AC 29/5/2015
Item No. – 4.45

# UNIVERSITY OF MUMBAI

## Bachelor of Engineering

## Mechatronics Engineering

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

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

**Under**

## FACULTY OF TECHNOLOGY

(As per Credit Based Semester and Grading System)

**Deans Preamble**

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

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

Credit based semester and grading system enables a much-required shift in focus from teacher-centric to learner-centric education. It also focuses on continuous evaluation which will enhance the quality of education. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes and Faculty of Technology has devised a transparent credit assignment policy and adopted ten points scale to grade learner's performance. The program of Mechatronics Engineering is introduced from the academic year 2014-2015.

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

**Chairman Preamble**

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

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

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

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

In addition to Program Educational Objectives, for each course of undergraduate program, objectives and expected outcomes are also included in the curriculum. I strongly believe that even a small step taken in the right direction will definitely help in providing quality education to the major stake holders.

**Dr. S. M. Khot**

**Chairman, Board of Studies in Mechanical Engineering, University of Mumbai**

## Program Structure for B E Mechatronics Engineering

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

| Subject Code | Subject Name | Teaching Scheme (Contact Hours) | | Credits Assigned | | |
|---|---|---|---|---|---|---|
| | | Theory | Pract. | Theory | Pract. | Total |
| MTC701 | CAD/CAM/CAE[$] | 4 | -- | 4 | -- | 4 |
| MTC702 | Manufacturing Planning and Control | 4 | -- | 4 | -- | 4 |
| MTC703 | Communication Systems | 4 | -- | 4 | -- | 4 |
| MTC704 | Automotive Electronics | 4 | -- | 4 | -- | 4 |
| MTE705X | Elective- I | 4 | -- | 4 | -- | 4 |
| MTL706 | CAD/CAM/CAE Laboratory | -- | 2 | -- | 1 | 1 |
| MTL707 | Communication Systems Laboratory | -- | 2 | -- | 1 | 1 |
| MTEL705X | Elective- I Laboratory | -- | 2 | -- | 1 | 1 |
| MTP706 | Project- I | -- | 4[#] | -- | 3 | 3 |
| **Total** | | **20** | **10** | **20** | **6** | **26** |

| Subject Code | Subject Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term Work | Pract. /oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test1 | Test 2 | Avg. | | | | | |
| MTC701 | CAD/CAM/CAE[$] | 20 | 20 | 20 | 80 | 03 | -- | -- | 100 |
| MTC702 | Manufacturing Planning and Control | 20 | 20 | 20 | 80 | 03 | -- | -- | 100 |
| MTC703 | Communication Systems | 20 | 20 | 20 | 80 | 03 | -- | -- | 100 |
| MTC704 | Automotive Electronics | 20 | 20 | 20 | 80 | 03 | -- | -- | 100 |
| MTE705X | Elective- I | 20 | 20 | 20 | 80 | 03 | -- | -- | 100 |
| MTL706 | CAD/CAM/CAE Laboratory | -- | -- | -- | -- | -- | 25 | 25 | 50 |
| MTL707 | Communication Systems Laboratory | -- | -- | -- | -- | -- | 25 | 25 | 50 |
| MTEL705X | Elective- I Laboratory | -- | -- | -- | -- | -- | 25 | 25 | 50 |
| MTP706 | Project- I | -- | -- | -- | -- | -- | 50 | -- | 50 |
| **Total** | | **--** | **--** | **100** | **400** | **--** | **125** | **75** | **700** |

**[$]Course common with Mechanical Engineering**

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

| Subject Code | Subject Name | Teaching Scheme (Contact Hours) | | Credits Assigned | | |
|---|---|---|---|---|---|---|
| | | Theory | Pract. | Theory | Pract. | Total |
| MTC801 | Design of Mechatronic Systems | 4 | -- | 4 | -- | 4 |
| MTC802 | Engineering Management and Economics | 4 | -- | 4 | -- | 4 |
| MTC803 | Modeling and Simulation | 4 | -- | 4 | -- | 4 |
| MTE804X | Elective- II | 4 | -- | 4 | -- | 4 |
| MTL805 | Simulation Laboratory | -- | 2 | -- | 1 | 1 |
| MTL806 | Mechatronics Laboratory | -- | 2 | -- | 1 | 1 |
| MTP807 | Project- II | -- | 12# | -- | 6 | 6 |
| **Total** | | **16** | **16** | **16** | **8** | **24** |

| Subject Code | Subject Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | | Term Work | Pract. /oral | Total |
| | | Internal Assessment | | | End Sem. Exam. | Exam. Duration (in Hrs) | | | |
| | | Test1 | Test 2 | Avg. | | | | | |
| MTC801 | Design of Mechatronic Systems | 20 | 20 | 20 | 80 | 03 | -- | -- | 100 |
| MTC802 | Engineering Management and Economics | 20 | 20 | 20 | 80 | 03 | -- | -- | 100 |
| MTC803 | Modeling and Simulation | 20 | 20 | 20 | 80 | 03 | -- | -- | 100 |
| MTE804X | Elective- II | 20 | 20 | 20 | 80 | 03 | -- | -- | 100 |
| MTL805 | Simulation Laboratory | -- | -- | -- | -- | -- | 50 | 25 | 75 |
| MTL806 | Mechatronics Laboratory | -- | -- | -- | -- | -- | 50 | 25 | 75 |
| MTP807 | Project- II | -- | -- | -- | -- | -- | 50 | 100 | 150 |
| **Total** | | **--** | **--** | **80** | **320** | **--** | **150** | **150** | **700** |

# indicates work load of Learner (Not faculty) in VII and VIII semester for Project

Student group size and load of faculty per week for Project I and II shall be as follows:
Project Groups: Students can form groups with minimum 2 (Two) and not more than 4 (Four)
Faculty Load : In semester VII 1/2 hour per week per project group
In semester VIII 1 hour per week per project group
Each faculty is permitted to take (guide) maximum 4 (Four) project groups.

| Course codes | **Elective I** | Course codes | **Elective II** |
|---|---|---|---|
| MTE7051 | Digital Signal Processing | MTE8041 | Medical Mechatronics |
| MTE7052 | Neural Network and Fuzzy Logic | MTE8042 | Robotics and Machine Vision |
| MTE7053 | Micro-Electro Mechanical Systems | MTE8043 | Microfabrication Processes |
| MTE7054 | Optimization | MTE8044 | Machine Interface Design |
| MTE7055 | Finite Element Analysis | MTE8045 | Product Design and Development |

| CLASS: BE (Mechatronics) | Subject Code:MTEL7052 | Semester:-VII |
|---|---|---|
| SUBJECT: **Neural Network and Fuzzy Logic Laboratory** | | Credit-1 |
| Practical to be conducted for batch of students | Practical | Slot of 02 hours per week |

**Pre-requisites:**

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

**Objectives:**

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

**Outcomes:** Learner will be able to…

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

**List of Experiments:**

All the programs should be implemented in C/C++/Java/MATLAB under Windows or Linux or Ubuntu environment. Experiments can also be conducted using available open source tools like OCTAVE and SCILAB.

1. One case study on Fuzzy/Neural/GA based papers published in IEEE/ACM/Springer or any prominent journal.
2. To implement activation function and problems on linear separability
3. To implement Fuzzy sets and Relations.
4. To implement Fuzzy Controllers.(Application to be designed for electromechanical industry)
5. To implement Basic Neural Network learning rules.
6. To implement any Supervised Learning algorithm.
7. To implement any Unsupervised Learning algorithm.
8. To implement a simple application using ANFIS.(Eg. Color recipes prediction, Automobile Fuel Efficiency Prediction)

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

**Term Work:**

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

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

1. Exercises : 20 Marks
2. Attendance (Practical) : 05 Marks

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

**Practical / Oral Examination:**

Practical exam will be based on the performance of one of the experiments mentioned in the list.

The distribution of marks for oral-practical examination shall be as follows: Practical Examination …… 15 marks

Oral …… 10 Marks

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

| CLASS: BE (Mechatronics) | Subject Code: MTE7053 | | Semester:-VII |
|---|---|---|---|
| SUBJECT: **Micro-Electro Mechanical Systems** | | | Credit-4 |
| Periods per week: 1Period of 60 min. | Lecture | 4 | |
| | Tutorial | -- | |
| | | Hours | Marks |
| Evaluation System | Theory Examination | 3 | 80 |
| | Internal Assessment | | 20 |
| | **TOTAL** | | **100** |

**Pre-requisites:**

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

**Objectives:**

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

**Outcome:** Learner will be able to…

1. Design fabrication process plan for development of MEMS
2. Identify characterization and assembly techniques for developed MEMS.
3. Develop physics based model of MEMS.

| Modules. | Details | Hrs. |
|---|---|---|
| **01** | **Introduction to MEMS & Applications**<br>• Introduction to Micro-Electro-Mechanical Systems,<br>• Applications and materials for MEMS,<br>• Advantages & disadvantages of micro-sensors, and micro-actuators. | 6 |
| **02** | **Sensors and Actuators in Micro-domain**<br>• Concept of sensors & actuators,<br>• Sensing & Actuation principles: Mechanical Sensing, Capacitive, Electrostatic, Electromagnetic, Piezo Resistive, Piezo Electric, Thin Films, Shape Memory Alloys<br>• Comb Drive Actuation & Sensing. Micro-mechanisms, Air-Bag Sensors, Chemical Sensors<br>• Sensors & Actuators for Automotive, Biomedical, Industrial applications | 8 |
| **03** | **Fabrication Methods**<br>Microfabrication Methods (VLSI Techniques)<br>• Positive and Negative Photoresists,<br>• Bulk Micromachining,<br>• Surface Micromachining,<br>• Etching (Isotropic and Anisotropic),<br>• Deposition techniques such as CVD (Chemical Vapor Deposition), Metallization Techniques.<br>3D High Aspect Ratio Techniques<br>• LIGA,<br>• Microstereolithography,<br>• IH-Process,<br>• Ion-beam Lithography<br>Bulk Lithography (layer-less 3D microfabrication) | 12 |

| | | |
|---|---|---|
| **04** | **Modelling and Simulation Techniques**<br>• Scaling Laws, Governing Equations<br>• Modelling of Mechanical Structures via classical methods, Newtons Laws, Thermal Laws, Fluid Flow Analysis<br>• Micro-mechanism modelling and analysis techniques : Lumped Parameter Modelling and Distributed Parameter Modeling<br>• Modelling of Micro-channel as heat exchanger, accelerometers<br>• Numerical Methods used for analysis of MEMS. | 8 |
| **05** | **Characterization Techniques**<br>**Topography Methods** (Optical, Electrical and Mechanical Methods)<br>• Microscopy, STM (Scanning Tunneling Microscopes),<br>• SEM (Scanning Electron Microscopes), AFM (Atomic Force Microscopes)<br>**Mechanical Structure Analysis**<br>• Deformation & Vibration Measurement Techniques (Piezo resistive and piezo electric)<br>**Interferometry Techniques,**<br>• ESPI (Electronic Speckle Pattern Interferometry),<br>• Laser Techniques, Laser Doppler Vibro-meters,<br>**Fluid, Thermal and Chemical Techniques**<br>• Fluid Flow Pattern Analysis, Electro-chemical Analysis,<br>• PIV Techniques<br>• Spectroscopy | 10 |
| **06** | **Introduction to Nanotechnology**<br>• CNT (Carbon Nano Tubes) Applications, its properties, and Fabrication Method,<br>• Nano-mechanical Systems (NEMS),<br>• Nano-tribology, & nano-indentation techniques,<br>• Domestic and Industrial Applications of nanotechnology. | 8 |

**Internal Assessment:**

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

**Theory Examination:**

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

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

**References:**


1. Julian W. Garden, Vijay K. Varadan and Osama O. Awadelkarim "Microsensors MEMS and Smart devices", John Wiley and sons, Ltd.
2. Nadim Mulaf and Kirt Williams, "An Introduction to Microelectromechanical systems Engineering", Artech House.
3. Nicolae Lobontiu and Ephrahim Garcia, "Mechanics of Microelectromechanical systems", Kluwer Academic Publication.
4. Stanley Wolf and Richard Tauber, "Silicon Processing for the VLSI era Volume -1 Technology", Lattice press.
5. Vijay K. Varadan, K.J.Vinoy and S. Gopalkrishnan, "Smart Material Systems and MEMS: Design and Development Methodologies", John Wiley and sons Ltd.
6. Bhushan, "Springer Handbook of Nanotechnology", Springer Inc.

| CLASS: BE (Mechatronics) | Subject Code:MTEL7053 | Semester:-VII |
|---|---|---|
| SUBJECT: **Micro-Electro Mechanical Systems Laboratory** | | Credit-1 |
| Practical to be conducted for batch of students | Practical | Slot of 02 hours per week |

**Pre-requisites:**

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

**Objectives:**

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

**Outcome:** Learner will be able to….

1. Design the process plan for fabrication of microstructure for MEMS
2. Identify the characterization technique for the MEMS

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

**Term Work:**

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

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

1. Exercises : 20 Marks
2. Attendance (Practical) : 05 Marks

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

**Practical / Oral Examination:**

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

Practical Examination …… 15 marks
Oral …… 10 Marks

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

| CLASS: BE (Mechatronics) | Subject Code: MTE7054 | Semester:-VII |
|---|---|---|
| SUBJECT: **Optimization** | | Credit-4 |

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

**Pre-requisites:**

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

**Objectives:**

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

**Outcomes:** Learner will be able to…..

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

| Module | Details | Hrs. |
|---|---|---|
| 01 | **Linear Programming**: Linear Programming Problem Formulation, Graphical solution, Simplex method, Twophase method, Big-M method, Principle of Duality, Dual Simplex, Sensitivity Analysis. | 12 |
| 02 | **Transportation problem**: Formulation - Optimal solution, Degeneracy.<br>**Assignment problem:** Formulation - Optimal solution, Traveling Salesman problem.<br>**Sequencing:** Introduction - Flow Shop sequencing - n jobs through two machines - n jobs through three machines - Job shop sequencing - two jobs through 'm' machines. | 08 |
| 03 | **Replacement**: Introduction - Replacement of items that deteriorate with time - when money value is not counted and counted - Replacement of items that fail completely, group replacement.<br>**Queuing Models**: Introduction -Single Channel - Poisson arrivals - Exponential service times - with infinite population and finite population models, Multichannel - Poisson arrivals - Exponential service times with infinite population single channel Poisson arrivals. | 08 |
| 04 | **Game Theory**: Introduction - Minimax (Maximin) -Criterion and optimal strategy - Solution of games with saddle points – Rectangular games without saddle points - 2 X 2 games - dominance principle - m X2 & 2 X n games, graphical method. | 08 |

| | | |
|---|---|---|
| **05** | **Inventory Models**: Introduction - Single item - Deterministic models - Purchase inventory models with one price break and multiple price breaks - shortages are not allowed - Stochastic models - demand may be discrete variable or continuous variable -Instantaneous production - Instantaneous demand and continuous demand and no set up cost. | **08** |
| **06.** | **Dynamic programming**: Introduction - Bellman's Principle of optimality - Applications of dynamic programming- capital budgeting problem - shortest path problem – Minimum Spanning Tree.<br>**Simulation**: Definition - Types of simulation models - phases of simulation - applications of simulation - Inventory and Queuing problems - Advantages and Disadvantages - Simulation Languages. | **08** |

**Internal Assessment:**

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

**Theory Examination:**

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

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

**References:**


1. *Operations Research: Principle and Practices*, A. Ravindran, D. Phillips, Wiley India.
2. *Operations Research*, S. D. Sharma, KedarNath Ram Nath-Meerut.
3. *Operations Research*, R. Panneerselvam, PHI Publications.
4. *Operations Research*, A. M. Natarajan, P. Balasubramani, A. Tamilarasi, Pearson Education
5. *Operations Research* - An introduction, Hamdy A Taha, Pearson Education.
6. *Operations Research*, KantiSwarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons.
7. *Operations Research: Methods and Problems*, Maurice Saseini, ArhurYaspan and Lawrence Friedman.
8. *Introduction to O.R*, Hiller & Libermann (TMH)

| | | |
|---|---|---|
| CLASS: BE (Mechatronics) | Subject Code: MTEL7054 | Semester:-VII |
| SUBJECT: **Optimization Laboratory** | | Credit: 1 |
| Practical to be conducted for batch of students | Practical | Slot of 02 hours per week |

**Pre-requisites:**

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

**Objectives:**

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

**Outcomes:** Learner will be able to…..

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

**Term Work**

Term work shall consist of;

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

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

- Laboratory work (problem solving: manual/programs and journal): **10** marks
- Assignments: **10** marks
- Attendance (Theory and Practical): **05** marks

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

**Practical/oral Examination:**

Practical examination of 2 hours duration based on any one of the problem solving technique on software platform. Oral examination will be based on entire syllabus.

| CLASS: BE (Mechatronics) | Subject Code: MTE7055 | | Semester:-VII |
|---|---|---|---|
| SUBJECT: **Finite Element Analysis** | | | Credit-4 |
| Periods per week: 1Period of 60 min. | Lecture | 4 | |
| | Tutorial | -- | |
| | | Hours | Marks |
| Evaluation System | Theory Examination | 3 | 80 |
| | Internal Assessment | | 20 |
| | **TOTAL** | | **100** |

**Prerequisites:**

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

**Objectives:**

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

**Outcomes:** Learner will be able to…

1. Solve ordinary and partial differential equations using the Galerkin method.
2. Develop the finite element equations to model engineering problems governed by $2^{nd}$order partial differential equations.
3. Apply the basic finite element formulation techniques to solve engineering problems.
4. Use commercial FEA software, to solve problems related to mechanical engineering.

| Module | Detailed Contents | Hrs. |
|---|---|---|
| **01** | **Introduction**<br>1.1 Introductory Concepts: Introduction to FEM, Historical Background, General FEM procedure. Applications of FEM in various fields. Advantages and disadvantages of FEM.<br>1.2 Mathematical Modeling of field problems in Engineering, Governing Equations, Differential Equations in different fields.<br>1.3 Approximate solution of differential equations-- Weighted residual techniques, Least squares, Galerkin methods, Boundary Value problems. | 08 |
| **02** | **FEA Procedure**<br>2.1 Discrete and continuous models, Weighted Residual Methods – Ritz Technique – Basic concepts of the Finite Element Method.<br>2.2 Definitions of various terms used in FEM like element, order of the element, internal and external node/s, degree of freedom, primary and secondary variables, boundary conditions.<br>2.3 Minimization of a functional. Principle of minimum total potential. Piecewise Rayleigh-Ritz method. Formulation of "stiffness matrix"; transformation and assembly concepts. | 08 |
| **03** | **One-Dimensional Problems**<br>3.1 One Dimensional Second Order Equations – Discretization – Element types- Linear and Higher order Elements – Derivation of Shape functions and Stiffness matrices and force vectors.<br>3.2 Assembly of Matrices - solution of problems in one dimensional structural analysis, heat transfer and fluid flow (Stepped and Taper Bars, Fluid Network, Spring-Cart systems)<br>3.3 Analysis of Plane Trusses, Analysis of Beams.<br>3.4 Solution of one Dimensional structural and thermal problems using FE Software, Selection of suitable Element Type, Modeling, Meshing, Boundary Condition, Convergence of solution, Result analysis, Case studies. | 10 |

| | | |
|---|---|---|
| **04** | **Two Dimensional Finite Element Formulations**<br>4.1 Introduction, Three nodded triangular element, four nodded rectangular element, four nodded quadrilateral element, eight nodded quadrilateral element.<br>4.2 Natural coordinates and coordinates transformations: serendipity and Lagranges methods for deriving shape functions for triangular and quadrilateral element<br>4.3 Sub parametric, Isoperimetric, super parametric elements. Compatibility, Patch Test, Convergence criterion, Sources of errors. | 10 |
| **05** | **Two Dimensional Vector Variable Problems**<br>5.1 Equations of elasticity – Plane stress, plane strain and axisymmetric problems.<br>5.2 Jacobian matrix, stress analysis of CST and four node Quadratic element<br>5.3 Solution of 2-D Problems using FE Software (structural and Thermal), selection of element type, meshing and convergence of solution. (Can be covered during practical hours). | 08 |
| **06** | **Finite Element Formulation of Dynamics and Numerical Techniques**<br>6.1 Applications to free vibration problems of rod and beam. Lumped and consistent mass matrices.<br>6.2 Solutions Techniques to Dynamic problems, longitudinal vibration frequencies and mode shapes. Fourth Order Beam Equation, Transverse deflections and Natural frequencies of beams.<br>6.3 Finding frequencies of beam using FE Software (Can be covered during practical hours). | 08 |

**Internal Assessment:**

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

**Theory Examination:**

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

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

**References:**


1. Seshu. P. "Textbook of Finite Element Analysis" Prentice Hall of India, 2003.
2. J.N. Reddy, "Finite Element Method" Tata McGraw Hill, 2003.
3. Chandrupatla and Belegundu, "Introduction to Finite Elements in Engineering" PHI / Pearson Education, 2003.
4. Logan. D.L. "A first course in Finite Element Method", Thomson Asia Pvt. Ltd., 2002.
5. Cook R.D., Malkus. D.S. Plesha, ME., "Concepts and Applications of Finite Element Analysis", John – Wiley Sons 2003.
6. S.S. Rao, "The Finite Element Method in Engineering "Butter worth Heinemann, 2001.
7. M. Asghar Bhatti, " FUNDAMENTAL Finite Element Analysis and Applications with Mathematica and MATLAB Computations", Wiley India Pvt. Ltd.

| CLASS: BE (Mechatronics) | Subject Code:MTEL7055 | Semester:-VII |
|---|---|---|
| SUBJECT: **Finite Element Analysis Laboratory** | | Credit-1 |
| Practical to be conducted for batch of students | Practical | 02 hours per week |

**Pre-requisites:**

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

**Objectives:**

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

**Outcomes:** Learner will be able to…

1. Use FEA software for solutions of various engineering problems.

**List of Assignment:**

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

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

**Course Project:**

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

**Term Work:**

Term work shall consist of minimum 06 exercises and course project. The distribution of marks for term work shall be as follows:

- Laboratory work (experiments/assignments): 10 Marks.
- Course project: 10 Marks.
- Attendance: (Theory and Practicals): 05 Marks

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

**Practical/Oral examination:**

1. Practical examination duration is 2 hours.
2. Assignment for the examination shall be based on the list of exercises mentioned in the term work.
3. The distribution of marks for practical/oral examination shall be as follows:
   i. Practical performance: 15 marks
   ii. Oral: 10 marks
4. Evaluation of practical examination to be done based on the experiment performed and the output of the experiments during practical examination.
5. Students work along with evaluation report to be preserved till the next examination

| Course Code | Course/Subject Name | Credits |
|---|---|---|
| **MTP706 / MTP807** | **Project I/ II** | **3 / 6** |

**Objective:**

1. To acquaint with the process of undertaking literature survey/industrial visit and identifying the problem
2. To familiarize the process of solving the problem in a group
3. To acquaint with the process of applying basic engineering fundamental in the domain of practical applications
4. To inculcate the process of research

**Outcome:** Learner will be able to…

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

**Guidelines for Project:**

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

**Guidelines for Assessment of Project I**

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

**Guidelines for Assessment of Project II**

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

| CLASS: BE (Mechatronics) | Subject Code: MTC801 | | Semester:-VIII |
|---|---|---|---|
| SUBJECT: **Design of Mechatronics Systems** | | | Credit-4 |
| Periods per week: 1Period of 60 min. | Lecture | 4 | |
| | Tutorial | -- | |
| | | Hours | Marks |
| Evaluation System | Theory Examination | 3 | 80 |
| | Internal Assessment | | 20 |
| | **TOTAL** | | **100** |

**Pre-requisites:**

1. MTC503: Sensors and Actuators
2. MTC504: Control Systems
3. MTC502: Machine Design
4. MTC505: Embedded Systems

**Objectives:**

1. To present architecture of the mechatronics system design
2. To study on broad spectrum the characteristics of the mechanical and electrical actuators and their selection for mechatronic systems.
3. Development of process plan and templates for design of mechatronic systems

**Outcome:** Learner should be able to..

1. Interface sensor and actuator for a mechatronic system.
2. Indigenously design and develop a mechatronic system.

| Module | Details | Hrs. |
|---|---|---|
| **01** | Introduction to mechatronics systems. Basic building blocks of mechatronic systems. Mechatronics key elements, Mechatronics in home, office and industry automation, Scope of Mechatronics. Advantages of Mechatronics, pre-requisites for Mechatronics. | 05 |
| **02** | **Mechanical Engineering and Machines in Mechatronics**: Mechanical translation and rotational systems, Fluid systems, guideways, Mechanism used in mechatronics (High resolution scanning mechanisms, Indexing mechanisms), compliant mechanisms, Assembly techniques, Hydraulic and pneumatic actuators, microactuators. Piezoelectric actuators. | 08 |
| **03** | Electrical systems, Electrical actuators, brushless permanent magnet DC motor, Interfacing of DC motors, stepper motor, interfacing of stepper motors, AC servomotor, Drive selection and its applications.<br>Analog to Digital Conversion, Digital to Analog conversion.<br>Performance characteristics of sensors and transducers. Selection criteria for sensors and actuators, interfacing of sensors and actuators. | 09 |
| **04** | **Generalized Mechatronics Design Process:** Recognition of the Need, Conceptual Design and Functional Specification, First principle Modular Mathematical Modeling, Sensor and Actuator Selection, Drivers for Actuators, Detailed Modular Mathematical Modeling, Control System Design, Design Optimization, Prototyping Hardware-in-the-loop Simulation, Deployment/Life Cycle, Deployment of Embedded Software, Life Cycle Optimization. | 12 |

| | | |
|---|---|---|
| | **Advance Approaches in Mechatronics:** Servo control, Process Control, Supervisory Control, Shop Floor Control, Plant Control.<br><br>**Design of Autonomous Mobile Robot:** Introduction, Mechanical Design Alternatives (Gearhead DC Motors, Modified Servo Motors, Skid Steering, Explicit Steering), Design Specifications (Drive Motor Sizing, Steering Motor Sizing, Gear System, Kinematic Analysis, Mechanical Constructions), Electronic Circuits and Interfacing (Sensors, Serial Communication Circuit, Robot Circuitry, Motor Driving Circuitry, Communication Strategy, Interfacing the Servo Steering Motor), Software Development (Serial Communication Algorithm, Data Collection, Motion Algorithm, Map Generation). | |
| **05** | **Design of cantilever beam vibration control system based on piezo sensors and actuators:** Introduction, Modeling of the Cantilever Beam and PZT Actuator (Modeling of the Beam, Modeling of the PZT Actuator, Modeling of the Sensor), Beam Experimental Setup (properties and dimensions of the beam, dimensions and bonding techniques), instrumental setup (Charge amplifier, Voltage amplifier, Data Acquisition), Controller and Software (Development of the PID VI), | 09 |
| **06** | **Design of Photopolymerization based CAD compatible stereo 3D Printer:** Working principle and process plan of Scanning type and Projection type of 3D printer. Components of scanning and projection type printer. Laser system, Dynamic mask mirror, Optical modulator, scanning mechanisms, Slicing, scan path and image projection strategies. Selection of actuator for scanning mechanism, optical sensors and its selection criteria. Layer preparation system. Interfacing of the sensors and actuators. Data communication schemes for projection and scanning systems. System identification and controller design (PID). | 09 |

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

**Theory Examination:**

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

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

**References:**


1. *Mechatronics, Kenji Uchino and Jayne R. Giniewicz, publication: Marcel Dekker, Inc.*
2. *Applied Mechatronics- A. Smaili and F. Mrad, OXFORD university press.*
3. *Mechatronics System Design , Shetty and Kolk CENGAGE Learning, India Edition*
4. *Introduction to Mechatronics and Measurement Systems , Alciatore and Histand Tata McGraw-Hill*
5. *Mechatronics, Necsulescu, Pearson education.*
6. *Mechatronics - Electromechanics and Control Mechanics , Mill Springer-Verlag*
7. *Mechatronics - Electronic Control Systems in Mechanical Engineering , Bolton Pearson eduaction*
8. *Mechatronics - Electronics in products and processes , Bradley, et al. Chapman and Hall*
9. *Mechatronics - Mechanical System Interfacing , Auslander and Kempf, Prentice Hall*
10. *Introduction to Mechatronics, Appu Kuttan K.K., OXFORD Higher Education*
11. *The Art of Electronics, Horowitz and Hill Cambridge, University Press*
12. *Electromechanical Design Handbook , Walsh, McGraw-Hill*
13. *Electro-mechanical Engineering - An Integrated Approach , Fraser and Milne*
14. *Handbook of Electromechanical Product Design , Hurricks Longman, John Wiley, Addison Wesley*
15. *Understanding Electro-Mechanical Engineering - An Introduction to Mechatronics , Kamm IEEE*
16. *Modeling and control of Dynamic Systems, Macia and Thaler, CENGAGE Learning, India Edition*
17. *Computer Numerical Control of Machine Tools: Thyer. G.R.*
18. *Automatic Control Engineering: Francis. H. Raven.*
19. *Mechatronics, Nitaigour Mahalik, Tata McGraw-Hill*
20. *Mechatronics, HMT*
21. *System Identification: Theory for the User (2nd Edition) , Lennart Ljung*
22. *Design with Microprocessors for Mechanical Engineers, Stiffler McGraw-Hill*

| CLASS: BE (Mechatronics) | Subject Code: MTC802 | | Semester:-VIII |
|---|---|---|---|
| SUBJECT: **Engineering Management and Economics** | | | Credit-4 |
| Periods per week: 1Period of 60 min. | Lecture | 4 | |
| | Tutorial | -- | |
| | | Hours | Marks |
| Evaluation System | Theory Examination | 3 | 80 |
| | Internal Assessment | | 20 |
| | **TOTAL** | | **100** |

**Pre-requisites:**

1. MTC501: Manufacturing Processes
2. MTC702: Manufacturing Planning and Control

**Objectives:**

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

**Outcomes:** Learner will be able to…

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

| Module | Details | Hrs. |
|---|---|---|
| **01** | **Introduction to management:** Brief history of Indian business scenario and recent changes, Globalization and competition, Need for managerial knowledge and skills. **Management:** Science, Theory and Practice: Definition of Management, Its nature and purpose, Managing- Science or Art? Contributions of F.W. Taylor and Henry Fayol to management theory, Functions of managers, Management and Society: Social responsibility of managers, Ethics of managing. | **08** |
| **02** | **Decision making:** Importance and limitations of rational decision making, Rationality in decision making, Evaluation of alternatives, Selecting an alternative- three approaches, Programmed and Non-programmed decisions. **Organizing:** The nature and purpose of organizing, formal and informal organization. Organization levels and Span of management, Principle of span of management and the factors determining an effective span. The structure and process of organizing, Matrix organization, Strategic business units, Line & staff concepts, Functional authority, Benefits and limitations of staff, Decentralization of authority, Delegation of authority. | **11** |

| | | |
|---|---|---|
| **03** | **Planning:**<br>Types of plans, Steps in planning, The planning process, Objectives- Nature of objectives. Concept in Management By Objectives (MBO), Process of MBO, How to Set Objectives? Benefits and weakness of MBO, MBO in the Indian Context.<br>**Staffing:**<br>HRM and selection: Definition of Staffing, Systems approach to HRM: Overview of staffing, Situational factors affecting staffing. Selection-matching the person with the job, Systems approach to selection, Position requirements and job design, Skills and personal characteristics needed by managers, Matching qualifications with position requirements, Selection process, techniques and instruments, Performance appraisal and its purpose, Choosing the appraisal criteria.<br>**Leading:**<br>Human factors in managing, Behavioral models, Motivation: Motivation and motivators. Theory of Maslow's Hierarchy of needs, Motivation-Hygiene approach to motivation, Theory X and Theory Y, Special motivational techniques.<br>**Leadership:**<br>Definition, Ingredients of leadership, Leadership behavior and styles, Communication: Communication process, Communication in an enterprise, Barriers and breakdowns in communications, Effective communication.<br>**Controlling:**<br>Basic control process, Critical control points and standards, Control as a feedback system, Feed forward control, Requirements for effective controls, Control techniques: Budget and Non-budgetary control devices. | **12** |
| **04** | **Introduction to economics :**<br>Definition of Economy, Central problems of an economy: what, how and for whom to produce; concepts of production possibility frontier and opportunity cost. Economics, its scope and importance. Introduction to Micro and Macro economics and their comparison. | **07** |
| **05** | **MICRO ECONOMICS :**<br>5.1 Consumer's Behaviour : meaning of utility, marginal utility and law of diminishing marginal utility.<br>5.2 Conditions of consumer's equilibrium using marginal utility analysis: Concept of ordinal utility, law of demand and relation between law of demand & law of diminishing marginal utility.<br>5.3 Producer's Behaviour: law of supply, variation in supply, Types of elasticity of supply. Types of Market: perfect competition, pure competition, Monopoly and Multi-plant monopoly. | **08** |
| **06** | **MACRO ECONOMICS:**<br>6.1 Concept of National Income : Circular flow of income, Distinction between Gross and Net National Income. Different Methods of Measuring National Income, Definition of Money, Functions of Money, Value of Money and Different concepts of Money.<br>6.2 Economic Policy: Monetary, Income and Fiscal Policies.<br>6.3 Functions of Central Bank, Functions of Commercial Banks credit Creation, Credit Control Methods, Theory of Inflation, Concepts of Inflation, Effects of Inflation and Anti-inflationary policies. | **06** |

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

**Theory Examination:**

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

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

**References:**


1. *Introduction to Managerial Accounting*, Larry M. Walther , Christopher J. Skousen
2. *Managerial and Cost Accounting*, Larry M. Walther , Christopher J. Skousen
3. *Essentials of Microeconomics*, Krister Ahlersten
4. *Essentials of Macroeconomics*, Peter Jochumzen
5. *Central Banking & Monetary Policy: An Introduction*, Dr AP Faure, Rhodes University.
6. *Principles of Management*, Harold Koontz, H. Weihrich, and A.R. Aryasri, Tata McGraw-Hill, New Delhi.
7. *Essential of Management*, Harold Koontz and H. Weihrich,Tata Mc Graw-Hill, New Delhi.
8. *Management of Organizational Behavior*, Hersy, Paul and Kenneth Blanchard, PHI.

| CLASS: BE (Mechatronics) | Subject Code: MTC803 | | Semester:-VIII |
|---|---|---|---|
| SUBJECT: **Modeling and Simulation** | | | Credit-4 |
| Periods per week: 1Period of 60 min. | Lecture | 4 | |
| | Tutorial | -- | |
| | | Hours | Marks |
| Evaluation System | Theory Examination | 3 | 80 |
| | Internal Assessment | | 20 |
| | **TOTAL** | | **100** |

**Pre-requisite:**

1. MTC504 Control Systems ,
2. MTC605 Instrumentation and Controller Design

**Objectives:**

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

**Outcomes:** Learner will be able to..

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

| Module | Detailed content | Hrs. |
|---|---|---|
| **1. 0** | **System Modeling**<br>**1.1** Types of model Static and dynamic physical and mathematical model<br>1.2 Step response method two ,three and four parametric model | 06 |
| **2.0** | **Mathematical Model**<br>**2.1** Necessity of mathematical modeling, principles of mathematical modeling<br>2.2 Dimensional analysis, scale | 10 |
| **3.0** | **Approximating and validating models**<br>**3.1** Taylor's formula, algebraic approximations, Numerical approximations<br>3.2 Validating models | 10 |
| **4.0** | **Analysis and control of the systems**<br>**4.1** Solution Techniques for Ordinary Differential Equations, Free Response and Eigenvalues<br>4.2 State-space Equations: Converting to state space, simulating the models using any simulation | 08 |
| **5.0** | **Examples of System Models**<br>5.1 Exponential growth and decay – radioactive decay, capacitor charging-discharging<br>5.2 Freely vibrating pendulum, spring-mass oscillator | 08 |
| **6.0** | **System Simulation**<br>**6.1** Techniques of simulations, The Monte-Carlo Method<br>6.2 Types of system Simulation<br>6.3 Continuous System Simulation: Analog and Hybrid method<br>6.4 Probability concepts in simulation | 10 |

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

**Theory Examination:**

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

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

**References**:


1. Clive L. Dym, "Principles of Mathematical Modeling" Academic Press, Second Edition
2. Dean C. Karnopp, Donald L. Margolis, Ronald C. Rosenberg, "System Dynamics: Modeling, Simulation, and Control of Mechatronic Systems," 5th Edition, Wiley
3. Geoffrey Gordon , " System Simulation" Prentice Hall India
4. Karl J Astrom, Tore Huggland " PID Controllers" 2nd Edition
5. Fundamentals of Process Control Theory, Paul Murrill, ISA

| | | | |
|---|---|---|---|
| CLASS: BE (Mechatronics) | Subject Code: MTE8041 | | Semester:-VIII |
| SUBJECT: **Medical Mechatronics** | | | Credit-4 |
| Periods per week: 1Period of 60 min. | Lecture | 4 | |
| | Tutorial | -- | |
| | | Hours | Marks |
| Evaluation System | Theory Examination | 3 | 80 |
| | Internal Assessment | | 20 |
| | **TOTAL** | | **100** |

**Pre-requisite:**

1. MTC405 Application of Integrated Circuit
2. MTC605 Instrumentation and Controller Design

**Objectives:**

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

**Outcomes:** Learner will be able to …

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

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

| | | |
|---|---|---|
| **5** | **Fundamentals of medical imaging**<br>5.1 X-ray computed Tomography, Spiral or Helical C T: Slip Ring Technology, C T Angiography. Clinical use & Biological effects and safety, Magnetic resonance imaging Biological effects and safety. Nuclear medical imaging Biological effects and safety, Infrared imaging, Liquid crystal thermography. Microwave hermography.<br>5.2 Endoscopy, gastroscope, bronchoscope, cystoscope, colonoscope, Enteroscope Lithotripsy. | 10 |
| **6** | **Electrical safety, Telementry and Hospital Information system**<br>6.1 Macroshocks and microshocks hazards, electrical safety and EMI/RFI interference and its testing<br>6.2 Biomedical telemetry, wireless and multi patient telemetry<br>6.3 Hospital Information system: Role of database in HIS. Need of Networking in HIS. Overview of Networking, topologies and its configuration. Structuring medical record to carry out functions like admissions, discharges, treatment history etc. Computerization in pharmacy & billing. Automated clinical laboratory systems & radiology information system. | 08 |
| | | 52 |

**Internal Assessment:**

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

**Theory Examination:**

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

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

**References**:


1. Khandpur R. S., Handbook of Biomedical Instrumentation, Tata McGraw Hill, second edition, 2003
2. Carr and Brown, Introduction to biomedical equipment technology, fourth edition, Pearson press, 2003
3. Sujata V. Bhat, Biomaterials, Narosa Publishing House, 2002.
4. W.R.Hendee & E.R.Ritenour, Medical Imaging Physics (3rd eds), Mosbey Year-Book, Inc., 1992.
5. Lesslie Cromwell, Fred J. Weibell, rich J. Pfeiffer Biomedical Instrumentation and Measurements, 2nd Edition, PHI
6. John G. Webster, Bioinstrumentation John Wiley and sons, 2004
7. Joseph Bronzino (Editor-in-Chief), Handbook of Biomedical Engineering, CRC Press, 1995.
8. L.A.Geddes and L.E.Baker,.Principles of Applied Bio-Medical Instrumentation. John Wiley & Sons 1975.
9. Harold E. Smalley, .Hospital Management Engineering . A guide to the improvement of hospital management system. PHI.

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|---|---|---|---|
| CLASS: BE (Mechatronics) | Subject Code: MTE8042 | | Semester:-VIII |
| SUBJECT: **Robotics and Machine Vision** | | | Credit-4 |
| Periods per week: 1Period of 60 min. | Lecture | 4 | |
| | Tutorial | -- | |
| | | Hours | Marks |
| Evaluation System | Theory Examination | 3 | 80 |
| | Internal Assessment | | 20 |
| | **TOTAL** | | **100** |

**Pre-requisites:**

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

**Objectives:**

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

**Outcomes:** Learner will be able to..

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

| Modules | Details | Hrs |
|---|---|---|
| 1 | **Introduction:** Automation & robotics, Robotic System & Anatomy Classification, Future Prospects **Robotic Application in Manufacturing:** Material transfer, Machine loading & unloading, Processing operations, Assembly & Inspectors **Drives:** Control Loops, Basic Control System Concepts & Models, Control System Analysis, Robot Activation & Feedback Components, Position & Velocity Sensors, Actuators ,Power Transmission Systems**.** | 8 |
| 2 | **Robot Kinematics**: Coordinate Frames, Rotations, Homogeneous Coordinates, Arm Equation of Planer Robot, Four axis SCARA Robot, TCV, Inverse Kinematics of Planer Robot, Four Axis SCARA Robot. | 10 |
| 3 | **Trajectory Planning & Robot Dynamics:** Manipulator Path Control- Linear, Quadratic and Cubic Interpolation, Work Space Analysis, Robot Dynamics –Langrangian Dynamics of one and two link robot arm | 8 |
| 4 | **Programming For Robots:** Methods, Robot programme as a path in space, Motion interpolation, level & task level languages, Robot languages; Programming in suitable languages Characteristics of robot | 8 |

| | | |
|---|---|---|
| **5** | **Machine Vision:**<br>Introduction, Low level & High level vision, Sensing & Digitising, Template Matching, Image processing & analysis, Segmentation, Edge detection, Object description& recognition, Interpretation, Noises in Image, Applications. | 10 |
| **6** | **Robot Intelligence& Task Planning:** Introduction, State space search, Problem reduction, Use of predictive logic, Means -Ends Analysis, Problem solving, Robot Learning, Robot task planning, Robot Vision<br>**Social Issues and Economics of robotics** | 8 |

**Internal Assessment:**

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

**Theory Examination:**

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

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

**References:**


1. 1.YoremKoren, “Robotics for Engineers”
2. J. F. Engelberger, “Robotics in Practice”
3. Ulrich Rembolds, ChristialBlume, “Computer Integrated Manufacturing Technology and
4. Systems”
5. Ramamurthy, “Computer Aided Design in Mechanical Engineering”
6. Mark Spong, “Robot Dynamics and Control”, Wiley India
7. John Craig, “Robotics”
8. Paul R.P., “Robot Manipulators: Mathematics, Programming and Control”
9. Groover and Simmers,“Industrial Robotics”
10. Ernest Deoblin,“Measurement systems”
11. Beckwith and Lewisbuck, “Mechanical Measurements”
12. K. Ogata,“Modern Control Engineering”,PHI
13. Benjamin Kuo, “Automatic Control Systems”, Wiley India
14. Richard D. KIafter et al, “Robotic Engineering -an Integrated Approach”, PHI
15. Spyros G. Tzafestas, “Intelligent Robotic Systems”

| CLASS: BE (Mechatronics) | Subject Code: MTE8043 | | Semester:-VIII |
|---|---|---|---|
| SUBJECT: **Microfabrication Processes** | | | Credit-4 |
| Periods per week: 1Period of 60 min. | Lecture | 4 | |
| | Tutorial | -- | |
| | | Hours | Marks |
| Evaluation System | Theory Examination | 3 | 80 |
| | Internal Assessment | | 20 |
| | **TOTAL** | | **100** |

**Pre-requisites**

1. MTC501: Manufacturing Processes

**Objectives:**

1. To gain an understanding of standard microfabrication techniques (fundamental principles) and the issues surrounding them.
2. To know the major classes, components, and applications of microfabrication.
3. To understand the essentials and constraints of microfabrication processes.

**Outcome:** Learner will be able to ..

1. Identify appropriate microfabrication process for development of functional microsystem.
2. Apply knowledge of microfabrication techniques to the design and develop a microsystem.
3. Understand the working principle of different microfabrication processes

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

| | | |
|---|---|---|
| **06** | LIGA and Micromolding:<br><br>Synchrotron orbital Radiation (SOR), X-ray masks, resist requirement, exposure, development, metal deposition, molding, demolding, sacrificial layers | 08 |

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

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

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

**References:**

1. Sami Franssila, "Introduction to Micro fabrication", Wiley 2nd Edition.
2. Marc J Madou, Fundamentals of Microfabrication, The Science of minituarization, second edition, CRC press.
3. Yi Qin, Micromanufacturing Engineering and Technology, Micro and Nanotechnology series, Elsevier.
4. Nadim Mulaf and Kirt Williams, "An Introduction to Microelectromechanical systems Engineering", Artech House.
5. Stanley Wolf and Richard Tauber, "Silicon Processing for the VLSI era Volume -1 Technology", Lattice press.
6. Vijay K. Varadan, K.J.Vinoy and S. Gopalkrishnan, "Smart Material Systems and MEMS: Design and Development Methodologies", John Wiley and sons Ltd.

| CLASS: BE (Mechatronics) | Subject Code: MTE8044 | | Semester:-VIII |
|---|---|---|---|
| SUBJECT: **Machine Interface Design** | | | Credit-4 |
| Periods per week: 1Period of 60 min. | Lecture | 4 | |
| | Tutorial | -- | |
| | | Hours | Marks |
| Evaluation System | Theory Examination | 3 | 80 |
| | Internal Assessment | | 20 |
| | **TOTAL** | | **100** |

**Pre-requisites:**

1. MTL307: Object Oriented Programming Laboratory.

**Objectives:**

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

**Outcomes:** Learner will be able to..

1. Design innovative and user friendly interfaces for industrial application.
2. Criticize existing interface designs, and improve them.
3. Design application for social and technical task with safety concern.

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

| | | |
|---|---|---|
| 6 | **Case studies:**<br>Designing and evaluating Human-Machine Interface (HMI) for<br>1. Process control application.<br>2. Flight control system<br>3. Robotics Welding<br>4. Air-conditioning system<br>5. Smart phones<br>6. Medical Devices | **08** |

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

**Theory Examination:**

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

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

**References:**


1. Donald A. Normann, "Design of everyday things", Basic Books; Reprint edition 2002.
2. Wilbert O. Galitz, "The Essential Guide to User Interface Design", Wiley publication.
3. Ben Shneiderman and Catherine Plaisant,: Desinging the user Interface:,Pearson,Addison Wesley.
4. Alan Cooper, Robert Reimann, David Cronin, "About Face3: Essentials of Interaction design", Wiley publication.
5. Jeff Johnson, "Designing with the mind in mind", Morgan Kaufmann Publication.
6. "Human-Machine Interface Design for Process Control Applications", Jean-Yves Fiset, ISA,2009
7. Dix A. et al., Human-Computer Interaction. Harlow, England: Prentice Hall, 2004, ISBN-10: 0130461091
8. Yvonne Rogers, Helen Sharp, Jenny Preece, Interaction Design: Beyond Human Computer Interaction, 3rd Edition, Wiley, 2011, ISBN-10: 0470665769
9. Guy A. Boy "The Handbook of Human Machine Interaction", Ashgate publishing Ltd.

| CLASS: BE (Mechatronics) | Subject Code: MTE8045 | | Semester:-VIII |
|---|---|---|---|
| SUBJECT: **PRODUCT DESIGN & DEVELOPMENT** | | | Credit-4 |
| Periods per week: 1Period of 60 min. | Lecture | 4 | |
| | Tutorial | -- | |
| | | Hours | Marks |
| Evaluation System | Theory Examination | 3 | 80 |
| | Internal Assessment | | 20 |
| | **TOTAL** | | **100** |

**Pre-requisites:**

1. MTC701: CAD/CAM/CAE.

**Objectives:**

1. To understand fundamental of product design concepts
2. To understand product design methodologies
3. To understand product design needs and issues in industry

**Outcomes:** Learner will be able to..

1. Design the products as per the customer/industry requirements
2. Apply product design tools and techniques

| Module | Detailed Contents | Hours |
|---|---|---|
| 1 | 1.1 Introduction to Product Design: product definition, specifications of product, product life cycle.<br>1.2 Concurrent engineering & Sequential engineering<br>1.3 Modern product development process.<br>1.4 Morphology of design. | 08 |
| 2 | 2.1 Conceptual Design: generation, selection & embodiment of concepts.<br>2.2 Product architecture.<br>2.3 Industrial design: process, need.<br>2.4 Design Optimization | 08 |
| 3 | 3.1 Design for Manufacturing (DFM) and Design for Assembly (DFA)<br>3.2 Designs for Maintainability.<br>3.3 Designs for Environment.<br>3.4 Design for Robustness: Taguchi Designs & Design of Experiments (DOE). | 10 |
| 4 | 4.1 Process selection: Important types of manufacturing process and their classification.<br>4.2 Process and material selection Methods : AHP and fuzzy approach<br>4.4 Ergonomics approach | 08 |
| 5 | 5.1 Value Engineering / Value Analysis. : definition, methodology-FAST<br>5.2 Case studies.<br>5.3 Design and Process Failure Mode Effect Analysis (FMEA)<br>5.4 Economic analysis: Qualitative & Quantitative. | 10 |
| 6 | 6.1 Rapid prototyping: Viz. Stereo lithography. FDM, SLS etc.<br>6.2 Quality function deployment (QFD)<br>6.3 Case studies<br>6.4 Legal and social issues<br>6.5 Patents and IP acts | 08 |

**Internal Assessment:**

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

**Theory Examination:**

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

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

**References:**


1. Karl T Ulrich, Steven D Eppinger , " Product Design & Development." Tata McGrawhill New Delhi 2003
2. Kevin Otto & Kristin Wood Product Design: "Techniques in Reverse Engineering and new Product Development." 1 / e 2004, Pearson Education New Delhi
3. L D Miles "Value Engineering."
4. Hollins B & Pugh S "Successful Product Design." Butter worths London.
5. A K Chitale & R C Gupta, "Product Design and Manufacturing", PHI, 2012.

| CLASS: BE (Mechatronics) | Subject code:MTL805 | Semester:-VIII |
|---|---|---|
| SUBJECT: **Simulation Laboratory** | Credit: 1 | |
| Practical to be conducted for batch of students | Practical | Slot of 02 hours per week |

**Pre-requisite:**

1. MTC504 Control Systems ,
2. MTC605 Instrumentation and Controller Design

**Objectives:**

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

**Outcomes:** Learner will be able to..

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

**List of Experiments:**

It is advisable to use required application software for simulation based experiments. Objective is students should get extensive experience in using the most popular modern simulation tools used worldwide. Use of open source software should be encouraged. This will give them confidence in coupling theory with practice and make them aware of trends in design and simulation of both research and industry. Instructors are requested to use their own ideas to help students excel in use of these simulation tools. Followings are the recommendations:

1. Circuit Design with Circuit simulation tools
2. Tools used in control system and instrumentation like Labview
3. Programming with Embedded tools
4. FPGA/CPLD programming tools
5. Modeling with autocad tools
6. Mathematical modeling tools like Scilab/Matlab
7. Tools for implementation of Real Time Operating System
8. Tools used for communication

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

**Term Work:**

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

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

1. Exercises : 25 Marks
2. Mini Project : 20 Marks
3. Attendance (Practical) : 05 Marks

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

**Practical / Oral Examination:**

Practical exam will be based on the performance on the design task given.

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

Practical Examination…… 15 mark
Oral …… 10 Marks

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

| CLASS: BE (Mechatronics) | Subject code:MTL806 | Semester:-VIII |
|---|---|---|
| SUBJECT: **Mechatronics Laboratory** | Credit: 1 | |
| Practical to be conducted for batch of students | Practical | Slot of 02 hours per week |

**Pre-requisites:**

1. MTC503: Sensors and Actuators
2. MTC504: Control Systems
3. MTC502: Machine Design
4. MTC505: Embedded Systems

**Objectives:**

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

**Outcome:** Learner will be able to…

1. Identify the suitable sensor and actuator for a control system
2. Indigenously design and develop a mechatronic system

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

**Term Work:**

Term work shall consist of exercises from the above list.

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

1. Exercises : 45 Marks
2. Attendance (Practical) : 05 Marks

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

**Practical / Oral Examination:**

Practical examination of 2 hours duration based on any one of the experiments mentioned in the list above.

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

Practical Examination …… 15 marks

Oral …… 10 Marks

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

| CLASS: BE (Mechatronics) | Subject Code: MTC701 | | Semester:-VII |
|---|---|---|---|
| SUBJECT: **CAD/CAM/CAE** | | | Credit-4 |
| Periods per week: 1Period of 60 min. | Lecture | 4 | |
| | Tutorial | -- | |
| | | Hours | Marks |
| Evaluation System | Theory Examination | 3 | 80 |
| | Internal Assessment | | 20 |
| | **TOTAL** | | **100** |

**Pre-requisites:**

1. MTC502: Machine Design
2. MTL306: Computer Aided Machine Drawing Laboratory

**Objectives:**

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

**Outcome:** A learner will be able to….

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

| Modules | Details | Hrs. |
|---|---|---|
| **01** | **Computer Graphics and Techniques for Geometric Modeling**<br>Computer Graphics: Two dimensional computer graphics, vector generation, the windowing transformation, Three dimensional Computer graphics, viewing transformation, Homogeneous coordinates, Perspective projection, Hidden line removal & hidden surface removal algorithm, light & shade ray tracing. The parametric representation of geometry, Bezier curves, Cubic Spline curve, B-Spline curve, parametric representation of line, circle, ellipse & parabola. Constructive solid geometry (CSG), Boundary Representation (B-Rep), Wire Frame Modeling, Solid Modeling, Surface Modeling, Parametric Modeling, feature based modeling, Feature recognition, Design by feature. | 08 |
| **02** | **Transformation, Manipulation & Data Storage**<br>2D & 3D Transformations (Translation, Rotation, & Scaling & Magnification), Concatenations, Matrix representation, Problems & object oriented programming on Transformations. Object transformation, mirror transformation, Artificial Intelligence in Design & Manufacturing, Representation of Knowledge, and Knowledge base Engineering. | 08 |
| **03** | **NC & CNC Technology**<br>Tape coding & format, Manual Part Programming, Computer Aided Part Programming, CNC functions & advantages, DNC, adaptive Control, CNC programming concepts, Trends & new developments in NC, Part programmers job, functions of a post processor, NC part programming languages, Elements of a APT language, The Macro Statement in APT, NC | 09 |

| | | |
|---|---|---|
| | programming with interactive graphics. Constructional details of CNC machines, Feedback devices- Velocity & displacement, Machining Centers and its types, Automated Material Handling & storage Systems like Robots, AGVs and AS/RS etc. | |
| **04** | **Computer Aided Engineering (CAE)**<br>Fundamentals of computer aided engineering,<br>CAE includes mass property calculations, kinematic analysis and animation (movement, visualization, simulation and FEA). Case study based on modeling and analysis of structural, thermal/fluid, and dynamic (vibration analysis) system. Parameter optimization. | 08 |
| **05** | **Computer Integrated Manufacturing & Technology Driven Practices**<br>Introduction, Evolution, Objectives, CIM Hardware and Software, CIM Benefits, Nature and role of the elements of CIM, Identifying CIM needs, Data base requirements of CIM, Role of CAD/CAM in CIM, Obstacles to Computer Integrated Manufacturing, Concept of the future CIM systems, Socio -techno- economic aspects of CIM. | 09 |
| **06** | **Rapid Prototyping and Tooling**<br>Introduction to RP, Technology Description, Overview of RP, Benefits and Application. RP Processes: Process overviews, STL file Generation, Classes of RP systems: Stereo-lithography Approach (SLA), SLA with photo-polymerization (mathematical modelling of the process), SLA with liquid thermal polymerization, Selective Laser Sintering (SLS), Fused deposition modelling, Laminated object manufacturing, Laser powder forming. Prototype properties: Material properties, colour, dimensional accuracy, stability, surface finish, machinability, environmental resistance, operational properties.<br>RP Applications: Design, Concept Models, Form & fit checking, Functional testing, CAD data verification, Rapid Tooling, Rapid manufacturing, Science & Medicine, RP processes for MEMS, Photolithography, Direct Laser Writer, Bulk Lithography for 3D micro fabrication (Modelling of beam propagation and curing in resin system). | 10 |

**Internal Assessment:**

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

**Theory Examination:**

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

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

**References:**


1. "CAD/CAM Computer Aided and Manufacturing" by Mikell P. Groover and Emory W. Zimmers, Jr., *Eastern Economy Edition*
2. "CAD/ CAM , Theory & Practice" by Ibrahim Zeid, R. Sivasubramanian, *Tata McGraw Hill Publications*
3. "Computer Graphics" by Donald Hearn and M. Pauline Baker, *Eastern Economy Edition*
4. "CAD/CAM Principles, Practice and Manufacturing Management" by Chris McMahon, Jimmie Browne, *Pearson Education*
5. "CAD/CAM/CIM" by P. Radhakrishan, S. Subramanyan, V. Raju, *New Age International Publishers*
6. "CAD/CAM Principles and Applications" by P.N. Rao, *Tata McGraw Hill Publications*
7. "Principle of Computer Graphics" by William .M. Neumann and Robert .F. Sproul, *McGraw Hill Book Co. Singapore.*
8. David L. Goetsch, Fundamental of CIM technology ,Delmar publication
9. David Bedworth, Computer Integrated Design and Manufacturing, *McGraw Hill.*
10. "CNC Machines" by B.S. Pabla and M. Adithan, *New Age International Publishers.*
11. "Numerical Control and Computer Aided Manufacturing" , T.K. Kundra, P.N. Rao, N.K. Tiwari, *Tata McGraw Hill*
12. "CNC Technology and Programming", Krar, S., and Gill, A., *McGraw Hill publishers*
13. "Computer Integrated Manufacturing- An Introduction with Case Studies" by Paul G. Ranky, *Prentice Hall International*
14. "Flexible Manufacturing Systems" by H.K. Shivanand, M.M. Benal, V.Koti, *New Age International Publishers*
15. "Automation, Production Systems and Computer Integrated Manufacturing ", Groover M.P., *Prentice-Hall of India Pvt. Ltd*
16. "Mathematical Elements for Computer Graphics", Rogers D F I and Adams J A, McGraw-Hill.
17. "Computer Integrated Manufacturing Hand Book" by Eric Teicholz, Joel N. Orr, McGraw Hill International Editions
18. "Rapid Prototyping" Chee Kai Chua World Scientific Publishing
19. "Rapid Prototyping: Principles and Applications" Rafiq Noorani, Wiley
20. "Rapid Prototyping: Principles and Applications" C.K. Chua, K. F. Leong, C.S. Lim

| CLASS: BE (Mechatronics) | Subject Code: MTC702 | Semester:-VII |
|---|---|---|
| SUBJECT: **Manufacturing Planning and Control** | | Credit-4 |
| Periods per week: 1Period of 60 min. | Lecture | 4 |
| | Tutorial | -- |
| | Hours | Marks |
| Evaluation System | Theory Examination | 3 | 80 |
| | Internal Assessment | | 20 |
| | **TOTAL** | | **100** |

**Pre-requisites:**

**1.** MTC501: Manufacturing Processes

2. MTC601: CNC Technology

**Objectives:**

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

**Outcomes:** The learner will be able to...

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

| Modules | Details | Hrs. |
|---|---|---|
| **01** | **Manufacturing Planning and control System:**<br>1.1 Manufacturing transformation process, Manufacturing as competitive advantage. Manufacturing system components and types. Types of products. MPC system overview objectives and functions such as planning routing, scheduling, dispatching and follow up.<br>1.2 Forecasting:<br>Need for forecasting, Types of forecast. Extrapolative methods- Moving average method, Exponential smoothing method, Forecast errors, Linear trend model. Causal methods- Simple regression analysis. | **09** |
| **02** | **Planning Function**: Capacity planning and aggregate planning.<br>Master production schedule, Shop floor Control. | **07** |
| **03** | **Inventory Control:**<br>3.1 Basic concepts of inventory, purpose of holding stock and influence of demand on inventory.<br>3.2 Ordering procedures, Two Bin system, ordering cycle, economical order quantity and economical lot size, ABC analysis and reorder procedures.<br>3.3 Recent trends- computer integrated PP systems, JIT system and MRP-I, MRP-II and ERP (only theory). | **09** |

| | | |
|---|---|---|
| **04** | **Scheduling & Sequencing**:<br>4.1 Inputs for scheduling, loading and scheduling devices, factors influencing scheduling, scheduling techniques, use of Gantt Charts and basic scheduling problems.<br>4.2 Product sequencing, dispatching: progress report & expectation of manufacturing lead time technique for aligning completion time &due dates.<br>4.3 Project management: concepts of project planning, monitoring and control, elements of network analysis –PERT & CPM, cost analysis & crashing. | **10** |
| **05** | **Advanced concepts in production planning I** :<br>Mathematical programming approaches- Linear programming problem, Formulation, Simplex method for maximization and minimization, concept of duality. | **09** |
| **06** | **Advanced concepts in production planning II** :<br>Assignment model, Transportation model.<br>**Simulation:** Need for simulation, Monte Carlo technique. | **08** |

**Internal Assessment:**

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

**Theory Examination:**

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

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

**References:**


1. Manufacturing Planning & Control Systems by Thomas E. Vollman. William L. Berry and others. Galgotia Publications
2. Production and Operations Mnagement by S. N. Chary - T. M. H. Publishing Company.
3. Modernization of Materials Management by L. C. Jhamb - Everest Publishing House.
4. Operation Research by Hamdy H. Taha, *Pearson/Prentice Hall*
5. Operation Research by Wayne Winston, *Cengage Learning*
6. Operation Research by Shah, Ravi, Hardik Soni, *PHI Learning*
7. Operation Research by Panneerselvam, *PHI Learning*
8. Production Operation Research by Adam Ebert, *PHI Learning*
9. Manufacturing Process Planning and System Engineering by Anand Bewoor, Dreamtech Press.
10. Modern production / Operations management by Elwood S. Buffa & Rakesh K. Sarin, *Wiley*
11. Industrial and Production management by Martand Telsang, *S.Chand*
12. Manufacturing, planning and control Systems by Thomos Vollman , William Berry and others, *Tata Mc-Grow Hill.*
13. Operation Research by J K Sharma, *Macmillan*
14. Production Planning and Inventory Control by S.L.Narasimhan and other. *Prentice Hall*

| CLASS: BE (Mechatronics) | Subject Code: MTC703 | | Semester:-VII |
|---|---|---|---|
| SUBJECT: **Communication Systems** | | | Credit-4 |
| Periods per week: 1Period of 60 min. | Lecture | 4 | |
| | Tutorial | -- | |
| | | Hours | Marks |
| Evaluation System | Theory Examination | 3 | 80 |
| | Internal Assessment | | 20 |
| | **TOTAL** | | **100** |

**Pre-requisite:**

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

**Objectives:**

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

**Outcomes:** Learner will be able to...

1. Compare and contrast the significance and limitations of analog and digital communication systems.
2. Demonstrate the knowledge of antennas in communication systems
3. Demonstrate a clear understanding of fundamentals of wireless and mobile communication systems and standards.

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

| | | |
|---|---|---|
| | 3.4 **FM demodulation:** Balance slope detector, Foster-Seely discriminator, ratio detector, Phase lock loop(PLL) FM demodulator, amplitude limiting and thresholding, comparison between FM demodulators, comparison between AM, FM and PM. | |
| **4.0** | **Digital Communication**<br>4.1 Introduction to digital communication system, significance of AWGN channel, pulse dispersion in the channel.<br>4.2 Digital Modulation formats, coherent and non-coherent reception.<br>4.3 **Binary Modulation Techniques:** BPSK, BFSK and BASK.<br>4.4 **M-ary Modulation techniques:** QPSK, M-ary PSK, MSK, M-ary FSK, M-ary QAM, Differential encoded BPSK & D-QPSK. | 12 |
| **5.0** | **Antennas and Wave Propagation**<br>5.1 **Antenna Parameters:** Radiation intensity, directive gain, directivity, power gain, beam width, band width, gain and radiation resistance of current element.<br>5.2 **Half-wave dipole and folded dipole:** Reciprocity principle, effective length and effective area, radiation from small loop and its radiation resistance, Helical antenna.<br>5.3 **Types of wave propagation:** Ground, space, and surface wave propagation, tilt and surface waves, impact of imperfect earth and earth's behavior at different frequencies. | 08 |
| **6.0** | **Wireless Networks and Mobile Communication Systems**<br>6.1 Description of cellular system, Frequency Reuse, Co-channel and Adjacent channel interference, Propagation Models for Wireless Networks, Multipath Effects in Mobile Communication, Models for Multipath Reception.<br>6.2 Evolution of Modern Mobile Wireless Communication System - First Generation Wireless Networks, Second Generation (2G) Wireless Cellular Networks, Major 2G standards, 2.5G Wireless Networks, Third Generation 3G Wireless Networks, Wireless Local Area Networks (WLANs), Cellular – WLAN Integration. | 06 |
| | **Total** | 52 |

**Internal Assessment:**

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

**Theory Examination:**

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

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

**References**:


1. Kennedy and Davis, "*Electronics Communication System*", Tata McGraw Hill, Fourth edition.
2. Taub Schilling and Saha, "*Principles Of Communication Systems*", Tata Mc-Graw Hill,
3. Third Ed.
4. R.K. Shevgaonkar, "*Electromagnetic Waves*", TATA McGraw Hill Companies, 3rd Edition, 2009.
5. Theodore S. Rappaport, " Wireless Communications", Prentice Hall of India, PTR publication
6. Vijay Garg, "Wireless Communications & Networking (The Morgan Kaufmann Series in Networking)", Morgan Kaufmann Publishers, 1st Edition

| CLASS: BE (Mechatronics) | Subject Code: MTC704 | | Semester:-VII |
|---|---|---|---|
| SUBJECT: **Automotive Electronics** | | | Credit-4 |
| Periods per week: 1Period of 60 min. | Lecture | 4 | |
| | Tutorial | -- | |
| | | Hours | Marks |
| Evaluation System | Theory Examination | 3 | 80 |
| | Internal Assessment | | 20 |
| | **TOTAL** | | **100** |

**Prerequisite:**

1. FEC102 Applied Physics
2. FEC105 Basic Electricity and Electronics
3. MTC 305 Applied Electrical and Electronics Engineering

**Objective:**

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

**Outcomes:** Learner will be able to ..

1. Identify and select sensors and actuators for specific task in automobile
2. Design microcontroller based system for automobile functions
3. Synthesize digital engine control system
4. Analyse electric vehicles

| Module | Detailed content | Hrs. |
|---|---|---|
| 1 | **Fundamentals of Automotive Electronics**<br>1.1 Current trends in modern automobiles<br>1.2 Open and closed loop control strategies, PID control, look up tables,<br>1.3 Introduction to modern control strategies like fuzzy logic and adaptive control.<br>1.4 Parameters to be controlled in SI and CI engines. | **10** |
| 2 | **Sensors and Actuators**<br>2.1 Hall Effect, hot wire, thermistor, piezoelectric snd piezoresistive based sensors.<br>2.2 Introduction, basic sensor arrangement, types of sensors, oxygen concentration sensor, lambda sensor, crankshaft angular position sensor, cam position sensor<br>2.3 Mass air flow (MAF) rate, Manifold absolute pressure (MAP), Throttle plate angular position, engine oil pressure sensor, vehicle speed sensor, stepper motors, relays, detonation sensor, emission sensors | **10** |
| 3 | **Microcontroller Based Systems**<br>3.1 Ideal ADC and DAC converters, quantization noise, performance limitations, different methods of ADC and DAC<br>3.2 Microprocessors, microcontrollers, types of memory, memory interface, interrupts, input/output interfacing<br>3.3 Engine control module, powertrain control module, hardware and software components, interfacing with sensors, system integration | **10** |

| | | |
|---|---|---|
| **4** | **Digital Engine Control System**<br>4.1 Open loop and close loop control system<br>4.2 Engine cooling and warm up control, idle speed control, acceleration and full load enrichment, deceleration fuel cutoff.<br>4.3 Fuel control maps, open loop control of fuel injection and closed loop lambda control exhaust emission control, on-board diagnostics, diagnostics<br>4.4 Future automotive electronic systems, electronic dash board instruments – Onboard diagnosis system | **10** |
| **5** | **Electric Vehicles**<br>5.1 Layout of an electric vehicle, traction motor characteristics, tractive effort<br>5.2 Transmission requirements, vehicle performance, energy consumption, advantage and limitations, specifications, system components, electronic control system | **08** |
| **6** | **Transmission Electronics**<br>Multiplexing and De-multiplexing electronically controlled automatic transmission system | **04** |
| | **Total** | **52** |

**Internal Assessment:**

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

**Theory Examination:**

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

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

**References**:


1. David A. Johns, Ken Martin, "Analog Integrated Circuit Design" John Wiley & Sons, 2002.
2. M. A. Mazadi and J. C. Mazadi, "*The 8051 Microcontroller and Embedded Systems*", Pearson Education, New Delhi
3. Robert Bosch, "Automotive Hand Book" SAE, 5th edition, 2000.
4. William B.Riddens -Understanding Automotive Electronics, 5th edition- Butter worth Heinemann Woburn- 1998.
5. Crouse W.H. "Automobile Electrical Equipment" McGraw Hill Book Co., Inc., New York 3rd edition,1986
6. Mehrdad Ehsani, Yimin Gao, sebastien E. Gay and Ali Emadi, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRS Press, 2004

| CLASS: BE (Mechatronics) | Subject Code: MTL706 | Semester:-VII |
|---|---|---|
| SUBJECT: **CAD / CAM / CAE Laboratory** | | Credit: 1 |
| Practical to be conducted for batch of students | Practical | Slot of 02 hours per week |

**Pre-requisites:**

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

**Objectives:**

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

**Outcome:** A learner will be able to….

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

**List of Exercises:**

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

**Term Work:**

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

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

1. Exercises : 15 Marks
2. Course Project : 05 Marks
3. Attendance (Practical) : 05 Marks

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

**Practical / Oral Examination:**

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

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

The distribution of marks for oral-practical examination shall be as follows: Practical Examination …… 15 marks

Oral …… 10 Marks

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

| CLASS: BE (Mechatronics) | Subject Code: MTL707 | Semester:-VII |
|---|---|---|
| SUBJECT: **Communication Systems Laboratory** | | Credit: 1 |
| Practical to be conducted for batch of students | Practical | Slot of 02 hours per week |

**Pre-requisite:**

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

**Objectives:**

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

**Outcomes:** Learner will be able to ..

1. Compare and contrast the significance and limitations of analog and digital communication systems.
2. Demonstrate the knowledge of antennas in communication systems
3. Demonstrate a clear understanding of fundamentals of wireless and mobile communication systems and standards.

**List of Experiments:**

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

**Term Work:**

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

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

1. Exercises : 20 Marks
2. Attendance (Practical) : 05 Marks

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

**Practical / Oral Examination:**

Practical exam will be based on the performance of one of the experiments mentioned in the list.

The distribution of marks for oral-practical examination shall be as follows: Practical Examination …… 15 marks

Oral …… 10 Marks

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

| CLASS: BE (Mechatronics) | Subject Code: MTE7051 | | Semester:-VII |
|---|---|---|---|
| SUBJECT: **Digital Signal Processing** | | | Credit-4 |
| Periods per week: 1Period of 60 min. | Lecture | 4 | |
| | Tutorial | -- | |
| | | Hours | Marks |
| Evaluation System | Theory Examination | 3 | 80 |
| | Internal Assessment | | 20 |
| | **TOTAL** | | **100** |

**Pre-requisite:**

1. MTC406: Signals and Systems

**Objectives:**

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

**Outcomes:** Learner will be able to ...

1. Analyze LSI systems in *z*-transform domain.
2. Apply algorithms for efficient computation of DFT in solving numerical problems.
3. Design FIR and IIR digital filters based on given specifications.
4. Analyze effect of finite word length on digital signal processing.
5. Explain basic architecture of DSP processors & some of the applications of DSP.
6. Demonstrate spoken, written and presentation skills in the subject of DSP.

| Module | Topics | Hrs. |
|---|---|---|
| **1. 0** | **Transform Analysis of Linear Shift Invariant (LSI) System**<br>1.1 Review of *z*-transform and its properties, response to sinusoidal and complex exponential signals, steady-state response to periodic input signals, response to aperiodic input signals, relationships between the system function and the frequency response function, computation of the frequency response function.<br>1.2 LSI systems as frequency-selective filters like; low pass, high pass, band pass, notch, comb, all-Pass filters, and digital resonators.<br>1.3 Invertibility of LSI systems, minimum-phase, maximum-phase, mixed-phase systems. | 12 |
| **2.0** | **The Discrete Fourier Transform and Efficient Computation.**<br>2.1 Frequency domain sampling and reconstruction of discrete time signals, discrete Fourier transform (DFT), DFT as a linear transformation, properties of the DFT, relationship of the DFT to other transforms.<br>2.2 Fast Fourier Transform: Radix-2 and split-radix fast Fourier transform (FFT) algorithms and their applications | 12 |
| **3.0** | **Design of Digital filters and Implementation**<br>3.1 Design of Infinite Impulse Response (IIR) filters using impulse invariant method and bilinear transformation method, Butterworth and Chebyshev filter approximation.<br>3.2 Concepts of Finite Impulse Response (FIR) filter, symmetric and anti-symmetric FIR filter, FIR filter design using window method and frequency sampling method.<br>3.3 Realization structures for IIR and FIR filters using direct form structures, cascade, parallel structures, and lattice, ladder structure (only conceptual understanding) | 12 |

| | | |
|---|---|---|
| **4.0** | **Analysis of Finite Word length effects:**<br>Representation of Numbers in Digital System - Fixed and Floating point Numbers, Finite word length effects, Errors due to quantization, rounding and truncation, Limit cycle oscillation. | 06 |
| **5.0** | **Introduction to Digital Signal Processors**<br>5.1 Introduction to TMS320C54 Processor architecture<br>5.2 Features of digital signal processor, Central processing unit, MAC Unit, CSSU, Memory, Addressing modes, Pipelining. | 05 |
| **6.0** | **Applications of Digital Signal processing:**<br>6.1 Dual –Tone multi frequency signal detection, spectral analysis of sinusoidal signals, spectral analysis of non-stationary signals, and spectral analysis of random signals.<br>6.2 Application to Digital Communications: Pulse Code Modulation, Time-Division Multiplexing, Spread Spectrum & Orthogonal Frequency-Division Multiplexing. | 05 |
| | | 52 |

**Internal Assessment:**

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

**Theory Examination:**

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

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

**References**:


1. Alan V. Oppenheim and Ronald Schafer, "*Discrete Time Signal Processing*", Pearson Education
2. J. Proakis, D. G. Manolakis, and D. Sharma, "*Digital Signal Processing: Principles, Algorithms and Applications*", Pearson Education.
3. Robert Schilling and Sandra Harris, "*Fundamentals of Digital Signal Processing using MATLAB"*, Cengage Learning.
4. Sanjit K.Mitra, "*Digital Signal Processing*", McGrawHill education
5. Luis F. Chaparro, "Signals & Systems using Matlab", Academic Press, 2011.

| CLASS: BE (Mechatronics) | Subject Code:MTEL7051 | Semester:-VII |
|---|---|---|
| SUBJECT: **Digital Signal Processing Laboratory** | | Credit-1 |
| Practical to be conducted for batch of students | Practical | Slot of 02 hours per week |

**Pre-requisite:**

1. MTC406: Signals and Systems

**Objectives:**

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

**Outcomes**: Learner will be able to ...

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

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

**Suggested list of experiments:**

1. Generation of various basic digital signals and analyzing them in time & frequency domain.
2. Understanding concept of convolution by passing sum of sinusoidal through a digital low-pass filter.
3. Understanding concept of auto- and cross-correlation.
4. Simulating & analyzing notch/comb/all-pass/digital resonator filters in time & frequency domain.
5. Concept of minimum phase system.
6. Concept of frequency resolution & zero-padding.
7. Analyzing various types of windows with respect to transition width & stop band attenuation.
8. Design of basic FIR filter based on windowing.
9. Design of basic FIR filter based on frequency domain sampling method.
10. Design of basic IIR filter.
11. Implementing linear filter using circular convolution.
12. Implementation of radix-2 FFT algorithm & demonstrating use of DFT properties.
13. Analyzing finite word length effect on a digital filter.
14. Generation of PWM waveform using a DSP processor.
15. Computation of DFT using DSP processor.
16. Implementation of a filter using DSP processor.
17. Real-time filtering of speech signal using DSP processor.

**Term Work:**

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

1. Exercises : 20 Marks
2. Attendance (Practical) : 05 Marks

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

**Practical / Oral Examination:**

Practical exam will be based on the performance of one of the experiments mentioned in the list.

The distribution of marks for oral-practical examination shall be as follows: Practical Examination …… 15 marks

Oral …… 10 Marks

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

| CLASS: BE (Mechatronics) | Subject Code: MTE7052 | | Semester:-VII |
|---|---|---|---|
| SUBJECT: **Neural Network and Fuzzy Logic** | | | Credit-4 |
| Periods per week: 1Period of 60 min. | Lecture | 4 | |
| | Tutorial | -- | |
| | | Hours | Marks |
| Evaluation System | Theory Examination | 3 | 80 |
| | Internal Assessment | | 20 |
| | **TOTAL** | | **100** |

**Pre-requisites:**

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

**Objectives:**

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

**Outcomes:** Learner will be able to ...

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

| Module | Detailed Contents | Hours |
|---|---|---|
| 1 | **Introduction: S**oft computing techniques**.**<br>1.1 **Basics of Neural Networks:** Introduction to Neural Networks, Biological Neural Networks, McCulloch Pitt model.<br>1.2 S**upervised Learning algorithms:** Perceptron (Single Layer, Multi layer), Linear separability, Delta learning rule, Back Propagation algorithm.<br>1.3 **Un-Supervised Learning algorithms:** Hebbian Learning, Winner take all, Self-Organizing Maps, Learning Vector Quantization. | **10** |
| 2 | **Fuzzy Logic: Introduction to fuzzy logic:**<br>2.1 **Classical Sets (Crisp sets) :** Crisp Sets and Fuzzy Sets, Operations on crisp sets, Properties of crisp sets.<br>2.2 **Fuzzy Sets:** Membership functions, Basic Fuzzy set operations, Properties of Fuzzy sets. | **08** |
| 3 | **Fuzzy Relations:**<br>3.1 **Crisp Relations:** Cartesian product, operations on Relations.<br>3.2 **Fuzzy Relations:** Fuzzy Cartesian product, Operations on Fuzzy Relations. | **07** |
| 4 | **Fuzzy System:**<br>**Fuzzy Logic and application:** Fuzzy qualifiers, Fuzzy inference, Fuzzy Inference System(FIS),Types of FIS, Fuzzification ,defuzzification methods, design of fuzzy controllers. | **08** |

| | | |
|---|---|---|
| **5** | **Hybrid system:**<br>**Introduction to genetic algorithm**<br>5.1 **Integration of Neural networks, Fuzzy logic and genetic algorithms:** Introduction to Adaptive Neuro Fuzzy Inference System(ANFIS) and its application for electromechanical industries.<br>5.2 **Fuzzy back propagation(Fuzzy BP) Network:** Fuzzy Neuron, Fuzzy BP Architecture, Learning in Fuzzy BP. | **09** |
| **6** | **Case Studies using Neural network and Fuzzy Logic:**<br>Expert System design for sensor and actuator selection, Fuzzy Controller design for Metro Train, Washing Machine, Refrigerator, Air Conditioners., Applications of fuzzy logic in pattern recognition and Image processing for electromechanical industries, Model for computing Automobile Fuel Efficiency , Model for color recipes prediction. | **10** |
| | | **52** |

**Internal Assessment:**

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

**Theory Examination:**

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

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

**References:**


1. Timothy J.Ross "Fuzzy Logic With Engineering Applications" Wiley.
2. S.N.Sivanandam, S.N.Deepa "Principles of Soft Computing" Second Edition, Wiley Publication.
3. S.Rajasekaran and G.A.Vijayalakshmi Pai "Neural Networks, Fuzzy Logic and Genetic Algorithms" PHI Learning.
4. J.-S.R.Jang "Neuro-Fuzzy and Soft Computing" PHI 2003.
5. Satish Kumar "Neural Networks A Classroom Approach" Tata McGrawHill.
6. Zimmermann H.S "Fuzzy Set Theory and its Applications"Kluwer Academic Publishers.
7. Hagan, Demuth, Beale,"Neural Network Design" CENGAGE Learning, India Edition.