**NOIDA INTERNATIONAL UNIVERSITY**



**School of Engineering & Technology**

**SCHEME OF EVALUATION & SYLLABUS**

**for**

**BACHELOR OF TECHNOLOGY in Mechatronics Engineering [B. Tech. (Mechatronics)]**

**w.e.f. Academic Session 2022-2023onwards**

**Program Curriculum**

**FOR B. Tech. (Mechatronics)**

**(Effective from Academic Session 2022-2023)**

***B. Tech. in Mechatronics is undoubtedly one of the most sought-after specializations of Engineering. B. Tech. Mechatronics is a Four-Year Undergraduate program with strong focus on students’ learning in the modern fields of mechatronics which are the harbinger of Digital Transformation worldwide. Mechatronics refers to the deployment of machines to enable them to perform tasks with intelligence like humans. The goal of mechatronics generally is to design intelligent machines that can assist people in their everyday life. It is an interdisciplinary branch that includes electronics, mechanical, information, and computer science engineering. It deals with the design and development of robots. The mechatronics graduates can find jobs in private manufacturing & design companies, public organizations, military & defence, education, agriculture, healthcare, etc. Some of the jobs available in the field of mechatronics are Robotics Engineer, Robotics Designer & Analyst, Robotics Sales Engineer, Research Scientist, Automation engineer etc. The mechatronics graduates will be demanded in sectors like mining industry, telecommunications, forest industry, food industry, industrial engineering, space exploration, healthcare, transportation, etc. So, they can find jobs in any of the above-mentioned sectors.***

**Program Educational Objectives (POs)**

The Department of Mechatronics has developed and maintained a well-defined set of Program Educational Objectives and desired Program Outcomes. Educational objectives of the program cater to the requirements of the stakeholders such as students, parents, employers, alumni, faculty etc. The Program Educational Objectives are as follows:

After few years of Graduation, the Graduates of **B. Tech. (Mechatronics)** will be able to:

|  |  |
| --- | --- |
| * **PEO1:** | Achieve professional growth in an engineering position in regional and national industries. Growth can be evidenced by promotions and appointment in the workplace (management positions, technical specialization), entrepreneurial activities, and consulting activities. |
| * **PEO2:** | Success in advanced engineering studies evidenced by enrolment in graduate courses, completion of graduate degree programs, presentations and publications at professional events, and awards or licenses associated with advanced studies. |
| * **PEO3:** | Realization of impactful achievements in societal roles demonstrated by attainment of community leadership roles, mentoring activities, civic outreach service, and active roles in professional societies. |

**Program Outcomes (POs)**

***On successful completion of B. Tech. (Mechatronics) Engineering Graduates will be able to:***

* **PO**1. **Engineering Knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
* **PO**2. **Problem Analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
* **PO**3. **Design/Development of Solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
* **PO**4. **Conduct Investigations of Complex Problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
* **PO**5. **Modern Tool Usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
* **PO**6. **The Engineer and Society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues, and the consequent responsibilities relevant to the professional engineering practice.
* **PO**7. **Environment and Sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
* **PO**8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
* **PO**9. **Individual and Team Work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
* **PO**10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
* **PO**11. **Project Management and Finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
* **PO**12**. Life-Long Learning**: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

**Program Specific Outcomes (PSOs)**

On successful completion of the program, the graduates of B. Tech (Mechatronics) program will be able to:

* **PSO1:** Provide the solutions to problems faced in the industrial area related to the field of Mechatronics Engineering.
* **PSO2:** Design and develop new application with help of Mechatronics using modern tools.

**Credit System:** Credit requirement for award of B. Tech (Mechatronics):

* Every semester shall offer a minimum of **21 credits** and a maximum of **29 credits**.
* Total Credits for the Project or Thesis in the program can vary from **12 to 18**.
* The total number of credits for the B. Tech Degree program could vary from a **minimum of 145** credits to a **maximum of 163** credits.
* All courses of study put together in the program would engage the students for a **minimum of 28 periods** or hours of study a week and a **maximum of 37 periods** or hours a week.

Under the CHOICE BASED CREDIT SYSTEM (CBCS), which is a student or learner centric system, the courses of study in the B. Tech Degree program shall be as under:

1. Basic Sciences and Engineering Science (BS and ES) Course: A course which informs the Professional core and should compulsorily be studied.
2. Professional Core (PC) Course: A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.
3. Elective Course: Generally, a course which can be chosen from a pool of courses and are of two types:
   1. Professional Elective (PE) which may be very specific or specialized or advanced or supportive to the discipline or subject of study or which provides an extended scope
   2. Open Elective (OE) which enables an exposure to some other discipline or subject or domain or nurtures the candidates’ proficiency or skill

The Weightage in terms of Credits for each of the above in the prescribed curriculum of the School is as follows:

|  |  |  |
| --- | --- | --- |
| **S.**  **No.** | **Credit Breakups** | **Credits** |
| 1 | Humanities and Social Sciences including Management Courses | 12 |
| 2 | Basic Science Courses | 21 |
| 3 | Mechatronics Engineering Core Courses | 101 |
| 4 | Professional Elective Core Courses | 6 |
| 5 | Open Elective Courses relevant to chosen Specialization/Branch | 6 |
| 6 | Project Work, Seminar, and Internship in Industry or elsewhere | 17 |
| 7 | Audit Course | Non-Credit |
|  | **Total Credits** | 163 |

While calculating credits the following guidelines is adopted, namely: -

* 1 Hr. Lecture (L) per week 1 credit
* 1 Hr. Tutorial (T) per week 1 credit
* 1 Hr. Practical (P) per week 0.5
* 2 Hours Practical (Lab)/week 1 credit **Credit distribution in each semester** (199 credits to 8 semesters)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Semester** | **Hrs. (Credits)** | | | |
| **Lecture** | **Tutorials** | **Practical** | **Total** |
| **1st** | 17 **(15)** | 2 **(2)** | 14 **(7)** | 33 **(24)** |
| **2nd** | 18 **(16)** | 2 **(2)** | 12 **(6)** | 32 **(24)** |
| **3rd** | 17 **(17)** | 5 **(5)** | 6 **(3)** | 28 **(25)** |
| **4th** | 17 **(17)** | 5 **(5)** | 6 **(3)** | 28 **(25)** |
| **5th** | 21 **(21)** | 4 **(4)** | 6 **(3)** | 31 **(28)** |
| **6th** | 23 **(21)** | 1 **(1)** | 8 **(4)** | 32 **(27)** |
| **7th** | 18 **(18)** | 0 **(0)** | 14 **(7)** | 32 **(25)** |
| **8th** | 11 **(11)** | 0 **(0)** | 18 **(9)** | 35 **(20)** |
| **Total Credits** | 142 **(136)** | 19 **(19)** | **84 (42)** | 245 **(198)** |

**Course Coding System**: Every Course coded as follows:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Type of Course** | **First 2 Alphabets** | **Next 2 Alphabets** | **X1** | **X2** | **X3** | **X4** | **Second Last Alphabet** | **(Last Alphabet)** | **Example** |
| Basic Science Courses (BSC) | BT | SC | Version | Semester | Course Number | | T: Theory  P: Practical  E: Professional Elective  O: Open Elective  S: Seminar/Industrial Training/Project/Thesis | Thread Identifier for Professional Elective  (Only where Professional Elective Threads are implemented.) | BTSC1101T |
| Engineering Science Course (ESC) | BT | ES | Version | Semester | Course Number | | BTES1101T |
| Humanities and Social Sciences including Management (HSMC) | BT | HM | Version | Semester | Course Number | | BTHM1101T |
| Program Core Courses (PCC) | BT | CS | Version | Semester | Course Number | | BTME1301T |
| Program Elective Courses (PEC) | BT | CS | Version | Semester | Course Number | | BTME1501E(A) |
| Open Elective Courses (OEC) | BT | CS | Version | Semester | Course Number | | BTME1701O |
| Mandatory Courses (MC) | BT | MC | Version | Semester | Course Number | | BTMC1101T |
| Any Course Common to Other Department | BT | <##> | Version | Semester | Course Number | | BTEC1403T |

**## Parent Department where this Course belongs to:**

AE: Automobile Engineering

BT: Bio Technology

CE: Civil Engineering

CS: Computer Science & Engineering

EC: Electronics & Communication Engineering

EE: Electrical Engineering

EN: Electrical & Electronics Engineering

IT: Information Technology

MR: Mechatronics Engineering

**Bachelor of Technology (Mechatronics)**

**Seventh Semester**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| **S.**  **No.** | **University**  **Course Code** | **Course Name** | **Period Schedule** | | | **Evaluation Scheme** | | | | | | | |
| **Internal Assessment** | | | | **External**  **Assessment** | **Total** | **Total Credits** | |
| **L** | **T** | **P** | **CT** | **TA** | **AT** | **Total** |
| 1 | BTMR1701T | Robotics | 3 | 0 | 0 | 20 | 10 | 10 | 40 | 60 | 100 | 3 | |
| 2 | BTMR1702T | Mechatronics System | 3 | 0 | 0 | 20 | 10 | 10 | 40 | 60 | 100 | 3 | |
| 3 | BTMR1703T | Computer Aided Manufacturing | 3 | 0 | 0 | 20 | 10 | 10 | 40 | 60 | 100 | 3 | |
| 4 | MT-70X | Professional Elective Course II | 3 | 0 | 0 | 20 | 10 | 10 | 40 | 60 | 100 | 3 | |
| **PRACTICALS** | | | | | | | | | | | | | | |
| 1 | BTMR1701S | Robotics Lab | 0 | 0 | 2 | 20 | 10 | 10 | 40 | 60 | 100 | 2 | |
| 2 | BTMR1702S | Computer Aided Manufacturing Lab | 0 | 0 | 2 | 20 | 10 | 10 | 40 | 60 | 100 | 1 | |
| 3 | BTMR1703S | Project Work | 0 | 0 | 4 | 20 | 10 | 10 | 40 | 60 | 100 | 2 | |
| 4 | BTMR1704S | Mini Project or Internship | - | - | - | - | - | - | - | - | 100 | 1 | |
| **Total [Seventh Semester]** | | | **12** | **0** | **8** | **140** | **70** | **70** | **280** | **420** | **800** | **18** |

**Bachelor of Technology (Mechatronics)**

**Eight Semester**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S.**  **No.** | **University**  **Course Code** | | **Course Name** | **Period Schedule** | | | **Evaluation Scheme** | | | | | | | |
| **Internal Assessment** | | | | **External**  **Assessment** | **Total** | **Total Credits** | |
| **L** | **T** | **P** | **CT** | **TA** | **AT** | **Total** |
| 1 | BTMR1801T | | Open Elective-I | 2 | 0 | 0 | 20 | 10 | 10 | 40 | 60 | 100 | 3 | |
| 2 | BTMR1802T | | Open Elective-II | 3 | 0 | 0 | 20 | 10 | 10 | 40 | 60 | 100 | 3 | |
| **PRACTICALS** | | | | | | | | | | | | | | | |
| 1 | BTMR1801S | Project Work II | | 0 | 0 | 20 | 20 | 10 | 10 | 40 | 60 | 100 | 10 | |
| **Total [Eighth Semester]** | | | | **11** | **0** | **20** | **60** | **30** | **30** | **120** | **180** | **300** | **16** |

**Bachelor of Technology (Mechatronics)**

**List of Professional Elective Courses**

|  |  |  |
| --- | --- | --- |
| **Elective(s)** | **University**  **Course Code** | **Course Name** |
| Elective I | BTMR1501E(A) | Optimization Technique |
| Elective I | BTMR1601E(A) | Operation Research |
| Elective I | BTMR1701E(A) | Total Quality Management |
| Elective II | BTMR1702E(A) | Product Development |
| Elective II | BTMR1801E(A) | Rapid Prototyping |
| Elective II | BTMR1802E(A) | Machine Learning |

**Bachelor of Technology (Mechatronics)**

**List of Open Elective Courses**

|  |  |  |
| --- | --- | --- |
| **Elective(s)** | **University**  **Course Code** | **Course Name** |
| Elective I | BTMR1801O | Virtual and Augmented Reality |
| Elective I | BTMR1802O | Image Processing and Computer Vision |
| Elective I | BTMR1803O | Wireless Network & Communication |
| Elective II | BTMR1804O | Artificial Intelligence |
| Elective II | BTMR1805O | Real Time System |
| Elective II | BTMR1806O | Artificial Neural Network |

**SEMESTER-VII**

**DETAILED CURRICULUM CONTENTS**

|  |  |  |
| --- | --- | --- |
| Course Code | : | BTMR1701T |
| Course Title | : | Robotics |
| Number of Credits | : | 3 (L: 3; T: 0; P: 0) |
| Course Category | : | MT |

##### Course Objective:

* To acquire the knowledge on advanced algebraic tools for the description of motion.
* To develop the ability to analyze and design the motion for articulated systems.
* To develop an ability to use software tools for analysis and design of robotic systems.

##### Course Contents:

**Module I: Introduction:**

Definition, Classification of Robot – Industrial Robot & Service Robot, Anatomy, Spatial coordinates, Geometric configurations and work envelope, Machine intelligence, Criteria for robot selection, Safety standards for Industrial Robot, Economic justification, Robot Applications-Material handling, Machine loading and unloading, Assembly, Inspection, Welding, Spray painting, Medical Industry, Future of Robotics.

##### Module II: Robot Programming:

Introduction, On-line programming: Manual input, Lead through -programming, Teach pendant programming, Off-line programming language, Simulation, Introduction to ROS Concept

##### Module-III: Kinematics of Robotic Manipulators:

Introduction to manipulator kinematics, Homogeneous transformations and robot kinematics, Denavit- Hartenberg (D-H) representation, Concept of forward and inverse kinematics.

##### Module-IV: Control of Robot Manipulator:

Open and closed loop control system, Control system concepts, Linear control schemes, PID control system, Types of motion control, drives and control, Planning of trajectories, Human Robot Collaboration

##### Module V: Control Components and Sensors:

Mechanical control by stops and cams, Solenoids, Relays; Internal Sensors, potentiometers, resolvers and encoders; External sensing: Simple touch sensing, strain sensing, tactile sensing, acoustic sensing, magnetic sensing, capacitive sensing, laser sensing & machine vision

##### Text Books/References:

1. K.S Fu, R.C. Gonzalez, C.S.G. Lee, Robotics, McGraw Hill, 1987.
2. Y. Koren, Robotics for Engineers, McGraw Hill, 1985.
3. J.J. Craig, Robotics, Addison-Wesley, 1986.
4. Saeed B. Niku, “Introduction to Robotics – Analysis, Systems and Application” : PHI 2006.
5. Richard D, Klafter, Thomason A ChmielOwski, Michel Nagin “Robotics Engg-an Integrated Approach” PHI 2005.
6. R.K. Mittal & I.J. Nagrath, “Robotics & Control” TMH-2007.
7. Saha, S.K., “Introduction to Robotics, 2nd Edition, McGraw-Hill Higher Education, New Delhi, 2014.
8. Ghosal, A., “Robotics”, Oxford, New Delhi, 2006**.**

##### Alternative NPTEL/SWAYAM Course:

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No.** | **NPTEL Course Name** | **Instructor** | **Host Institute** |
| 1. | Robotics | Prof. Dilip Kumar Pratihar | IIT Kharagpur |
| 2. | Robotics | PROF. D.K. PRATIHAR | IIT Kharagpur |

**Course Outcomes:**

1. To Understand the basic knowledge on robotics.
2. To demonstrate the different type of robot programing & distinguish between them
3. To Design various types of linkage mechanism for obtaining specific motion and analyze them for optimal functioning.
4. To inspect the knowledge related to control techniques related to robot systems.
5. To Understand the knowledge of different types of sensor used in robot systems.

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| --- | --- | --- |
| Course Code | : | BTMR1702T |
| Course Title | : | Mechatronics System |
| Number of Credits | : | 3 (L: 2; T: 1; P: 0) |
| Course Category | : | MT |

**Course Objective:** This course aims at providing fundamental understanding about the elements of a mechatronics system, interfacing, and its practical applications.

##### Course Contents:

**Module I: Introduction:** Definition of Mechanical Systems, Philosophy and approach; Systems and Design: Mechatronic approach, Integrated Product Design, Modelling, Analysis and Simulation, Man-Machine Interface;

**Module II: Sensors and transducers:** classification, Development in Transducer technology, Opto-Electronics-Shaft encoders, CD Sensors, Vision System, etc.;

**Module III: Drives and Actuators:** Hydraulic and Pneumatic drives, Electrical Actuators such as servo motor and Stepper motor, Drive circuits, open and closed loop control; Embedded Systems: Hardware Structure, Software Design and Communication, Programmable Logic Devices, Automatic Control and Real Time Control Systems;

**Module IV: Replacement Programmable Logic Controllers:** Basic Structure, Types and Working Principle, Concept of Scan Cycle and Scan Time, IO’s and its Types, Selection Criteria and Applications

**Programming Techniques:** Ladder diagram –Concept of Contacts and Coil, Latching/ Holding Circuit, Memory Bits, Timers and Counter.

**Module V: Micro mechatronic systems:** Microsensors, Microactuators; Micro- fabrication techniques LIGA Process: Lithography, etching, Micro-joining etc. Application examples; Case studies Examples of Mechatronic Systems from Robotics Manufacturing, Machine Diagnostics, Road vehicles and Medical Technology.

##### Text Books/References:

1. Mechatronics System Design, Devdas Shetty & Richard A. Kolk, PWS Publishing Company (Thomson Learning Inc.).
2. Mechatronics: A Multidisciplinary Approach, William Bolton, Pearson Education.
3. A Textbook of Mechatronics, R.K.Rajput, S. Chand & Company Private Limited.
4. Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, William Bolton, Prentice Hall.

##### Alternative NPTEL/SWAYAM Course:

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No.** | **NPTEL Course Name** | **Instructor** | **Host Institute** |
| 1. | Mechatronics & Manufacturing Automation | Dr. Shrikrishna N. Joshi | IIT Guwahati |

**Course Outcomes:** Upon completion of this course, students will get an overview of mechatronics applications and the use of micro-sensors and microprocessors.

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| Course Code | : | BTMR1703T |
| Course Title | : | Computer Aided Manufacturing |
| Number of Credits | : | 3 (L: 3; T: 0; P: 0) |
| Course Category | : | MT |

##### Course Objective:

1. To educate students by covering different aspects of computer Aided Manufacturing.
2. To create strong skills of writing CNC programs, PLC programs.
3. To educate students to understand different advances in manufacturing systems like: GT, CAPP and FMS.
4. To educate students by covering different integrated production management systems.

##### Course Content:

**Module I:** Fundamentals of Numerical Control, elements of NC machine tools, classification of NC machine tools, Advantages, suitability and limitations of NC machine tools, Application of NC system.

Definition and designation of control axes, Constructional details of Numerical Control Machine Tools, MCU structure and functions, Methods of improving accuracy and productivity using NC.

**Module II:** Computer Numerical Control (CNC): Features of CNC, Elements of CNC machines, the machine control Module for CNC, Direct Numerical Control(DNC) and Adaptive Controls.

System Devices: Drives, Feedback devices, counting devices, DAC and ADCs, Interpolator systems, Control loop circuit elements in PTP system, Contouring system, Incremental and absolute systems.

**Module III:** NC Part Programming- (a) Manual (word address format) programming Examples Drilling, Turning and Milling; canned cycles, Subroutine, and Macro.

Computer Assisted Part programming (APT) Geometry, Motion and Additional statements, Macro- statement.

**Module IV:** Computer Integrated manufacturing system, Group Technology, Flexible Manufacturing System, Computer aided process Planning-Retrieval and Generative System. Manufacturing Execution System; Overview, Components and Functionality, Relationship between MES and ERP, Benefits of MES.

**Module V:** Smart Manufacturing; Introduction to additive manufacturing, IoT, Smart Sensing, Smart Machines, Data Visualization and Analysis, Augmented Reality, Automated material handling & Cobots. Overview of 3D printing Technology, Materials used in 3D printing, Cyber-security for manufacturing.

##### Text Books/References:

1. Automation, Production System and Computer Integrated Manufacturing, by Mikell P. Grover, Prentice Hall of India Pvt Ltd.
2. CAD/CAM – Theory and Practice, by Ibrahim Zeid, McGraw Hill.
3. Computer Aided Manufacturing, by Cheng, Pearson India.
4. CAD/CAM: Principles and Operations, by P. N. Rao, McGraw Hill.
5. CAD/CAM: Computer Aided Design and Manufacturing, by M. Groover, Pearson India. CAD/CAM: Concepts and Applications by Alavala, PHI India.
6. Computer Aided Manufacturing, by Srinivas, Oxford University Press.

**Course Outcomes:** After learning the course:

1. To describe basic concepts of CAM application and understand CAM wheel.
2. To design CNC programs for manufacturing of different geometries on milling and lathe machines.
3. To illustrate logic diagrams for different applications of automation.
4. To classify different components using different techniques of group technology.
5. To develop process planning for different components.

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| --- | --- | --- |
| Course Code | : | MT-70X |
| Course Title | : | Professional Elective II |
| Number of Credits | : | 3 (L: 3; T: 0; P: 0) |
| Course Category | : | MT |

Any one course from following options can be opted under ‘Professional Elective II’:

* 1. Product Development (BTMR1702E(A))
  2. Rapid Prototyping (BTMR1801E(A))
  3. Machine Learning (BTMR1802E(A))

##### Refer Appendix I on Professional Electives.

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| --- | --- | --- |
| Course Code | : | BTMR1071S |
| Course Title | : | Robotics Lab |
| Number of Credits | : | 2 (L: 0; T: 0; P: 4) |
| Course Category | : | MT |

##### Course Objective:

1. To introduce different types of robotics and demonstrate them to identify different parts and components.
2. To write programming for simple operations.

##### List of Experiments:

1. Study the major equipment/Software/Components in Robotics Lab, e.g. Robotic Arm components, Arena etc.
2. Study components of a real robot and its DH parameters.
3. Integration of assorted sensors (IR, Potentiometer, strain gages etc.), micro controllers and ROS (Robot Operating System) in a robotic system

##### Exercise on any Robotic Simulation Software

1. Determination of maximum and minimum position of links.
2. Study Forward kinematics and validation.
3. Study Inverse kinematics o and validation.
4. Measure the knowledge of Robotic arm, material handling, Scorbase Software and Homing and Moving Robot
5. Recoding Robot positions (Absolute positions, Delete Positions, Save and load positions and Move the Robot to recorded positions.)
6. Verification of transformation (Position and orientation) with respect to gripper and world coordinate system.
7. Robot Programming and Simulation using linear and nonlinear paths.
8. Writing and running Robot programs – Activity material handling operation.
9. Estimation of accuracy, repeatability and resolution.
10. Make a model using software to simulate the processing in small manufacturing cell.
11. Study and Simulate path planning and navigation in ROS.
12. Study the implementation of PID Control in ROS.

##### Text Books/References:

1. Saha, S.K., “Introduction to Robotics, 2nd Edition, McGraw-Hill Higher Education, New Delhi, 2014.
2. Richard D, Klafter, Thomason A ChmielOwski, Michel Nagin “Robotics Engg-an Integrated Approach” PHI 2005.
3. R.K. Mittal & I.J. Nagrath, “Robotics & Control” TMH-2007.

##### EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

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| --- | --- | --- |
| **S. No.** | **Experiment Name** | **Experiment Link(s)** |
| 1 | Study components of a real robot and its DH parameters. | [http://vlabs.iitkgp.ernet.in/mr/exp2](http://vlabs.iitkgp.ernet.in/mr/exp2/index.html)  [/index.html](http://vlabs.iitkgp.ernet.in/mr/exp2/index.html) |

**Course Outcomes:** Upon Completion of the course, the students will be able;

1. To assess kinematics & dynamic analysis of robot manipulators.
2. To understand the functionality and limitations of robot actuators.
3. To program a robot to perform a specified task in a target environment and solve problems in areas such as robot control and navigation.
4. To Understand how simulations of robots, where they can be useful and where they can break down.

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| --- | --- | --- |
| Course Code | : | BTMR1072S |
| Course Title | : | Computer Aided Manufacturing Lab |
| Number of Credits | : | 1 (L: 0; T: 0; P: 2) |
| Course Category | : | MT |

##### Course Objective:

1. Acquire fundamental understanding of the principles of CAD/CAM, including engineering drawing, geometric and surface and feature-based design.
2. Math behind geometry to understand CAD.
3. Applying CAD/CAM concept to product design and manufacturing.
4. Exposure to CAD/CAM software’s.
5. Exposure to machines at Imagineering lab.

##### List of Experiments:

1. Study of CNC VMC part programming fundamentals and writing part program.
2. Study and demonstration of CNC VMC.
3. Part Programming (in word address format) experiment for turning operation (including operations such as grooving and threading) and running on CNC machine.
4. Part Programming (in word address format or ATP) experiment for drilling operation (point to point) and running on CNC machine.
5. Part Programming (in word address format or ATP) experiment for milling operation (contouring) and running on CNC machine.
6. Experiment on difference between ordinary machine and NC machine, study or retrofitting.

##### Text Books/References:

1. Chang, T. C., Wysk, R. A., Wang, H. P, “Computer aided Manufacturing,” Prentice Hall, Third Ed.,
2. Nanua Singh, “Systems Approach to Computer Integrated Design and Manufacturing, “John Wiley and Sons Ltd, First Ed.

**Course Outcomes:** The student will be able:

* 1. To Understand engineering design concepts.
  2. To illustrate Product specification methods.
  3. To Construct 3D part models.
  4. To examine Geometric tolerance.
  5. To Understand process planning.
  6. To design Rapid Manufacturing.

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| --- | --- | --- |
| Course Code | : | BTMR1073S |
| Course Title | : | Project Work I |
| Number of Credits | : | 2 (L: 0; T: 0; P: 4) |
| Course Category | : | MT |

The objective of Project Work-I is to enable the student to take up investigative study in the broad field of Mechatronics Engineering, either fully theoretical/practical or involving both. Theoretical and practical work to be assigned by the Department on an individual basis or two/three students in a group, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. The assignment normally includes:

* Survey and study of published literature on the assigned topic;
* Working out a preliminary Approach to the Problem relating to the assigned topic;
* Conducting preliminary Analysis / Modeling / Simulation / Experiment / Design / Feasibility;
* Preparing a Written Report on the Study conducted for presentation to the Department;
* Final Seminar, as oral Presentation before a Departmental Committee.

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| --- | --- | --- |
| Course Code | : | BTMR1074S |
| Course Title | : | Mini Project or Internship. |
| Number of Credits | : | 1 |
| Course Category | : | MT |

##### Mini Project or Internship of 3 to 4 Weeks shall be performed during summer break after semester VI and this will be assessed as part of Semester VII.

During the summer vacations, after the 6th Semester, students are required to be involved in Inter/ Intra Institution Activities viz.; Training with higher Institutions; Soft skill training organized by Training and Placement Cell of the respective institution; contribution at incubation/ innovation /entrepreneurship cell of the Institution; participation in conferences/ workshops/ competitions etc.; Learning at Departmental Lab/ Tinkering Lab/ Institutional workshop; Working for consultancy/ research project within the institutes and Participation in all the activities of Institute’s Innovations Council for e.g.: IPR workshop/ Leadership Talks/ Idea/ Design/ Innovation/ Business Completion/ Technical Expos etc.

After completion of Mini-project or Internship the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period or while working on mini-project. The student may contact Industrial Supervisor/ Faculty Mentor/TPO for assigning special topics and problems and should prepare the final report on the assigned topics.

Student’s Diary and Internship Report should be submitted by the students along with an attendance record and an evolution sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training. It will be evaluated on the basis of the following criteria:

* Regularity in maintenance of the diary.
* Adequacy & quality of information recorded.
* Drawing, sketches and data recorded.
* Thought process and recording techniques used.
* Organization of the information.

**SEMESTER-VIII**

**DETAILED CURRICULUM CONTENTS**

|  |  |  |
| --- | --- | --- |
| Course Code | : | BTMR1801T |
| Course Title | : | Open Elective I |
| Number of Credits | : | 3 (L: 3; T: 0; P: 0) |
| Course Category | : | MTOE |

Any one course from following options can be opted under ‘Open Elective I’:

1. Virtual and Augmented Reality (MTOE-801)
2. Image Processing & Computer Vision (MTOE-802)
3. Wireless Network & Communication (MTOE-803)

##### For syllabus, Refer Appendix II on Open Electives.

**\*\*\*\*\***

|  |  |  |
| --- | --- | --- |
| Course Code | : | BTMR1802T |
| Course Title | : | Open Elective II |
| Number of Credits | : | 3 (L: 3; T: 0; P: 0) |
| Course Category | : | MTOE |

Any one course from following options can be opted under ‘Open Elective II’:

1. Artificial Intelligence (MTOE-804)
2. Real Time System (MTOE-805)
3. Artificial Neural Network (MTOE-806)

##### For syllabus, Refer Appendix II on Open Electives.

**\*\*\*\*\***

|  |  |  |
| --- | --- | --- |
| Course Code | : | BTMR1801S |
| Course Title | : | Project Work II |
| Number of Credits | : | 10 |
| Course Category | : | MT |

The object of Project Work II & Dissertation is to enable the student to extend further the investigative study taken up under EC P1, either fully theoretical/practical or involving both theoretical and practical work, under the guidance of a Supervisor from the

Department alone or jointly with a Supervisor drawn from R&D laboratory/Industry. This is expected to provide a good training for the student(s) in R&D work and technical leadership. The assignment to normally include:

1. In depth study of the topic assigned in the light of the Report prepared under EC P1;
2. Review and finalization of the Approach to the Problem relating to the assigned topic;
3. Preparing an Action Plan for conducting the investigation, including team work;
4. Detailed Analysis/Modeling/Simulation/Design/Problem Solving/Experiment as needed;
5. Final development of product/process, testing, results, conclusions and future directions;
6. Preparing a paper for Conference presentation/Publication in Journals, if possible;
7. Preparing a Dissertation in the standard format for being evaluated by the Department;
8. Final Seminar Presentation before a Departmental Committee.

**\*\*\*\*\***

**Appendix – I**

## Professional Electives

### Professional Elective I

|  |  |  |
| --- | --- | --- |
| **List of available courses under Professional Elective – I (L: 3, T: 0, P: 0)** | | |
| **S. No.** | **Subject Code** | **Subject** |
| 1 | BTMR1501E(A) | Optimization Techniques |
| 2 | BTMR1601E(A) | Operation Research |
| 3 | BTMR1701E(A) | Total Quality Management |

**Professional Elective II**

|  |  |  |
| --- | --- | --- |
| **List of available courses under Professional Elective – II (L: 3, T: 0, P: 0)** | | |
| **S. No.** | **Subject Code** | **Subject** |
| 1 | BTMR1702E(A) | Product Development |
| 2 | BTMR1801E(A) | Rapid Prototyping |
| 3 | BTMR1802E(A) | Machine Learning |

### Professional Elective I

|  |  |  |
| --- | --- | --- |
| **S. No.** | **Subject Code** | **Subject** |
| 1 | BTMR1501E(A) | Optimization Techniques |
| 2 | BTMR1601E(A) | Operation Research |
| 3 | BTMR1701E(A) | Total Quality Management |

##### -------------------------------------------------------------------------------------------------------------------

|  |  |  |
| --- | --- | --- |
| Course Code | : | BTMR1501E(A) |
| Course Title | : | Optimization Techniques |
| Number of Credits | : | 3 (L: 3, T: 0, P: 0) |
| Course Category | : | MTPE |

**Course Objective:** The main objective of the course is to formulate mathematical models and to understand solution methods for real life optimal decision problems. The emphasis will be on basic study of linear programming problem, Integer programming problem, Transportation problem, two person zero sum games with economic applications and project management techniques using PERT and CPM.

##### Course Content:

**Module I:** Scope of Operations Research: Introduction to linear and non-linear programming formulation of different models.

**Module II:** Linear Programming: Geometry of linear programming, Graphical method, Linear programming (LP) in standard form, Solution of LP by simplex method, Exceptional cases in LP, Duality theory, Dual simplex method, Sensitivity analysis.

Integer Programming: Branch and bound technique.

**Module III:** Transportation and Assignment Problem: Initial basic feasible solutions of balanced and unbalanced transportation/assignment problems, optimal solutions.

**Module IV:** Project Management**:** Construction of networks, Network computations, Floats (free floats and total floats), Critical path method (CPM), Crashing.

**Module V:** Game Theory**:** Two persons zero-sum game, Game with mixed strategies, Graphical method and solution by linear programming.

##### Text/ References Books:

1. Chandra, S., Jayadeva.,Mehra, A., Numerical Optimization and Applications, Narosa Publishing House, (2013).
2. Taha H.A., Operations Research-An Introduction, PHI (2007).
3. Pant J. C., Introduction to optimization: Operations Research, Jain Brothers (2004)
4. BazaarraM.S., Jarvis J.J., and ShiraliH.D., Linear Programming and Network flows, John Wiley and Sons (1990)
5. Swarup, K., Gupta, P. K., Mammohan, Operations Research, Sultan Chand & Sons,

**Course Outcomes:** Upon Completion of this course the students will be able:

1. To Formulate and solve linear programming problems.
2. To solve the transportation and assignment problems

##### \*\*\*\*\*

|  |  |  |
| --- | --- | --- |
| Course Code | : | BTMR1601E(A) |
| Course Title | : | Operations Research |
| Number of Credits | : | 3 (L: 3, T: 0, P: 0) |
| Course Category | : | MTPE |

**Course Objective:** This course aims at familiarizing the students with quantitative tools and techniques, which are frequently applied to business decision-making & to provide a formal quantitative approach to problem solving and an intuition about situations where such an approach is appropriate.

##### Course Content:

**MODULE I:** Introduction to Operations research- Scope, applications of operations research, phases and models of operations research, advantages and limitations of operations research. Linear programming problem (LPP)- formulation of linear programming problem (LPP), graphical method of solution, simplex method, artificial variable technique- Big M method and two phase method, duality in LPP, sensitivity analysis.

**MODULE II:** Transportation Problem (TP)-Mathematical formulation of TP, methods to obtain initial basic feasible solution, TP without degeneracy and TP with degeneracy. Assignment Problem (AP) - Mathematical formulation of AP, comparison with TP, variations of AP, Traveling salesman problem. Sequencing Problem- Assumptions in sequencing problem, processing of n jobs through two machines, processing of n jobs through three machines, and processing of n jobs through m machines.

**MODULE III:** Replacement models- Introduction, replacement of items that detoriates- replacement of items whose maintenance and repair cost increases with time, ignoring money value and - replacement of items whose maintenance and repair cost increases with time, considering money value, replacement of items that fail suddenly- group replacement.Queuing model- Kendall’s notation for representing queuing models, single channel Poisson arrivals with exponential service times, infinite population.

**MODULE IV:** Games theory- Minimax (Maximin) criterion for optimality, characteristics of games, dominance principles, 2X2 game arithmetic and algebraic method, 2Xn and mX2 game-graphical method and method of subgames, 3X3 game- method of matrices, iteration method and applications of games theory.

**MODULE V:** Inventory models- Need and types of inventory, inventory associated costs, Economic order quantity, Classical EOQ inventory model with uniform demand rate and infinite replenishment. EOQ model with multiple price breaks. Simulation- Monte Carlo simulation, advantages and limitations of simulation, applications of simulations.

**MODULE VI:** Network analysis- Network construction, identification of critical path, various types of floats and their computations, Programme Evaluation and Review Technique (PERT) time calculations, crashing of network, resource scheduling, network updating.

##### Text Books:

1. Operations Research: S. D. Sharma, Kedar Nath Ram Nath, Meerut.
2. Operations Research: P. K. Gupta, Sultan, Chand & Sons.

##### References:

1. Operations Research-An Introduction: Hamdy A Taha, Pearson Eduction.
2. Operations Research: Methods and Problems, Maurice Saseini, ArhurYaspan and Lawrence Friedman.

##### Alternative NPTEL/SWAYAM Course:

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No.** | **NPTEL Course Name** | **Instructor** | **Host Institute** |
| 1. | Fundamentals of Operations Research | Prof. G. Srinivasan | IIT Madras |

**Course Outcomes:** After completion of this course, the students will be able

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

##### \*\*\*\*\*

|  |  |  |
| --- | --- | --- |
| Course Code | : | BTMR1701E(A) |
| Course Title | : | Total Quality Management |
| Number of Credits | : | 3 (L: 3, T: 0, P: 0) |
| Course Category | : | MTPE |

**Course Objective:** To learn about

1. Total customer satisfaction
2. Totality of functions
3. Total range of products and services
4. Addressing all aspects of dimensions of quality
5. Addressing the quality aspect in everything – products, services, processes, people, resources and interactions.
6. Satisfying all customers – internal as well as external
7. Addressing the total organizational issue of retaining customers and
8. Improving profits, as well as generating new business for the future.
9. Involving everyone in the organization in the attainment of the said objective.
10. Demanding total commitment from all in the organization towards the achievement of the objective

##### Course Content:

**MODULE I: Introduction to Quality Management**

Definitions – TOM framework, benefits, awareness and obstacles. Quality – vision, mission and policy statements. Customer Focus – customer perception of quality, Translating needs into requirements, customer retention. Dimensions of product and service quality. Cost of quality.

##### MODULE II: Principles and Philosophies of Quality Management

Overview of the contributions of Deming, Juran Crosby, Masaaki Imai, Feigenbaum, Ishikawa, Taguchi techniques – introduction, loss function, parameter and tolerance design, signal to noise ratio. Concepts of Quality circle, Japanese 5S principles and 8D methodology.

##### MODULE III: Statistical Process Control and Process Capability

Meaning and significance of statistical process control (SPC) – construction of control charts for variables and attributed.

Process capability – meaning, significance and measurement – Six sigma concepts of process capability.

Reliability concepts – definitions, reliability in series and parallel, product life characteristics curve. Total productive maintenance (TMP) – relevance to TQM, Terotechnology. Business process re-engineering (BPR) – principles, applications, reengineering process, benefits and limitations.

##### MODULE IV: Tools and Techniques for Quality Management

Quality functions development (QFD) – Benefits, Voice of customer, information organization, House of quality (HOQ), building a HOQ, QFD process. Failure mode effect analysis (FMEA) – requirements of reliability, failure rate, FMEA stages, design, process and documentation. Seven old (statistical) tools. Seven new management tools. Bench marking and POKA YOKE.

##### MODULE V: Quality Systems Organizing and Implementation

Introduction to IS/ISO 9004:2000 – quality management systems – guidelines for performance improvements. Quality Audits. TQM culture, Leadership – quality council, employee involvement, motivation, empowerment, recognition and reward- Introduction to software quality.

##### Text Books:

1. Dale H. Besterfield et al, Total Quality Management, Third edition, Pearson Education (First Indian Reprints 2004).
2. Shridhara Bhat K, Total Quality Management – Text and Cases, Himalaya Publishing House, First Edition 2002.
3. Sharma S.C. & Poonia M.P., Total Quality Management, Khanna Book Publishing, 2018.

**Course Outcomes:** After completion of this course, the students will be able

1. To Evaluate the principles of quality management and to explain how these principles can be applied within quality management systems.
2. To Identify the key aspects of the quality improvement cycle and to select and use appropriate tools and techniques for controlling, improving and measuring quality.
3. To Critically appraise the organizational, communication and teamwork requirements for effective quality management.
4. To Critically analyse the strategic issues in quality management, including current issues and developments, and to devise and evaluate quality implementation plans.

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### Professional Elective II

|  |  |  |
| --- | --- | --- |
| **S. No.** | **Subject Code** | **Subject** |
| 1 | BTMR1702E(A) | Product Development |
| 2 | BTMR1801E(A) | Rapid Prototyping |
| 3 | BTMR1802E(A) | Machine Learning |

##### -------------------------------------------------------------------------------------------------------------------

|  |  |  |
| --- | --- | --- |
| Course Code | : | BTMR1702E(A) |
| Course Title | : | Product Development |
| Number of Credits | : | 3 (L: 3, T: 0, P: 0) |
| Course Category | : | MTPE |

**Course Objective:** This course aims at introducing the students to the basic concepts of engineering design and product development with focus on the front end processes. At the end of this course the student is expected to demonstrate an understanding of the overview of all the product development processes and knowledge of concept generation and selection tools.

##### Course Content:

**MODULE I:** Need for developing products – the importance of engineering design – types of design –the design process – relevance of product lifecycle issues in design –designing to codes and standards- societal considerations in engineering design –generic product development process – various phases of product development-planning for products – establishing markets- market segments- relevance of market research.

**MODULE II:** Identifying customer needs –voice of customer –customer populations- hierarchy of human needs gathering methods – affinity diagrams – needs importance- establishing engineering characteristics-competitive benchmarking- quality function deployment- house of quality- product design specification-case studies.

**MODULE III:** Creative thinking –creativity and problem solving- creative thinking methods- generating design concepts-systematic methods for designing –functional decomposition – physical decomposition – functional representation –morphological methods-TRIZ- axiomatic design.

**MODULE IV:** Decision making –decision theory –utility theory –decision trees –concept evaluation methods – Pugh concept selection method- weighted decision matrix –analytic hierarchy process – introduction to embodiment design –product architecture – types of modular architecture –steps in developing product architecture.

**MODULE V:** Industrial design – human factors design –user friendly design – design for serviceability – design for environment – prototyping and testing – cost evaluation – categories of cost –overhead costs – activity based costing –methods of developing cost estimates – manufacturing cost –value analysis in costing**.**

##### Text Books/References:

1. George E. Dieter, Linda C. Schmidt, “Engineering Design”, McGraw-Hill International Edition, 4th Edition, 2009, ISBN 978-007-127189-9.
2. Anita Goyal, Karl T Ulrich, Steven D Eppinger, “Product Design and Development “, 4th Edition, 2009, Tata McGraw-Hill Education, ISBN-10-007-14679-9.
3. Kevin Otto, Kristin Wood, “Product Design”, Indian Reprint 2004, Pearson Education, ISBN 9788177588217.
4. Yousef Haik, T. M. M. Shahin, “Engineering Design Process”, 2nd Edition Reprint, Cengage Learning, 2010, ISBN 0495668141.
5. Clive L.Dym, Patrick Little, “Engineering Design: A Project-based Introduction”, 3rd Edition, John Wiley & Sons, 2009, ISBN 978-0-470-22596-7.

**Course Outcomes:** After completion of this course, the students will be able

1. To analyze the product design and development processes in manufacturing industry.
2. To understand the components and their functions of product design and development processes and their relationships from concept to customer over whole product lifecycle.
3. To evaluate the methodologies for product design, development and management.
4. To illustrate product development to satisfy customer needs.
5. To Carry out cost and benefit analysis through various cost models.
6. To outline design protection and Intellectual Property.

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|  |  |  |
| --- | --- | --- |
| Course Code | : | BTMR1801E(A) |
| Course Title | : | Rapid Prototyping |
| Number of Credits | : | 3 (L: 3, T: 0, P: 0) |
| Course Category | : | MTPE |

**Course Objective:** Generating a good understanding of RP history, its development and applications. To expose the students to different types of Rapid prototyping processes, materials used in RP systems and reverse engineering.

##### Course Content:

**MODULE I: Introduction**

History – Development of RP systems – Applications in Product Development, Reverse Engineering, Rapid Tooling, Rapid Manufacturing- Principle – Fundamental – File format –Other translators – medical applications of RP – On demand manufacturing – Direct material deposition – Shape Deposition Manufacturing.

##### MODULE II: Liquid Based and Solid Based Rapid Prototyping Systems

Classification – Liquid based system – Stereo Lithography Apparatus (SLA), details of SL process, products, Advantages, Limitations, Applications and Uses. Solid based system – Fused Deposition Modelling, principle, process, products, advantages, applications and uses

– Laminated Object Manufacturing

##### MODULE III: Powder Based Rapid Prototyping Systems

Selective Laser Sintering – principles of SLS process, principle of sinter bonding process, Laser sintering materials, products, advantages, limitations, applications and uses. Three Dimensional Printing – process, major applications, research and development. Direct shell production casting – key strengths, process, applications and uses, case studies, research and development. Laser Sintering System, e-manufacturing using Laser sintering, customized plastic parts, customized metal parts, e-manufacturing – Laser Engineered Net Shaping (LENS).

##### Text Books:

1. Rafiq I. Noorani, Rapid Prototyping, “Principles and Applications”, Wiley & Sons, 2006.
2. Chua C.K, Leong K.F and Lim C.S, “Rapid Prototyping: Principles and Applications”, Second Edition, World Scientific, 2003.

##### References:

1. N.Hopkinson, R.J.M, Hauge, P M, Dickens, “Rapid Manufacturing – An Industrial revolution for the digital age”, Wiley, 2006
2. Ian Gibson, “Advanced Manufacturing Technology for Medical applications: Reverse Engineering, Software conversion and Rapid Prototying”, Wiley, 2006
3. Paul F.Jacobs, “Rapid Prototyping and Manufacturing: Fundamentals of Stereolithography”, McGraw Hill 1993.
4. Pham. D.T., and Dimov. S.S., “Rapid Manufacturing”, Springer Verlog 2001.

##### Alternative NPTEL/SWAYAM Course:

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No.** | **NPTEL Course Name** | **Instructor** | **Host Institute** |
| 1. | Rapid Manufacturing | Prof. Janakranjan Ramkumar | IIT Kanpur |

**Course Outcomes:** At the end of course, student will have knowledge on different types of Rapid Prototyping systems and its applications in various fields.

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|  |  |  |
| --- | --- | --- |
| Course Code | : | BTMR1802E(A) |
| Course Title | : | Machine Learning |
| Number of Credits | : | 3 (L: 3, T: 0, P: 0) |
| Course Category | : | MTPE |

##### Course Objective:

1. To introduce students to the basic concepts and techniques of Machine Learning.
2. To have a thorough understanding of the Supervised and Unsupervised learning techniques.
3. To study the various probability based learning techniques
4. To understand graphical models of machine learning algorithms

##### Course Contents:

**MODULE I: Introduction**

Learning – Types of Machine Learning – Supervised Learning – The Brain and the Neuron – Design a Learning System – Perspectives and Issues in Machine Learning – Concept Learning Task – Concept Learning as Search – Finding a Maximally Specific Hypothesis – Version Spaces and the Candidate Elimination Algorithm – Linear Discriminants – Perceptron – Linear Separability – Linear Regression.

##### MODULE II: Linear Models

Multi-layer Perceptron – Going Forwards – Going Backwards: Back Propagation Error – Multi-layer Perceptron in Practice – Examples of using the MLP – Overview – Deriving Back- Propagation – Radial Basis Functions and Splines – Concepts – RBF Network – Curse of Dimensionality – Interpolations and Basis Functions – Support Vector Machines.

##### MODULE III: Tree and Probabilistic Models

Learning with Trees – Decision Trees – Constructing Decision Trees – Classification and Regression Trees – Ensemble Learning – Boosting – Bagging – Different ways to Combine Classifiers – Probability and Learning – Data into Probabilities – Basic Statistics – Gaussian Mixture Models – Nearest Neighbour Methods – Unsupervised Learning – K means Algorithms – Vector Quantization – Self Organizing Feature Map.

##### MODULE IV: Dimensionality Reduction and Evolutionary Models

Dimensionality Reduction – Linear Discriminant Analysis – Principal Component Analysis – Factor Analysis – Independent Component Analysis – Locally Linear Embedding – Isomap – Least Squares Optimization – Evolutionary Learning – Genetic algorithms – Genetic

Offspring: - Genetic Operators – Using Genetic Algorithms – Reinforcement Learning – Overview – Getting Lost Example – Markov Decision Process.

##### MODULE V: Graphical Models

Markov Chain Monte Carlo Methods – Sampling – Proposal Distribution – Markov Chain Monte Carlo – Graphical Models – Bayesian Networks – Markov Random Fields – Hidden Markov Models – Tracking Methods.

##### Text Books:

1. Stephen Marsland, ―Machine Learning – An Algorithmic Perspective‖, Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014.
2. Tom M Mitchell, ―Machine Learning‖, First Edition, McGraw Hill Education, 2013.
3. Jeeva Jose, - Introduction to Machine Learning‖, First Edition, Khanna Publishing House.

##### References:

1. Peter Flach, ―Machine Learning: The Art and Science of Algorithms that Make Sense of Data‖, First Edition, Cambridge University Press, 2012.
2. Jason Bell, ―Machine learning – Hands on for Developers and Technical Professionals‖, First Edition, Wiley, 2014.
3. Ethem Alpaydin, ―Introduction to Machine Learning 3e (Adaptive Computation and Machine Learning Series) ‖, Third Edition, MIT Press, 2014.
4. Rajiv Chopra, - Machine Learning‖, Second Edition, Khanna Book Publishing.

**Course Outcomes:** Upon completion of the course, the students will be able:

1. To Distinguish between, supervised, unsupervised and semi-supervised learning
2. To Apply the apt machine learning strategy for any given problem
3. To classify supervised, unsupervised or semi-supervised learning algorithms for any given problem.
4. To Design systems that uses the appropriate graph models of machine learning.
5. To Modify existing machine learning algorithms to improve classification efficiency.

**\*\*\*\*\***

## Appendix – II

**Open Electives**

**Open Elective I**

|  |  |  |
| --- | --- | --- |
| **List of available courses under Open Subject – I (L: 3, T: 0, P: 0)** | | |
| **S. No.** | **Subject Code** | **Subject** |
| 1 | BTMR1801O | Virtual and Augmented Reality |
| 2 | BTMR1802O | Image Processing and Computer Vision |
| 3 | BTMR1803O | Wireless Network & Communication |

**Open Elective II**

|  |  |  |
| --- | --- | --- |
| **List of available courses under Open Subject – II (L: 3, T: 0, P: 0)** | | |
| **S. No.** | **Subject Code** | **Subject** |
| 1 | BTMR1804O | Artificial Intelligence |
| 2 | BTMR1805O | Real Time System |
| 3 | BTMR1806O | Artificial Neural Network |

### Open Elective I

|  |  |  |
| --- | --- | --- |
| **S. No.** | **Subject Code** | **Subject** |
| 1 | BTMR1801O | Virtual and Augmented Reality |
| 2 | BTMR1802O | Image Processing and Computer Vision |
| 3 | BTMR1803O | Wireless Network & Communication |

**-------------------------------------------------------------------------------------------------------**

|  |  |  |
| --- | --- | --- |
| Course Code | : | BTMR1801O |
| Course Title | : | Virtual and Augmented Reality |
| Number of Credits | : | 3 (L: 3, T: 0, P: 0) |
| Course Category | : | MTOE |

**Course Objective:** To understand the basic concepts of Augmented and Virtual Reality. The student must be able to apply the various concepts of Augmented and Virtual Reality in other application areas.

##### Course Content:

**Introduction of Virtual Reality:** Fundamental concept and components of Virtual Reality, primary features and present development on Virtual Reality.

**Multiple Models of Input and Output Interface in Virtual Reality:** Input -- Tracker, Sensor, Digital Glove, Movement Capture, Video-based Input, 3D Menus & 3DScanner etc. Output -- Visual /Auditory / Haptic Devices.

**Visual Computation in Virtual Reality:** Fundamentals of computer graphics, software and hardware technology on stereoscopic display, advanced techniques in CG: Management of large scale environments & real time rendering.

**Environment Modelling in Virtual Reality:** Geometric Modelling, Behavior Simulation, Physically Based Simulation.

**Interactive Techniques in Virtual Reality:** Body Track, Hand Gesture, 3D Menus, Object Grasp.

**Introduction of Augmented Reality (AR):** System structure of Augmented Reality, key technology in AR.

**Development Tools and Frameworks in Virtual Reality:** Frameworks of software development tools in VR, X3D Standard, Vega, MultiGen, Virtools etc.

**Mixed Reality:** Augmented reality methods, visualization techniques for augmented reality, wireless displays in educational augmented reality applications, mobile projection

interfaces, marker-less tracking for augmented reality, enhancing interactivity in AR environments, evaluating AR systems.

**Application of VR in Digital Entertainment:** VR technology in film & TV production, VR technology in physical exercises and games, demonstration of digital entertainment by VR.

**Laboratory Work:** To implement various techniques studied during the course.

##### Text Books:

1. Doug A. B., Kruijff E., LaViola J. J. and Poupyrev I., 3D User Interfaces: Theory and Practice, Addison-Wesley (2005,2011p) 2nd ed.
2. Parisi T., Learning Virtual Reality, O’Reilly (2016) 1st ed.
3. Schmalstieg D. and Hollerer T., Augmented and Virtual Reality, Addison-Wesley (2016).

##### References:

1. Whyte J., Virtual Reality and the Built Environment, Architectural Press (2002).
2. Aukstakalnis S., Practical Augmented Reality: A Guide to the Technologies, Applications, and Human Factors for AR and VR, Addison-Wesley (2016)

**Course Outcomes:** After the completion of the course, the student will be able:

1. To Analyze the components of AR and VR systems, its current and upcoming trends, types, platforms, and devices.
2. To Assess technologies in the context of AR and VR systems design.
3. To Implement various techniques and algorithms used to solve complex computing problems in AR and VR systems.
4. To Develop interactive augmented reality applications for PC and Mobile based devices using a variety of input devices.
5. To Demonstrate the knowledge of the research literature in augmented reality for both compositing and interactive applications.

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|  |  |  |
| --- | --- | --- |
| Course Code | : | BTMR1802O |
| Course Title | : | Image Processing and Computer Vision |
| Number of Credits | : | 3 (L: 3, T: 0, P: 0) |
| Course Category | : | MTOE |

**Course Objective:**

1. To review image processing techniques for computer vision.
2. To understand shape and region analysis.
3. To understand Hough Transform and its applications to detect lines, circles, ellipses.
4. To understand three-dimensional image analysis techniques.
5. To understand motion analysis.
6. To study some applications of computer vision algorithms.

##### Course Content:

**MODULE I: IMAGE PROCESSING FOUNDATIONS**

Review of image processing techniques – classical filtering operations – thresholding techniques – edge detection techniques – corner and interest point detection – mathematical morphology – texture.

##### MODULE II: SHAPES AND REGIONS

Binary shape analysis – connectedness – object labeling and counting – size filtering – distance functions – skeletons and thinning – deformable shape analysis – boundary tracking procedures – active contours – shape models and shape recognition – centroidal profiles – handling occlusion – boundary length measures – boundary descriptors – chain codes – Fourier descriptors – region descriptors – moments.

##### MODULE III: HOUGH TRANSFORM

Line detection – Hough Transform (HT) for line detection – foot-of-normal method – line localization – line fitting – RANSAC for straight line detection – HT based circular object detection – accurate center location – speed problem – ellipse detection – Case study: Human Iris location – hole detection – generalized Hough Transform (GHT) – spatial matched filtering – GHT for ellipse detection – object location – GHT for feature collation.

##### MODULE IV: 3D VISION AND MOTION

Methods for 3D vision – projection schemes – shape from shading – photometric stereo – shape from texture – shape from focus – active range finding – surface representations – point-based representation – volumetric representations – 3D object recognition – 3D reconstruction – introduction to motion – triangulation – bundle adjustment – translational alignment – parametric motion – spline-based motion – optical flow – layered motion

##### MODULE V: APPLICATIONS

Application: Photo album – Face detection – Face recognition – Eigen faces – Active appearance and 3D shape models of faces Application: Surveillance – foreground- background separation – particle filters – Chamfer matching, tracking, and occlusion – combining views from multiple cameras – human gait analysis Application: In-vehicle vision system: locating roadway – road markings – identifying road signs – locating pedestrians.

##### Text Books/References:

1. E. R. Davies, “Computer & Machine Vision”, Fourth Edition, Academic Press, 2012.
2. R. Szeliski, “Computer Vision: Algorithms and Applications”, Springer 2011.
3. Simon J. D. Prince, “Computer Vision: Models, Learning, and Inference”, Cambridge University Press, 2012.
4. Mark Nixon and Alberto S. Aquado, “Feature Extraction & Image Processing for Computer Vision”, Third Edition, Academic Press, 2012.
5. D. L. Baggio et al., “Mastering OpenCV with Practical Computer Vision Projects”, Packt Publishing, 2012.
6. Jan Erik Solem, “Programming Computer Vision with Python: Tools and algorithms for analyzing images”, O'Reilly Media, 2012.

**Course Outcomes:** Upon completion of the course, the students will be able:

1. To implement fundamental image processing techniques required for computer vision.
2. To design shape analysis.
3. To implement boundary tracking techniques.
4. To Apply chain codes and other region descriptors.
5. To Apply Hough Transform for line, circle, and ellipse detections.
6. To Apply 3D vision techniques.
7. To implement motion related techniques.
8. To Develop applications using computer vision techniques.

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| --- | --- | --- |
| Course Code | : | BTMR1803O |
| Course Title | : | Wireless Network and Communication |
| Number of Credits | : | 3 (L: 3, T: 0, P: 0) |
| Course Category | : | MTOE |

**Course Objective:**

* + To study about Wireless networks, protocol stack and standards.
  + To study about fundamentals of 3G Services, its protocols and applications.
  + To study about evolution of 4G Networks, its architecture and applications.

##### Course Content:

**MODULE I: WIRELESS LAN**: Introduction-WLAN technologies: Infrared, UHF narrowband, spread spectrum -IEEE802.11: System architecture, protocol architecture, physical layer, MAC layer, 802.11b, 802.11a – Hiper LAN: WATM, BRAN, HiperLAN2 – Bluetooth: Architecture, Radio Layer, Baseband layer, Link manager Protocol, security – IEEE802.16- WIMAX: Physical layer, MAC, Spectrum allocation for WIMAX.

**MODULE II: MOBILE NETWORK LAYER**: Introduction – Mobile IP: IP packet delivery, Agent discovery, tunnelling and encapsulation, IPV6-Network layer in the internet- Mobile IP session initiation protocol – mobile ad-hoc network: Routing, Destination Sequence distance vector, Dynamic source routing.

**MODULE III: MOBILE TRANSPORT LAYER**: TCP enhancements for wireless protocols – Traditional TCP: Congestion control, fast retransmit/fast recovery, Implications of mobility

– Classical TCP improvements: Indirect TCP, Snooping TCP, Mobile TCP, Time out freezing, Selective retransmission, Transaction oriented TCP – TCP over 3G wireless networks.

##### Text Books:

1. Jochen Schiller,” Mobile Communications”, Second Edition, Pearson Education 2012. (Module I, II, III).
2. Vijay Garg, “Wireless Communications and networking”, First Edition, Elsevier 2007. (Module IV, V).

##### Reference Books:

1. Erik Dahlman, Stefan Parkvall, Johan Skold and Per Beming, “3G Evolution HSPA and LTE for Mobile Broadband”, Second Edition, Academic Press, 2008.
2. Anurag Kumar, D.Manjunath, Joy kuri, “Wireless Networking”, First Edition, Elsevier 2011.
3. Simon Haykin, Michael Moher, David Koilpillai, “Modern Wireless Communications”, First Edition, Pearson Education 2013.

**Course Outcomes:** Upon completion of the course, the students will be able

* To explain 3G/4G and WiMAX networks and its architecture.
* To Design and implement wireless network environment for any application using latest wireless protocols and standards.
* To Implement different type of applications for smart phones and mobile devices with latest network strategies.

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### Open Elective II

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| --- | --- | --- |
| **S. No.** | **Subject Code** | **Subject** |
| 1 | BTMR1804O | Artificial Intelligence |
| 2 | BTMR1805O | Real Time System |
| 3 | BTMR1806O | Artificial Neural Network |

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| --- | --- | --- |
| Course Code | : | BTMR1804O |
| Course Title | : | Artificial Intelligence |
| Number of Credits | : | 3 (L: 3, T: 0, P: 0) |
| Course Category | : | MTOE |

**Course Objective:** The student should be made to:

* Study the concepts of Artificial Intelligence.
* Learn the methods of solving problems using Artificial Intelligence.
* Introduce the concepts of Expert Systems and machine learning.

##### Course Content:

**MODULE I: Introduction to Al and Production Systems**

Introduction to AI-Problem formulation, Problem Definition -Production systems, Control strategies, Search strategies. Problem characteristics, Production system characteristics - Specialized productions system- Problem solving methods – Problem graphs, Matching, Indexing and Heuristic functions -Hill Climbing-Depth first and Breath first, Constraints satisfaction – Related algorithms, Measure of performance and analysis of search algorithms.

##### MODULE II: Representation of Knowledge

Game playing – Knowledge representation, Knowledge representation using Predicate logic, Introduction to predicate calculus, Resolution, Use of predicate calculus, Knowledge representation using other Logic-Structured representation of knowledge.

##### MODULE III: Knowledge Inference

Knowledge representation -Production based system, Frame based system. Inference – Backward chaining, forward chaining, Rule value approach, Fuzzy reasoning – Certainty factors, Bayesian Theory-Bayesian Network-Dempster – Shafer theory.

##### MODULE IV: Planning and Machine Learning

Basic plan generation systems – Strips -Advanced plan generation systems – K strips - Strategic explanations -Why, Why not and how explanations. Learning- Machine learning, adaptive Learning.

##### MODULE V: Expert Systems

Expert systems – Architecture of expert systems, Roles of expert systems – Knowledge Acquisition – Meta knowledge, Heuristics. Typical expert systems – MYCIN, DART, XOON, Expert systems shells.

##### Text Books:

1. Kevin Night and Elaine Rich, Nair B., “Artificial Intelligence (SIE)”, Mc Graw Hill- 2008. (Modules-I, II, VI & V)
2. Dan W. Patterson, “Introduction to AI and ES”, Pearson Education, 2007. (Module-III).

##### References:

1. Peter Jackson, “Introduction to Expert Systems”, 3rd Edition, Pearson Education, 2007.
2. M.C. Trivedi, “A Classical Approach to Artificial Intelligence”, Khanna Book Publishing, 2018.
3. Stuart Russel and PeterB Norvig “AI – A Modern Approach”, 2nd Edition, Pearson Education 2007.
4. Deepak Khemani “Artificial Intelligence”, Tata Mc Graw Hill Education 2013.
5. [http://nptel.ac.in](http://nptel.ac.in/)

**Course Outcomes:** At the end of the course, the student should be able:

* To Identify problems that are amenable to solution by AI methods.
* To identify AI methods to solve a given problem.
* To illustrate problem in the language/framework of different AI methods.
* To Implement basic AI algorithms.
* To Design and carry out an empirical evaluation of different algorithms on a problem formalization, and state the conclusions that the evaluation supports.

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| Course Code | : | BTMR1805O |
| Course Title | : | Real Time System |
| Number of Credits | : | 3 (L: 3, T: 0, P: 0) |
| Course Category | : | MTOE |

**Course Objective:** To study the basic of tasks and scheduling

* To understand programming languages and databases.
* To analyze real time communication.
* To analyze evaluation techniques and reliability models for Hardware Redundancy.
* To understand clock synchronization.

\ Course Content:

**MODULE I - Introduction to Task Scheduling:** Introduction - Issues in Real Time Computing, Structure of a Real Time System, Task classes, Performance Measures for Real Time Systems, Task Assignment and Scheduling – Classical uniprocessor scheduling algorithms, RM algorithm with different Cases-Priority ceiling precedence constraints- using of primary and alternative tasks.

**MODULE II - Uni and Multi-Processor Scheduling:** Uniprocessor scheduling of IRIS tasks, Task assignment, Utilization balancing – Next fit- Bin packing- Myopic off-line - Focused addressing and bidding- Buddy strategy- Fault Tolerant Scheduling. -Aperiodic scheduling - Spring algorithm, Horn algorithm- Bratley. - Sporadic scheduling.

**MODULE III - Real Time Communication:** Introduction - VTCSMA – PB CSMA- Deterministic collision resolution protocol- DCR for multi packet messages- dynamic planning based- Communication with periodic and aperiodic messages.

**MODULE IV - Real Time Databases:** Basic Definition, Real time Vs General purpose databases, Main Memory Databases, Transaction priorities, Transaction Aborts, Concurrency control issues, Disk Scheduling Algorithms, Two-phase Approach to improve Predictability, Maintaining Serialization Consistency, Databases for Hard Real Time System.

**MODULE V - Real-Time Modelling and Case Studies:** Petrinets and applications in real- time modelling, Air traffic controller system – Distributed air defence system**.**

##### Text Books:

1. C.M. Krishna, Kang G. Shin, “Real Time Systems”, Tata McGraw - Hill, 2010.
2. Giorgio C. Bortuzzo, “Hard real-time computing systems: predictable scheduling algorithms and applications”, Springer, 2008.

##### References:

1. C. Siva Ram Murthy, G. Manimaran, “Resource management in real-time systems and networks”, PHI, 2009.

##### Alternative NPTEL/SWAYAM Course:

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| --- | --- | --- | --- |
| **S. No.** | **NPTEL Course Name** | **Instructor** | **Host Institute** |
| 1. | Real Time Systems | Prof. Rajib Mall | IIT Kharagpur |

**Course Outcomes:**

1. To understand advanced concepts in theory of computer science;
2. To understand advanced concepts in applications of computer science;
3. To apply knowledge of advanced computer science to formulate the problems in computing and solve them;
4. To learn emerging concepts in theory and applications of computer science;
5. To design and conduct experiments as well as to analyze and interpret data;

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| --- | --- | --- |
| Course Code | : | BTMR1806O |
| Course Title | : | Artificial Neural Network |
| Number of Credits | : | 3 (L: 3, T: 0, P: 0) |
| Course Category | : | MTOE |

##### Course Objective:

1. To understand the biological neural network and to model equivalent neuron models.
2. To understand the architecture, learning algorithms and issues of various feed forward and feedback neural networks.

##### Course Content:

**MODULE – I**

Introduction: A Neural Network, Human Brain, Models of a Neuron, Neural Networks viewed as Directed Graphs, Network Architectures, Knowledge Representation, Artificial Intelligence and Neural Networks Learning Process: Error Correction Learning, Memory Based Learning, Hebbian Learning, Competitive, Boltzmann Learning, Credit Assignment Problem, Memory, Adaption, Statistical Nature of the Learning Process

##### MODULE – II

Single Layer Perceptron: Adaptive Filtering Problem, Unconstrained Organization Techniques, Linear Least Square Filters, Least Mean Square Algorithm, Learning Curves, Learning Rate Annealing Techniques, Perceptron –Convergence Theorem, Relation Between Perceptron and Bayes Classifier for a Gaussian Environment Multilayer Perceptron: Back Propagation Algorithm XOR Problem, Heuristics, Output Representation and Decision Rule, Computer Experiment, Feature Detection.

##### MODULE – III

Back Propagation: Back Propagation and Differentiation, Hessian Matrix, Generalization, Cross Validation, Network Pruning Techniques, Virtues, and Limitations of Back Propagation Learning, Accelerated Convergence, Supervised Learning.

**MODULE – IV**

Introduction to Deep Learning**,** Deep Feed Forward network, regularizations, training deep models, dropouts, Convolutional Neural Network, Recurrent Neural Network, Deep Belief Network

##### Text Books:

1. Neural Networks a Comprehensive Foundations, Simon Haykin, PHI edition.

##### References:

1. Artificial Neural Networks – B. Yegnanarayana Prentice Hall of India P Ltd 2005
2. Neural Networks in Computer Intelligence, Li Min Fu TMH 2003
3. Neural Networks -James A Freeman David M S Kapura Pearson Education 2004.
4. Introduction to Artificial Neural Systems Jacek M. Zurada, JAICO Publishing House Ed. 2006.

##### Course Outcomes:

1. To Create different neural networks of various architectures both feed forward and feed backward.
2. To Perform the training of neural networks using various learning rules.
3. To Perform the testing of neural networks and do the analysis of these networks for various pattern recognition applications.

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