineering)  
As per 2017 Regulation

<table>
<thead>
<tr>
<th>04</th>
<th>16MST21</th>
<th>Group-4</th>
<th>COMPOSITE MATERIALS TECHNOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Module-1** Introduction to Composite Materials: Definition, Classification, Types of matrices material and reinforcements, Characteristics & selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction.  

Biaxial Strength Theories: Maximum stress theory, Maximum strain theory, Tsai-Hill theory, Tsai, Wu tensor theory, Numerical problems.

**Module-3** Macro Mechanical Analysis of Laminate: Introduction, code, Kirchoff hypothesis, CLT, A, B, and D matrices (Detailed derivation) Engineering constants, Special cases of laminates, Numerical problems.  
Manufacturing and Testing: Layup and curing - open and closed mould processing, Hand lay-up techniques, Bag moulding and filament winding, Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining, joining and repair. NDT tests – Purpose, Types of defects, NDT method - Ultrasonic inspection, Radiography, Acoustic emission and Acoustic ultrasonic method.

**Module-4** Metal Matrix Composites: Re-inforcement materials, Types, Characteristics and selection, Base metals, Selection, Applications.

**Module-5** Applications: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment- future potential of composites.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
# Visvesvaraya Technological University, Belagavi.
## PhD Coursework Courses – 2018 (Mechanical Engineering)
### As per 2017 Regulation

<table>
<thead>
<tr>
<th>05</th>
<th>16MST41</th>
<th>Group-4</th>
<th>PLASTIC PROCESSING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Module 1. Plastic Processing:** Basic principle of processing, shape and size, processing parameters, their effect and behavior, Rheology of ideal fluids, and real polymers, Effects of melt behavior on processing and product performance.

**Injection Moulding:** Principles, process variables, moulding cycle, machinery used, parts and function, specification, construction and maintenance of injection moulding machine, start up and shut down procedure, cylinder, nozzles, interaction of moulding variables, press capacity, projected area, shot weight, concepts and their relationship to processing, trouble shooting in injection moulding, microprocessors controlled injection moulding machines.

**Module 2. Extrusion:** Basic principles of extruders, and extrusion process, different types of extrudes i.e. barrel, screw, drive mechanics, head, constructional features of dies, sizing and haul-off equipment for extruders of mono filaments and tubes, blown film lines, wire and cable covering system, pipe profile extrusion, co-extrusion, process variables in extrusion like heating, temperature control, dies well, and melt fracture, spacing and orientation, treating, printing and sealing, quality of extruder products, fault, causes and remedy.

**Compression and Transfer Moulding:** Techniques, various types of compression moulds, machinery used, and common moulding faults and remedies. Transfer moulding, its advantage over compression moulding, equipment used, press capacity, integral mold, and auxiliary mould, moulding cycle, ram pressure, clamping pressure, faults and remedies.

**Module 3. Blow Moulding:** Blow moulding process, processing parameter, materials used, hand operated and automatic blow moulding machine, extrusion blow moulding, moulding cycle, faults and remedies.

**Thermo Forming:** Basic principles, types of thermoforming, thermoforming moulds, processing parameters, faults and remedies.

**Rotational Moulding:** Basic principle, charge size, wall thickness, temperature control, fault causes and remedies.

**Module 4. Calendaring:** Basic principle, process variable, end product properties and applications, secondary processing techniques like powder coating, casting, machining, and joining of plastics, metalizing, and printing.

**Module 5. Processing of Engineering Plastics:** precautions, and start up procedure, preheating, shutdown procedure, quality control, and waste management. Ram Extrusion of PTFE, Processing of reinforced plastics, like filament winding, Hand-lay-up, spray moulding, SMC, DMC, Centrifugal casting, pultrusion, resin transfer moulding.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**
1. Plastic Processing Data Hand Book – Dominic V Rosato P.E.

**REFERENCE BOOKS:**
<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Cryogenic Fluid Storage And Transfer Systems: Basic storage vessels, insulations, un insulated and porous insulated lines, vacuum insulated lines, cryogenic valves, cool down process. Measurement Systems For Low Temperatures : Introduction, Temperature scales and fixed points, Metallic resistance thermometers, thermo couples, constant volume gas thermometers, magnetic thermometers, vapour pressure thermometers. 12 Hours</td>
</tr>
<tr>
<td>4</td>
<td>Vacuum Technology : Importance flowregimes in vacuum system, components of vacuum system, mechanical vacuum pumps, diffusion pumps, vacuum gaugs and valves 6 Hours</td>
</tr>
<tr>
<td>5</td>
<td>Cryogenic In Aerospace Applications: Cryogenic liquids in missile launching and space simulation – storage of cryogenic liquids-Effect of cryogenic liquids on properties of Aerospace materials – Cryogenic loading problems – Zero gravity problems associated with cryogenic propellants – Phenomenon of tank collapse – Elimination of Geysering effect in missiles 7 Hours</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question paper pattern:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The question paper will have ten questions.</td>
</tr>
<tr>
<td>• Each full question consists of 20 marks.</td>
</tr>
<tr>
<td>• There will be 2 full questions (with a maximum of four sub questions) from each module.</td>
</tr>
<tr>
<td>• Each full question will have sub questions covering all the topics under a module.</td>
</tr>
<tr>
<td>• The students will have to answer 5 full questions, selecting one full question from each module.</td>
</tr>
</tbody>
</table>

TEXT BOOKS:

REFERENCE BOOKS:
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>No.</th>
<th>Code</th>
<th>Group</th>
<th>Module</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>07</td>
<td>16MST23</td>
<td>Group-4</td>
<td>TESTING OF MATERIALS</td>
<td>Exam Hours:03</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Module 1. Testing machines and sensors</td>
<td>types of Universal Testing machines and principles of operations, Machine stiffness, load and strain measurement. Calibration and verification of UTM.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Friction, wear and surface testing</td>
<td>Testing of sliding contact, damage, abrasive wear, adhesive wear, erosive wear. Testing and determination of surface characteristics of solid materials. (Surface roughness measurements)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Module 2. Importance of calibration of Testing Instruments</td>
<td>Calibration methods and standards. Tests / experiments based on methods with active reference to various codes and standard for each test.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Failure Analysis</td>
<td>Principles and Approaches of Failure analysis, objectives, scope, planning, preparation. Failure Analysis procedures. Examination of damages and materials evaluation. Tools and Techniques in FA – An overview. Appearances of fracture in common conditions like unit axial loads, tensional and shear loads, fatigue and creep loading.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Speed &amp; Control of Testing</td>
<td>Background, Developments in testing Machine Technology. Effects of testing rates on properties, Results before servo control, Results from servo controlled machines.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Module 5. Lubrication &amp; Determination of characteristics of lubricants</td>
<td>Introduction, Types of lubricants, characteristics of lubricants. Methods of lubrication, four ball testing.</td>
</tr>
</tbody>
</table>

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

REFERENCE BOOKS:
1. ASM Vol Testing of materials
4. Relevant codes and standards.
Module 1 Introduction: Overview of Nanoscience and Engineering, Classification of nanostructures, Nanoscale Architecture, Scaling and miniaturization laws, Why use miniaturization technology- Effect of the nanometer length scale, Fabrication processes- Top down and Bottom up processes, Characterization techniques


Module 2 Effects Of Nanometre Length Scale: Changes to the system total energy. Changes to the system structure. How nanoscale dimensions affect properties – structural, thermal, chemical, mechani cal, magnetic, optical and electrical. Semiconductor Physics – To Understand Inorganic Semiconductor Nanostructures: What is a semiconductor? Doping, The concept of effective mass, Carrier transport, mobility and electrical conductivity, Optical property of semiconductors, Excitons, The pn junction, Phonons, Types of semiconductors, Quantum Confinement In Semiconductor Nanostructures, Quantum confinement in one dimension : quantum well, Quantum confinement in two dimension : quantum wires, Quantum confinement in three dimension : quantum dots, Superlattices, Band offsets.


Nanotribology Composition And Structure Of Surfaces 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, composition –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 isotherm, 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),

<table>
<thead>
<tr>
<th>Module</th>
<th>Course Code</th>
<th>Group</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>08</td>
<td>16MCS254</td>
<td>Group-4</td>
<td>NANO TECHNOLOGY</td>
</tr>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

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.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

**REFERENCE BOOKS:**
## Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>09</th>
<th>16MCS423</th>
<th>Group-4</th>
<th>ANALYSIS AND DESIGN OF COMPOSITES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Module 1
**Introduction to Composite Materials:** Definition, Classification, Types of matrices material and reinforcements, Characteristics & selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction.


### Module 2

### Module 3
**Macro Mechanical Analysis of Laminate:** Introduction, code, Kirchoff hypothesis, CL T, A, B, and D matrices (Detailed derivation) Engineering constants, Special cases of laminates, Numerical problems.

**Manufacturing:** Lay up and curing - open and closed mould processing, Hand lay, Up techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining and joining, tooling. Quality assurance, Introduction, material qualification, Types of defects, NDT methods.

### Module 4
**Application Developments:** Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites.

### Module 5
**Metal Matrix Composites:** Re-inforcement materials, Types, Characteristics and selection, Base metals, Selection, Applications.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

**REFERENCE BOOKS:**
Visvesvaraya Technological University, Belagavi.  
PhD Coursework Courses – 2018 (Mechanical Engineering)  
As per 2017 Regulation

<table>
<thead>
<tr>
<th>10</th>
<th>16 MST153</th>
<th>Group-4</th>
<th>NON DESTRUCTIVE TESTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Module 1**  
**Introduction to ND Testing:** selection of ND methods, visual inspection, leak testing, Liquid penetration inspection, its advantages and limitation.  
**Magnetic Particle Inspection:** Methods of generating magnetic field, types of magnetic particles and suspension liquids steps in inspection – application and limitations .

**Module 2**  
**Eddy Current Inspection:** principles, operation variables, procedure, inspection coils, and detectable discounts by the method.  
**Microwave Inspection:** Microwave holography, applications and limitations.  
**Ultrasonic Inspection:** Basic equipment characteristics of ultrasonic waves, variables inspection, inspection methods pulse echo A,B,C scans transmission, resonance techniques, transducer elements couplets, search units, contact types and immersion types inspection standards-standard reference blocks.

**Module 3**  
**Radiography Inspection:** principles, radiation source X-rays and gamma rays, X-ray-tube, radio graphic films, neutron radiography, Thermal inspection principles, equipment inspection methods applications.

**Module 4**  
**Optical Holography:** Basics of Holography, recording and reconstruction - Acoustical Holography: systems and techniques applications. Indian standards for NDT.  
**Module 5**  
**Visual Inspection and Thermographic methods:** Acoustic emission, Total acoustic emission, felicity ratio, Generation of Acoustic Emission.

**Question paper pattern:**  
- The question paper will have ten questions.  
- Each full question consists of 20 marks.  
- There will be 2 full questions (with a maximum of four sub questions) from each module.  
- Each full question will have sub questions covering all the topics under a module.  
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**  

**REFERENCE BOOKS:**  
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>11</th>
<th>16MST422</th>
<th>Group-4</th>
<th>BIO MATERIAL AND TECHNOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Module 1. Introduction:** Definition of Bio materials, Classification of Bio materials, Comparison of properties of some common bio materials, effects of physiological fluid on properties of bio materials, surface properties, physical and Mechanical properties of Bio materials.

**Metallic Implants Materials:** Stainless Steel, Co-based alloys, Ti and Ti based alloys, Important of stress corrosion cracking, Host tissue reaction with Bio metal, corrosion behaviour, hard tissue replacement implant, orthopedic implant, dental implants, Percutaneous and skin implants, Vascular implants, Heart valve implant.

**Module 2. Polymeric Implant Materials:** Polyolefins, polyamides, acrylic polymers, fluoro carbon polymers, Silicon rubber acetals. Visco elastic behaviour, creep recovery, stress relaxation, strain rate sensitivity, importance of molecular structure, hydrophilic and hydrophobic surface properties, migration of additives, aging and environmental stress cracking, physiochemical characteristics of bio polymers, bio degradable polymers for medical purpose and their biological applications.

**Ceramic Implant Materials:** Definitions of Bio ceramics, common type of Bio ceramics, Aluminium oxides, Glass ceramics, Carbons. Bioreabsorbable and Bioactive ceramics, Importance of wear resistance and low fracture toughness. Host Tissue reactions, Importance of Interfacial tissue reaction.

**Module 3. Composite Implant Materials:** Mechanics of improvement of properties by incorporating different elements. Composite theory of fiber reinforcement, polymers filled with osteogenic fillers (e.g. hydroxyapatite). Host tissue reactions.

**Bio Compatibility And Toxicological Screening Of Bio Materials:** Definition of bio compatibility, blood compatibility and tissue compatibility, toxicity tests, acute and chronic toxicity ( in situ implantation, tissue culture, haemolysis, thermobogenic, potential test, systemic toxicity, intracutaneous irritation test), sensitization, carcinogenicity, mutagenesity and special tests.


**Module 5. Sterilisation Techniques:** ETO, gamma radiation, autoclaving, Effects of Sterilisation on material properties.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**

**REFERENCE BOOKS:**
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>12</th>
<th>16MST423</th>
<th>Group-4</th>
<th>MECHANICAL BEHAVIOUR OF MATERIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Strength of materials** - basic assumptions, elastic and plastic behaviour, stress–strain relationship for elastic behaviour, elements of plastic deformation of metallic materials Mohr’s circle, yielding theories.

**Theory of plasticity**: Elements of theory of plasticity, dislocation theory properties of dislocation, stress fields around dislocations, application of dislocation theory to work hardening, solid solution strengthening, grain boundary strengthening, dispersion hardening

**Ductile and Brittle Fracture**: Ductile and brittle fracture, Charpy and Izod testing, significance of DBTT, ECT, NDT and FATT; elements of fractography - Griffith’s theory, LEFM– COD and J integral –determination of KIC, COD and J integral.


**Introduction to creep**: creep mechanisms, creep curve, variables affecting creep, accelerated creep testing, development of creep resistant alloys, Larsen Miller parameter – Manson Hafred parameter

**Stages of failure analysis**: classification and identification of various types of fracture. Overview of fracture mechanics, characteristics of ductile and brittle fracture. General concepts, fracture characteristics revealed by microscopy, factors affecting fatigue life Creep, stress rupture, elevated temperature fatigue, metallurgical instabilities, environmental induced failure. Some case studies failures.


**Causes of failure in forging**: failure of iron and steel castings, improper heat treatment, stress concentration and service conditions. Failure of weldments - reasons for failure procedure for weld failure analysis.

**Question paper pattern**:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS**

**REFERENCES BOOKS**
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>13</th>
<th>16MST251</th>
<th>Group-4</th>
<th>SURFACE TREATMENT AND FINISHING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
</tr>
<tr>
<td>Module 5.</td>
<td>Advanced coating technologies: Hard facing, electro deposition technique, nanocoatings, coating characterization.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOK:**

**REFERENCE BOOKS:**
4. Metals Hand Book – ASM.
**Visvesvaraya Technological University, Belagavi.**

**PhD Coursework Courses – 2018 (Mechanical Engineering)**

As per 2017 Regulation

<table>
<thead>
<tr>
<th>14</th>
<th>16 MST154</th>
<th>Group-4</th>
<th><strong>SELECTIONS OF MATERIALS IN ENGINEERING</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
</tr>
</tbody>
</table>

**Module 1** Introduction to Selection of Mechanical Properties: Types of materials Static strength, Toughness, Stiffness, Fatigue Creep, Fatigue & Thermal Properties.

**Module 2** Selection for corrosion resistance
- The nature of the corrosion process
- Selection of materials for resistance to atmospheric corrosion
- Selection of materials for resistance to oxidation at elevated temperatures
- Selection of materials for resistance to corrosion in the soil
- Selection of materials for resistance to corrosion in water
- Selection of materials for chemical plant
- Degradation of polymeric materials.

**Selection of materials for resistance to wear**: The mechanisms of wear, The effect of environment on wear
- Surface treatment to reduce wear
- Erosive wear
- Selection of materials for resistance to erosive wear

**Module 3**

The relationship between materials selection and materials processing: The purpose of materials processing, the background to process selection. The casting of metals and alloys, wrought products, the manufacture of plastics. Fabrication from powder, Fastening and joining.

**Module 4**

Materials for Aerospace Application: Principal characteristics of aircraft structures, Property requirements of aircraft structures, Requirements for high-speed flight, Candidate materials for aircraft structures.

Materials for ship structures & automotive application: The ship girder, Factors influencing materials selection for ship hulls, Materials of construction

**Module 5**

Materials for engines and power generation: Internal combustion, External combustion.

Materials for bearings & High Temperature Application: Rolling bearings, Plain bearings.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS:**
1. F A A Crane and J A Charles.

**REFERENCE BOOKS:**
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>01</th>
<th>16MTR423</th>
<th>Group-5</th>
<th>Vibration Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Module 1.**
**Review of Mechanical Vibrations:** Basic concepts; free vibration of single degree of freedom systems with and without damping, forced vibration of single dof-system. Force and motion isolation. Two dof-systems: natural frequency.

**Transient Vibration of Single Degree-of Freedom System:** impulse excitation, arbitrary excitation, Laplace transform formulation, pulse excitation and rise time, shock response spectrum, shock isolation, finite difference numerical computation.

**Module 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.

**Module 3.**
**Modal Analysis and Condition Monitoring:** dynamic testing of machines and structures, experimental modal analysis, machine condition monitoring and diagnosis.


**Module 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.

**Module 5.**
**Continuous System:** vibrating string, longitudinal vibration of rods, tensional vibration of rods, suspension bridge as continuous system, Euler equation for beams, vibration of membrane.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**
3) Mechanical Vibrations,-S.S Rao, 4 edition Pearson Education.
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>02</th>
<th>16MTR13</th>
<th>Group-5</th>
<th>ADVANCED CONTROL SYSTEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

**MODULE 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.

**MODULE 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.

**MODULE 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.

**MODULE 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.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**REFERENCE BOOKS:**
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>03</th>
<th>16MTR154</th>
<th>Group-5</th>
<th>MECHATRONIC SYSTEMS IN AUTOMOBILE ENGINEERING</th>
</tr>
</thead>
</table>

Exam Hours:03  Exam Marks:100

Module 1
Types of Automobile. Limiting dimensions as per central motor vehicle Rules. Engine classification, construction, Materials of engine components. Prototype testing as per Central Motor Vehicle Rules.

Module 2

Module 3

Module 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.

Module 5
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.

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

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.
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

04 16MTR151 Group-5 AUTOMOTIVE ELECTRONICS

<table>
<thead>
<tr>
<th>Exam Hours:03</th>
<th>Exam Marks:100</th>
</tr>
</thead>
</table>

Module 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

Module 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

Module 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.

Module 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

Module 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.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Reference Books:**
### Module 1

### Module 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.

### Module 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.

### Module 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.

### Module 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.

### Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

### Text Books:

### Reference Books:
### Module 1
**Introduction:**
- Introduction.
- Review of Historical Events.
- Push and Pull for New Paradigms.
- Areas of Manufacturing Competitiveness.
- Product and Services.
- Process and Methodologies.
- Performance Indicators.

**Life-Cycle Management:**
- Shrinking Life Cycle.
- Life-Cycle Management.
- New Product Introduction.
- Strategic Technology Insertions.
- Managing Continuity.
- Managing Revision Changes.
- Life-Cycle Cost Drivers.
- Life-Cycle Management Tools.
- Sequential Versus Concurrent Engineering.
- Life-Cycle Management.

### Module 2
**Process Reengineering:**
- Understanding and Managing Change.
- Reengineering Approaches.
- Tenets of Process Improvement.
- Information Flow-Charting.
- Enterprise Models.
- Process Improvement Methodology.
- Change Management Methodology.
- Concurrent Process Reengineering.

### Module 3
**Concurrent Engineering Definitions:**
- Introduction.
- CE Definitions.
- Basic Principles of CE.
- Components Of CE.
- Concurrency And Simultaneity.
- Modes of Concurrency.
- Modes of Cooperation.
- Benefits Of Concurrent Engineering.

### Module 4
**System Engineering:**
- Introduction.
- An Automobile Manufacturing Process.
- System Engineering.
- Systems Thinking.
- Approaches to System Complexity.
- Sharing and Collaboration in CE 300.
- System Integration.
- Agile Virtual Company.

### Module 5
**Information Modeling:**
- Information Modeling.
- Modeling Methodology.
- Foundation of Information Modeling.
- Concurrent Engineering Process Invariant.
- Enterprise Model-Class.
- Specification Model-Class.
- Product Model-Class.
- Process Model-Class.
- Cognitive Models.
- Merits and Demerits.

### Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

### Text Books:

### Reference Books:
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODULE 1</td>
<td>Basic Concepts - Dimensionless form of equations; Simplified mathematical models; Hyperbolic, Parabolic &amp; Elliptic systems; Properties of numerical solutions (Consistency, Stability, Conservation, Convergence and Accuracy).</td>
</tr>
<tr>
<td>MODULE 2</td>
<td>Finite Difference Methods - Discretisation; Boundary conditions; error propagation; Introduction to spectral methods; examples.</td>
</tr>
<tr>
<td>MODULE 3</td>
<td>Finite volume method - Surface &amp; volume integrals; Interpolation &amp; differentiation; Boundary conditions; Examples</td>
</tr>
<tr>
<td>MODULE 4</td>
<td>Gaussian Elimination; LU decomposition; Tridiagonal Systems; Iterative methods; convergence; ADI &amp; other splitting methods. Multi-grid method - Coupled equations; Simultaneous solutions, sequential solutions &amp; under relaxation. Non linear systems</td>
</tr>
</tbody>
</table>

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books

Reference Books
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>08</th>
<th>16MTR152</th>
<th>Group-5</th>
<th>MICRO AND SMART SYSTEMS TECHNOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Module 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, piezoelectric 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 analyzer, active noise control in a helicopter cabin.

**Module 2**

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

**Module 3**

**Modelling:**

a) Scaling issues.


**Computer-aided simulation and design:** Background to the finite element method. Coupled-domain simulation using Matlab. Commercial software.

**Module 4**

**Electronics, circuits and control:**


**Module 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.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

REFERENCE BOOKS:
7. P.C. Mallik Marcel Decker: “Fibre Reinforced Composites”
<table>
<thead>
<tr>
<th>09</th>
<th>16MCM22</th>
<th>Group-5</th>
<th>FLEXIBLE MANUFACTURING SYSTEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Module 1. Introduction** Flexible and rigid manufacturing, F.M. Cell and F.M. System concept, Types and components of FMS, Tests of flexibility, Group Technology and FMS, unmanned factories, Economic and Social aspects of FMS.

**Module 2. Control Structure of FMS:** Architecture of typical FMS, Automated work piece flow, Control system architecture – Factory level, Cell level; hierarchical control system for FMS, LANs - characteristics, transmission medium, signaling, network topology, access control methods; Factory networks, Structure and functions of manufacturing cell, Distributed Numerical Control (DNC).

**Module 3. Scheduling & Loading Of FMS:** Introduction, Scheduling of operations on a single machine, 2 machine flow shop scheduling, 2 machine job shop scheduling, 3 machine flow shop scheduling, scheduling ‘n’ operations on ‘n’ machines, Scheduling rules, loading problems, Tool management of FMS, material Handling system schedule. Problems.

**Module 4. Tooling in FMS:** Modern cutting tools and tool materials, tool holders, modular tooling, tool monitoring, presetting and offsets, wear and radius compensation, tool magazines, automatic tool changers, roboticized tool assembly, tool management system.

**Module 5. Fixturing in FMS:** Part holding on Pallets, standard fixtures, pallet changers, pallet pool, flexible fixturing – principles and methodologies, modular fixturing system; T slot based, dowel pin based, fixturing components, computer aided fixture design – locating and clamping, use of GT in fixture design, fixture database

**Question Paper Pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books**

**Reference Books**
2. Radhakrishnan, Subramanyan, "CAD / CAM / CIM", John Wiley
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>10</th>
<th>16MST421</th>
<th>Group-5</th>
<th>MODELING, SIMULATION AND ANALYSIS OF MANUFACTURING SYSTEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Exam Hours:03, Exam Marks:100</td>
</tr>
</tbody>
</table>

**Module 1**
**Principles of Modeling & Simulation:** Basic Simulation Modeling, Limitation of Simulation, Monte Carlo Simulation, Areas of Applications, Discrete and Continuous Systems.

**Module 2**
**Modeling Approaches:** Modeling Complex Systems, Simulation Software, Basics Probability and Statistics, Building Valid and Credible Simulation Models

**Module 3**
**Random Number and Variable Generation:** Selecting Input Probability Distributions, Random Number Generators, Generating Random Variants, and Output Data Analysis for a Single System.

**Module 4**
**Statistical Techniques:** Comparison of Alternative Systems, Variance Reduction Techniques.

**Module 5**
**Simulation Studies:** Discrete Event Simulation, Simulation of Inventory Problems, Experimental Design and Optimization, Simulation of Manufacturing Systems, Case Studies.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
1. “System Simulation” - Gordon, PHI.
2. “System Simulation with Digital computer” – Deo, PHI
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>11</th>
<th>16CAE251</th>
<th>Group-5</th>
<th>DESIGN OPTIMIZATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


**Applications of Optimization in Engineering Design:** Automotive, Aerospace and General Industry Applications, Optimization of Metallic and Composite Structures, Minimization and Maximization Problems, MDO and MOO.


**Module 3. Sensitivity Analysis:** Linear and Non Linear Approximations. Gradient Based Optimization Methods – Dual and Direct.

**Optimization Disciplines:** Conceptual Design Optimization and Design Fine Tuning, Combined Optimization, Optimization of Multiple Static and Dynamic Loads, Transient Simulations, Equivalent Static Load Methods. Internal and External Responses, Design Variables in Each Discipline.

**Module 4. Manufacturability in Optimization Problems:** Design For Manufacturing, Manufacturing Methods and Rules, Applying Manufacturing Constraints to Optimization Problems.

**Design Interpretation:** Unbound Problems, Over Constrained Problems, Problems with No of Multiple Solutions, Active and Inactive Constraints, Constraint Violations and Constraint Screening, Design Move Limits, Local and Global Optimum .


**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

12 16MTR421 Group-5 ARTIFICIAL INTELLIGENCE & NEURAL NETWORKS

Exam Hours:03  Exam Marks:100

Module 1.

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

Module 3.

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

Module 5.

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXTBOOK:

REFERENCE BOOKS:
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

13  16MTR21  Group-5  ADVANCED ELECTRONIC DRIVES

<table>
<thead>
<tr>
<th>Exam Hours:03</th>
<th>Exam Marks:100</th>
</tr>
</thead>
</table>

**MODULE 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.

**MODULE 2 An introduction to electrical drives & its dynamics**:

**MODULE 3 Dc motor drives**

**MODULE 4 Three phase induction machines**

**MODULE 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.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOK:**

**REFERENCE BOOKS:**
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Group</th>
<th>Module</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>16MTR23</td>
<td>Group-5</td>
<td>SENSORS AND SIGNAL CONDITIONING</td>
<td></td>
</tr>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


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

**Module 2. SIGNAL CONDITIONING FOR RESISTIVE SENSORS:** Measurement of Resistance, Voltage Dividers, Wheatstone bridge, Balance Measurements, Instrumentation Amplifiers, and Interference.

**REACTIVE VARIATION AND ELECTROMAGNETIC SENSORS:** Capacitive Sensors, Inductive Sensors, Electromagnetic Sensors.

**Module 3. SIGNAL CONDITIONING FOR REACTIVE VARIATION SENSORS:** Problems and Alternatives, AC Bridges, Carrier Amplifiers, variable Oscillators, Resolver – to Digital and Digital-to-Resolvers Converters.

**SELF- GENERATING SENSORS:** Thermoelectric Sensors: Thermocouples, Piezoelectric Sensors, Photovoltaic Sensors, Electro chemical Sensors.

**Module 4. SIGNAL CONDITIONING FOR SELF- GENERATING SENSORS:** Chopper and Low-Drift Amplifiers, Electrometer Amplifiers, Charge Amplifiers, Noise in Amplifiers.

**DIGITAL SENSORS:** Position Encoders, Variable Frequency Sensors.

**Module 5. OTHER TRANSDUCTION METHODS:** Sensors based on Semiconductors Junctions, Sensors based on MOSFET Transistors, Charge-Coupled Sensors, Ultrasonic- based Sensors, Fiber-Optic Sensors.

**TELEMETRY AND DATA ACQUISITION:** Data- Acquisition System Structure, Telemetry Systems, Amplitude Telemetry, Frequency Telemetry.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Reference Book:**
Module 1. Introduction: Definition of Prototype, Types of prototype, Need for the compression in product development, History of RP systems, Survey of applications, Growth of RP industry, and classification of RP systems.


Concepts Modelers: Principle, Thermal jet printer, Sander’s model market, 3-D printer, Genisys Xs printer HP system 5, object Quadra systems, Laser Engineering Net Shaping.

Module 4. Rapid Tooling: Indirect Rapid tooling -Silicon rubber tooling —Aluminum filled epoxy tooling Spray metal tooling ,Cast kirkite ,3D keltool ,etc .Direct Rapid Tooling — Direct, AIM, Quick cast process, Copper polyamide, Rapid Tool ,DMILS, ProMetal ,Sand casting tooling ,Laminate tooling soft Tooling vs. hard tooling.

Module 5. Software for Rp: SIl files, Overview of Solid view, magics, imics, magic communicator, etc. Internet based software, Collaboration tools

Application of Rapid Prototyping and Technology: Functional models, pattern for investment and Vacuum casting, medical models, Art models, Engineering analysis models.

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

Reference Books:
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>02</th>
<th>16MCM154</th>
<th>Group-6</th>
<th>AGILE MANUFACTURING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Exam Hours:03</td>
</tr>
</tbody>
</table>

MODULE 1
Agile Manufacturing: Definition, business need, conceptual framework, characteristics, generic features.
Four Core concepts: Strategy driven approach-integrating organization, people technology, interdisciplinary design methodology. 6Hours

MODULE 2
Developing Agile Manufacturing: Enterprise design, System concepts as the basic manufacturing theory-
joint technical & Organizational design and a model for the design of agile manufacturing enterprise.
Enterprise design process insights into design processes, what is interdisciplinary design, main issues, simple design example.
Integration of Product /Process Development: Principles, Robust design approach, manufacturing, Role of QFD, Managing people in Agile organization, Approaches.

MODULE 3
Application of IT/IS Concepts In Agile Manufacturing: Strategies, Management of complexities and information,flow, approaches, applications of multimedia to improve agility in manufacturing, system concepts.

MODULE 4
Computer Control Of Agile Manufacturing: CAPP for Agile Manufacturing, Aggregate capacity planning and production line design / redesign in Agile manufacturing, Cellular manufacturing, concepts, examples.
Corporate Knowledge Management In Agile Manufacturing: Strategies, strategic options in Agile manufacturing. Role of standards.

MODULE 5
Design of Skill & Knowledge: Enhancing technology for Machine tool system, Resumption of design requirement geometry, definition, methods, decision support for selection of cutting parameters, design enhancements, parametric approach only.

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS:

REFERENCE BOOKS:
Module 1. Information Basics: Definition of information system, classification of IS, Need for Information system, Contemporary approaches to information system, Key system applications in the organization, Challenges of information systems. Impact of IT, IS for Knowledge work.

Module 2. Managing with Information and its Resources: Managing in 21st Century, Strategic planning and IS, Information needs for strategic planning, IS for decision support, Quality and privacy issues. Information resource management, strategic planning for IS function, justification for IS, IT/IS facilities and operations, security control and Audit.

Module 3. Information systems and Organizations: Relationship between organizations and information systems, feature of organizations, effect of organizations on information systems, effect of information systems on organizations.
Information, Management and Decision-making: Role of managers, Decision-making, Individual models of decision-making, Organizational models of decision-making.

Object Oriented Technology: Object orientation, object oriented analysis (OOA), system development through OOT, Object Oriented Languages. OOT and MIS.

Module 5. System modeling: Introduction to system modeling, system concepts for data modeling, logical data modeling, and construction of data model. Process modeling: Introduction to process modeling, system concepts for process modeling, data flow diagram, logical process modeling, construction of process model.
Decision Support Systems: DSS issues, Structure Constructions-approaches, generators, tools, software and cost benefits and simple examples of applications

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

Reference Books:
5. Management Information System- A Concise Study - S.A.Kelkar, PHI.
6. Management Information systems - W.S Jawadekar, TMH
7. Information System for modern management -Murdick Ross &Claggett, PHI.
Module 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.

Module 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.

Module 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.

Module 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.

Module 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.

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Reference Book:
Product Design and Development by Karl T Ulrich, Steven D Eppinger, Anita Goyal.
## Module 1
### Introduction:

### Market and Demand Analysis:
Situational Analysis and objectives specification, Collection of Information, Market survey, Market characterization, Demand Forecasting, Qualitative, Quantitative and Casual Methods of Forecasting, Uncertainties in demand forecasting, Market Planning.

## Module 2
### Technical Analysis:
Manufacturing Technology, Material Inputs, Product Mix, Plant Capacity, Location, Machineries and equipment, Structure and civil works, Environmental Aspects, Project charts and layouts, Project implementation, consideration of alternatives.

### Financial Analysis:
Cost of project, Means of Finance, Estimation of sales and production, cost of production, working capital requirements and financing, Profitability projections, Breakeven Analysis, Cash Flow and Balance sheet statements.

## Module 3
### Investment Analysis:

### Risk Analysis:
Sources, Measures and perspective of Risk, Sensitivity Analysis, Simulation Analysis, Decision Tree Analysis, Monte- Carlo Simulation, Project selection under Risk.

## Module 4
### Networks Techniques for Project Management:
Project Network, Time estimation, Critical Path determination, PERT/CPM Model, Network cost system.

## Module 5
### Manpower Management in Projects:
Functional Approach to Manpower Management- the element of decision process, project team concepts, filed autonomy, policies, government policies.

### Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

### Text Books:
4. Dennis lock: “Project Management”.

### Reference Books:
2. Dennis lock: “Project Management”.
**Visvesvaraya Technological University, Belagavi.**

**PhD Coursework Courses – 2018 (Mechanical Engineering)**

*As per 2017 Regulation*

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MODULE 3</strong></td>
<td>Design Considerations: Design of components with casting consideration. Pattern, Mould, and Parting line. Cored holes and Machined holes. Identifying the possible and probable parting line. Casting requiring special sand cores. Designing to obviates and cores. Component Design: Component design with machining considerations link design for turning components—milling, Drilling and other related processes including finish—machining operations.</td>
</tr>
<tr>
<td><strong>MODULE 5</strong></td>
<td>Design of Gauges: Design of gauges for checking components in assemble with emphasis on various types of limit gauges for both hole and shaft.</td>
</tr>
</tbody>
</table>

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>07</th>
<th>16MTR422</th>
<th>Group-6</th>
<th>RELIABILITY AND FAILURE ANALYSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Module 1.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reliability definition</strong></td>
<td>Introduction, definition, failure data, mean failure rate, mean time to failure, mean time between failure, graphical plots, four important points, mt tf terms of failure density, generalization, reliability in terms of hazard rate and failure density, int integral form, mean time to failure in integral form, reliability in other situations.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Module 2.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hazard models</strong>; constant hazard, linearly increasing hazard, the weilbull model, on 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.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Module 3.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Conditional probabilities and multiplication rule</strong>, 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.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Module 4.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Reliability improvement</strong>, 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.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Module 5.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Maintainability</strong>, 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.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books**
**Visvesvaraya Technological University, Belagavi.**

**PhD Coursework Courses – 2018 (Mechanical Engineering)**

**As per 2017 Regulation**

**08 16MTP152 Group-6 Nuclear Energy Conversion**

<table>
<thead>
<tr>
<th>Exam Hours:03</th>
<th>Exam Marks:100</th>
</tr>
</thead>
</table>


**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**READING:**
6. A Course in Power Plant Technology, Domkundwar, Dhanpat Rai Sons
Module 1. Introduction: Extensive definition of Concurrent Engineering (CE), CE design methodologies, Review of CE techniques like DFM (Design for manufacture), DFA (Design for assembly), QFD (Quality function deployment), RP (Rapid prototyping), TD (Total design), for integrating these technologies, organizing for CE, CE tool box, Collaborative product development.

Module 2. Use of Information Technology: IT Support Solid modelling, product data management, Collaborative product commerce, Artificial Intelligence, expert systems, Software hardware component design.

Module 3. Design Stage: Lifecycle design of products, opportunities for manufacturing enterprises, Modality of Concurrent engineering design, Automated analysis idealization control, CE in optimal structural design, Real time constraints.

Module 4. Need for PLM: Importance of PLM, Implementing of PLM, Responsibility for PLM, Benefits to different managers, Components of PLM, Emergence of PLM, Life cycle problems to resolve, Opportunities to seize.

Module 5. Components of PLM: components of PLM, Product lifecycle activities, Product organizational structure, Human resources in product lifecycle, Methods, techniques, practices, Methodologies, Processes, System components in lifecycle, slicing and dicing the systems, Interfaces, Information, Standards.

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Book
2. Design for Concurrent Engineering/ J Cleetus/ CE Research Centre, Morgantown.
3. Concurrent Engineering Fundamentals/ Prasad / Prentice hall India Integrated Product Development.
4. Concurrent Engineering in product Design and Development/ I.Moustapha / New age International

REFERENCE BOOK
2. Product Lifecycle Management/ Michael Grives/ Mc Graw Hill
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>10</th>
<th>16MAR23</th>
<th>Group-6</th>
<th>COMPUTER CONTROL OF MANUFACTURING SYSTEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exa m Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Module 1. Introduction to Computer integrated Manufacturing Systems:** Manufacturing Systems, Types of Manufacturing Systems, Machine Tools and related equipment’s, Material Handling Systems, Computer monitoring and control, Manufacturing support systems, The Product Cycle and CAD/ CAM, Functions of computers in CIMS: CIMS Data Files, System Reports, Benefits of Computer integrated Manufacturing Systems, 

**Fundamentals of Numerical Control:** Basic concepts of NC, Classification of NC- Point to Point and contouring, Incremental and absolute system, Open loop and closed loop system, Advantages of NC.


**Constructional Features of CNC Machines:** Design considerations of CNC machines for improving machining accuracy, Structural Members, Slide ways, bearings, Re-circulating ball Screws, Spindle drives, Work holding devices and tool holding devices, Automatic tool changers.

**Module 3. NC part programming:** Introduction, NC/ CNC programming methods: Manual part programming for turning and milling centers, G codes, M codes, canned cycles, Programming with CAD/CAM integration, CAM packages for CNC part program generation, Practical Exercises on CNC part programming.

**Computer Controls in NC:** CNC Technology: Functions of CNC Control in Machine Tools, Advantages of CNC, Direct Numerical Control(DNC Systems): Configuration of DNC system, Functions of DNC, Communication between DNC computer & MCU, Advantages of DNC.

**Module 4. Adaptive control:** machining systems. Adaptive control optimization system, adaptive control constraint system, applications to machining processes, Benefits of Adaptive control Machining.

**Industrial Robotics:** Robotics technology : Types of Robots, Robot Technology Levels, Robot geometric configurations and Technical Features, basic robot motions, Robot control systems, robot drive systems, Work-cell control and Interlocks, robot sensors, robot safety, Robot-computer interface, industrial robot applications and benefits.

**Module 5. Computerized Manufacturing Planning and Control Systems:** Computer aided process planning, Variant and Generative approaches, Computer integrated production planning and control systems, Typical production planning and control system, Material planning systems, Capacity planning, Shop Floor Control, Automatic identification, Automated data collection systems.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
11 16MCS13 Group-6 OPTIMIZATION TECHNIQUES

<table>
<thead>
<tr>
<th>Exam Hours:03</th>
<th>Exam Marks:100</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Module 1. Introduction:</strong> Engineering application of optimization, Statement of optimization problem, Classification of optimization problems, Classical optimization techniques I: single variable optimization, Multivariable optimization with no constraints.</td>
<td></td>
</tr>
<tr>
<td><strong>Classical Optimization Techniques II:</strong> Multivariable optimization with equality constraints and inequality constraints, Kuhn – Tucker conditions.</td>
<td></td>
</tr>
<tr>
<td><strong>Module 2. Non-linear Programming:</strong> One - dimensional minimization methods: Unimodal function, Unrestricted search, Exhaustive search, Dichotomous search, Fibonacci method, Golden section method.</td>
<td></td>
</tr>
<tr>
<td><strong>Interpolation Methods:</strong> Quadratic, Cubic and Direct root interpolation methods.</td>
<td></td>
</tr>
<tr>
<td><strong>Descent Methods:</strong> Steepest descent, Conjugate gradient, Quasi - Newton, Davidon - Fletcher - Powell method.</td>
<td></td>
</tr>
</tbody>
</table>

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>12</th>
<th>16MAR 423</th>
<th>Group-6</th>
<th>TOOLING FOR MANUFACTURE IN AUTOMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exam Hours:03</td>
<td></td>
<td>Exam Marks:100</td>
</tr>
</tbody>
</table>

**MODULE 1**
Mechanics of metal cutting: Introduction, measurement of cutting forces and chip thickness, force components, chip formation and primary plastic deformation, shear plane and slip line theories for continuous chip formation.

Modern Cutting tool materials: Material properties, HSS related materials, sintered tungsten carbide, cermets, ceramics, polycrystalline tools, tool coatings, coating methods, conventional coating materials, diamonds and CBN

Cutting tools: Basic types of cutting tools, turning tools, indexable inserts, groove geometry, edge preparation, wiper geometry, insert clamping methods, tool angles, threading tools, grooving and cut off tools, milling tools, types of milling cutters, milling inserts and edge clamping methods.

**MODULE 2**
Optimization: Machining cost and production rate verses cutting speed, role of computerized optimization system, economic considerations, optimization of machining system, machining conditions, constraints, depth of cut feed and speed.

Tooling Requirements for CNC Machines: Tool holding systems modular and quick change tool holding system, tool holder spindle connection, cutting tool clamping systems, milling cutter driver, side lock type chuck, collet chucks, hydraulic chucks, milling chucks. Tool magazines, Automatic Tool Changers, robotized tool assembly, tool management system. Tool monitoring, presetting and offsets, wear and radius compensation.

**MODULE 3**
Location and Clamping Methods: Basic principles of locating, locating methods & devices, Basic principles of clamping, clamping methods.


**MODULE 4**

**MODULE 5**

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXTBOOKS:**
2. Edward G Hoffman, Fundamentals of Tool Design -, SME, USA.

**REFERENCE BOOK**
1. William E Boyes, Handbook of Jigs & Fixtures Design -, SME, USA.
4. Dr. B.J. Ranganath, Metal cutting and tool design, Vikas publishing house
5. ASTME; Die Design Hand book; McGraw Hill.
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Mechanical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>13</th>
<th>16MAR14</th>
<th>Group-6</th>
<th>AUTOMATION IN MANUFACTURING SYSTEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**MODULE 1**


**Mathematical concepts and models:** Production concepts and mathematical models cost of manufacturing operation, numerical.


**MODULE 3**


**MODULE 4**

**Power Hydraulics & Pneumatics:** Concepts features & parameters governing the Selection of various components Necessary for Building the elements, Circuit Design & Analysis. Industrial Applications of Fluid power & pneumatic systems, Electro-Hydraulic Servo System, Fluid logic control

**MODULE 5**

**PLC:** Introduction, Micro PLC, Programming a PLC, Logic Functions, input & output Modules, PLC Processors, PLC Instructors, Documenting a PLC System, Timer & counter Instructions, Comparison & data Handling instructions, Sequencing Instructions, Computer Aided Planning and Control and Computer Monitoring.

Production Planning and control cost planning and control inventory management material requirements planning (MRP) shop floor control. Types of production monitoring systems.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOKS**
1. Performance modeling of automated Manufacturing Systems - Viswanandham, PHI.

**REFERENCE BOOKS:**
1. Principles of CIM - Vajpayee, PHI.
**Visvesvaraya Technological University, Belagavi.**  
**PhD Coursework Courses – 2018 (Mechanical Engineering)**  
**As per 2017 Regulation**

<table>
<thead>
<tr>
<th>14</th>
<th>16MAR 421</th>
<th>Group-6</th>
<th>Production Planning and Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
</tr>
</tbody>
</table>

**MODULE 1**  
**INTRODUCTION**  
Objectives and benefits of planning and control-Functions of production control-Types of production job- batch and continuous-Product development and design-Marketing aspect - Functional aspects- Operational aspect-Durability and dependability aspect-aesthetic aspect. Profit consideration- Standardization, Simplification & specialization-Break even analysis. Simple numerical.

**MODULE 2**  
**WORK STUDY**  
Method study, basic procedure-Selection-Recording of process - Critical analysis, Development -Implementation - Micro motion and memo motion study - work measurement - Techniques of work measurement - Time study - Production study - Work sampling - Synthesis from standard data - Predetermined motion time standards.

**MODULE 3**  
**PRODUCTION PLANNING** : Forecasting techniques – causal and time series models, moving average, exponential smoothing, trend and seasonality; aggregate production planning, numerical.

**MODULE 4**  
**MASTER PRODUCTION SCHEDULING**  
MRP and MRP-II; order control and flow control; routing, scheduling and priority dispatching; push and pull production systems, concept of JIT manufacturing system; logistics, distribution, and supply chain management;

**MODULE 5**  
**INVENTORY CONTROL AND RECENT TRENDS IN PPC**  
Inventory control-Purpose of holding stock-Effect of demand on inventories-Ordering procedures. Two bin system - Ordering cycle system-Determination of Economic order quantity and economic lot size- ABC analysis-Recorder procedure-Introduction to computer integrated production planning systems- elements of JUST IN TIME SYSTEMS.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**TEXT BOOK:**

**REFERENCES:**