HINDUSTAN
INSTITUTE OF TECHNOLOGY & SCIENCE
(DEEMED TO BE UNIVERSITY)

B. TECH. MECHATRONICS

(Duration: 4 Years)

CURRICULUM and SYLLABUS

(Applicable for Students admitted from Academic Year 2018-19)

DEPARTMENT OF MECHATRONICS ENGINEERING

SCHOOL OF MECHANICAL SCIENCES

HINDUSTAN INSTITUTE OF TECHNOLOGY AND SCIENCE

HINDUSTAN INSTITUTE OF TECHNOLOGY & SCIENCE

Motto:

To Make Every Man *a* Success *and* No Man *a* Failure

Vision:

To be an International Institute of Excellence, providing a conducive environment for education with a strong emphasis on innovation, quality, research and strategic partnership blended with values and commitment to society.

Mission:

- *To create an ecosystem that promotes learning and world class research.*
- *To nurture creativity and innovation.*
- *To instill highest ethical standards and values.*
- *To pursue activities for the development of the Society.*
- *To develop national and international collaborations with institutes and industries of eminence.*
- *To enable graduates to become future leaders and innovators.*

Value Statement:

Integrity, Innovation, Internationalization.

DEPARTMENT OF MECHATRONICS ENGINEERING

VISION

To be recognized internationally in providing Mechatronics education, nurturing professional engineers with outstanding competencies for innovation, research and entrepreneurial skills.

MISSION

The Mechatronics program continuously strives,

M1. To provide a conducive academic environment with state of art laboratory infrastructure

M2. To promote collaborative research and innovation with global institutions and industries

M3. To offer interdisciplinary curricula and learning practices to meet the dynamic global demands

M4. To impart technical, managerial and lifelong learning skills, embedded with ethical values and social relevance.

PROGRAMME EDUCATIONAL OBJECTIVES (PEO'S):

PEO1. Successful career and adaptability to industry: Graduates will have in-depth knowledge appropriate to the discipline of Mechanical Engineering which enables them to pursue higher studies and academic research.

PEO2. Modern design tools and multi-disciplinary project execution: Graduates will attain professionalism and shall be industry adaptive through a degree structure that isrelevant to industry, and responsive to changes in technology and the needs of the society with noble attitude and social responsibility.

PEO3. Contribution to mechanical field and lifelong learning: Graduates will posses multi and inter disciplinary knowledge and excel in innovation and teamwork with entrepreneurial capabilities

PROGRAM OUTCOMES [PO's]

PO 1 **:** Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex Mechanical engineering problems.

PO 2 **:** Problem analysis: Identify, formulate, 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 Mechanical 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, 5analysis 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 that are relevant to Mechanical engineering, 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 Mechanical engineering practice.

PO 7 : Environment and sustainability: Understand the impact of the Mechanical 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 Mechanical 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 OUTCOME (PSO's)

PSO1 : Design, develop and evaluate the elements of Mechatronics systems.

PSO2 : Interface and integrate Mechatronics systems to align with global industrial standards satisfying the societal needs

B.TECH –MECHATRONICS									
(165 - CREDIT STRUCTURE)									
SEMESTER - I									
SL. NO	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**S**	**TCH**
1	BS	MEA4101/ ELA4101	Engineering Graphics and Computer aided Design / Professional English and soft skills	1	1	2	3	1	4
2	BS	MAA4101	Matrices and calculus	3	0	2	4	1	5
3	BS	PHA4101/CYA4101	Engineering Physics / Engineering Materials	3	0	0	3	1	3
4	PC	CSA4101/ GEA4102	Problem Solving Using C* / Sustainable Engineering Systems	2	0	2*/ 0	3/2	1	4/3
5	PC	MHB4102/ MHB4101	Introduction to Digital Systems* Engineering and Design	2/3	0	2*/ 0	3	1	3
6	BS	GEA4131	Engineering Immersion Lab	0	0	2	0.5	2	2
7	BS	PHA4131/ CYA4131	Engineering Physics Lab / Materials Chemistry Lab	0	0	2	1	0	2
Total				**11/ 12**	**1**	**12/ 10**	**17.5/ 16.5**	**7**	**23/ 22**
***Project based Learning**									
SEMESTER - II									
SL. NO	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**S**	**TCH**
1	BS	MAA4117	Analytical Mathematics	3	0	2	4	0	5
2	BS	PHA4101/ CYA4101	Engineering Physics / Engineering Materials	3	0	0	3	1	3
3	BS	ELA4101/ MEA4101	Professional English and soft skills /Engineering Graphics and Computer aided Design	1	1	2	3	1	4
4	PC	GEA4102/ CSA4101	Sustainable Engineering Systems /Problem Solving Using C*	2	0	0/ 2*	2/3	1	3/4
5	PC	MHB4101 /MHB4102	Engineering and Design /Introduction to Digital Systems*	2/3	0	0/ 2*	3	1	3
6	PC	MEB4116	Engineering Mechanics	3	1	0	4	1	4
7	PC	MHB4117	Basics of Mechatronics	2	0	2	3	1	3
8	PC	MHB4141	Floor Shop Training	0	0	2	1	2	1
8	BS	PHA4131/ CYA4131	Engineering Physics Lab / Materials Chemistry Lab	0	0	2	1	0	2
9	BS	GEA4131	Engineering Immersion Lab	0	0	2	0.5	2	2

Total	**16/ 17**	**2**	**16**	**24.5/ 25.5**	**10**	**30/ 31**

SEMESTER - III									
SL. NO	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**S**	**TCH**
1	BS	MAA4201	Partial Differential Equations and Transforms	3	1	0	4	0	5
2	PC	MHB4201	Manufacturing Processes	3	0	0	3	0	3
3	PC	MHB4202	Mechanics of Machines	3	0	2	4	1	5
4	PC	MHB4203	Embedded Systems	3	0	2	4	1	5
5	DE		Department Elective – I	3	0	0	3	0	3
6	NE		Non Department Elective – I	2	0	0	2	0	2
7	PC	MHB4231	Computer Aided Design Lab	0	0	2	1	0	2
8	PC	MHB4232	Manufacturing Processes Lab	0	0	3	1	0	3
9	PC	MHB4233	Design Project-I	0	0	2	1	0	2
Total				**17**	**1**	**11**	**23**	**2**	**30**

SEMESTER - IV									
SL. NO	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**S**	**TCH**
1	PC	MHB4218	Electrical Machines and Drives	3	0	0	3	1	3
2	PC	GEA4216	Professional ethics and life skills	2	0	0	2	1	2
3	PC	MHB4219	Solid and Fluid Mechanics	3	0	0	3	2	3
4	PC	MHB4220	Statistics and Data Analytics	3	0	2	4	0	5
5	DE		Department Elective-II	3	0	0	3	0	3

6	NE		Non Department Elective–II	2	0	0	2	0	2
7	PC	MHB4242	Electrical Machines and Drives lab	0	0	2	1	0	2
8	PC	MHB4243	Solid and Fluid Mechanics Lab	0	0	3	2	0	3
9	PC	MHB4244	Design Project II	0	0	2	1	0	2
Total				**16**	**0**	**9**	**21**	**4**	**25**

SEMESTER - V									
SL. NO	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**S**	**TCH**
1	PC	MHB4301	Metrology and Measurements	3	0	2	4	0	5
2	PC	MHB4304	Control Systems	2	1	2	4	2	5
3	PC	MHB4305	Hydraulics and Pneumatics	3	0	0	3	1	3
4	HS	GEA4304	Business Economics	3	0	0	3	1	3
5	DE		Department Elective-III	3	0	0	3	0	3
6	NE		Non Department Elective–III	2	0	0	2	0	2
7	PC	MHB4334	Hydraulics and Pneumatics Lab	0	0	2	1	0	2
8	PC	MHB4335	Virtual Instrumentation Lab	0	1	3	3	2	4
9	PC	MHB4336	Design Project III	0	0	2	1	0	2
Total				**16**	**2**	**11**	**24**	**6**	**29**
SEMESTER - VI									
SL. NO	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**S**	**TCH**
1	PC	MHB4321	Sensors and Motion Control	3	0	0	3	2	3
2	PC	MHB4322	Design of Mechatronics System	3	0	2	4	3	5
3	PC	MHB4323	CNC Technology	3	0	2	4	3	5
4	PC	MHB4324	Industrial Electronics	3	0	0	3	3	3

5	DE		Department Elective-IV	3	0	0	3	0	3
6	NE		Non Department Elective–IV	2	0	0	2	0	2
8	PC	MHB4345	Sensors and Motion Control Lab	0	0	3	2	0	3
9	PC	MHB4346	Design Project IV	0	0	2	1	0	2
10	PC	MHB4347	Comprehension	1	0	0	1	0	1
Total				**18**	**0**	**9**	**23**	**11**	**27**

SEMESTER - VII

SL. NO	COURSE CATEGORY	COURSE CODE	NAME OF THE COURSE	L	T	P	C	S	TCH
1	PC	MHB4407	NDT and Condition Monitoring	3	0	0	3	2	3
2	PC	MHB4408	Robotics and Machine Vision	3	1	0	4	3	4
3	PC	MHB4409	Artificial Intelligence for Mechatronics	3	0	2	4	3	5
4	PC	MHB4410	Fundamentals of Signal Processing	3	0	2	4	0	5
5	DE		Department Elective - V	3	0	0	3	0	3
6	NE		Non Department Elective –V	2	0	0	2	0	2
7	PC	MHB4437	Robotics and Machine Vision Lab	0	0	2	1	0	2
8	PC	MHB4438	NDT and Condition Monitoring Lab	0	0	3	2	0	3
9	PC	MHB4439	Design Project V	0	0	2	1	0	2
Total				**17**	**1**	**11**	**24**	**8**	**29**

SEMESTER - VIII

SL. NO	COURSE CATEGORY	COURSE CODE	NAME OF THE COURSE	L	T	P	C	S	TCH
1	PC	MHB4448	Project	0	0	24	8	0	24
Total				**0**	**0**	**16**	**8**	**0**	**24**
Total							**165**		

LIST OF DEPARTMENTAL ELECTIVES WITH GROUPING - SEMESTER WISE									
SEM	**COURSE CATEGORY**	**COURSE CODE**	**NAME OF THE COURSE**	**L**	**T**	**P**	**C**	**S**	**TCH**
Elective I									
3	DE	MHC4251	Basics of Robotics	3	0	0	3	1	3
3	DE	MHC4252	Mechatronics System Applications	3	0	0	3	1	3
3	DE	MHC4253	Mobile Robots	3	0	0	3	1	3
Elective II									
4	DE	MHC4266	Industrial Robots	3	0	0	3	1	3
4	DE	MHC4267	Machining Technology	3	0	0	3	1	3
4	DE	MHC4268	Applied Pneumatics For Industrial Automation	3	0	0	3	1	3
4	DE	MHC4269	Product Development	3	0	0	3	1	3
Elective III									
5	DE	MHC4355	Building Automation	3	0	0	3	1	3
5	DE	MHC4356	Electronic Devices And Circuits	3	0	0	3	1	3
5	DE	MHC4357	Industrial Instrumentation	3	0	0	3	1	3
Elective IV									
6	DE	MHC4370	Analog Electronics	3	0	0	3	1	3
6	DE	MHC4371	Operational Research	3	0	0	3	1	3
6	DE	MHC4372	Robotic Operating System	3	0	0	3	1	3
6	DE	MHC4373	Virtual Reality	3	0	0	3	1	3
Elective V									
7	DE	MHC4459	Robotic Process Automation	3	0	0	3	1	3

7	DE	MHC4460	Industrial Engineering	3	0	0	3	1	3
7	DE	MHC4461	Total Quality Management	3	0	0	3	1	3
7	DE	MHC4462	Finite Element Analysis	3	0	0	3	1	3

LIST OF NON DEPARTMENTAL ELECTIVES OFFERED BY MECHATRONICS WITH GROUPING - SEMESTER WISE

SEM	COURSE CATEGORY	COURSE CODE	NAME OF THE COURSE	L	T	P	C	S	TCH
Elective I									
3	NE	MHD4281	Building of Mobile Robots	2	0	0	2	1	2
Elective II									
4	NE	MHD4292	AI in Robotics	2	0	0	2	1	2
4	NE	MHD4293	Robotics & IOT, Sensors for Autonomous Vehicles	2	0	0	2	1	2
Elective III									
5	NE	MHD4382	Machine Vision	2	0	0	2	1	2
Elective IV									
6	NE	MHD4392	Immersive Technologies	1	1	0	2	0	2
6	NE	MHD4393	Design Thinking and Product Development	2	0	0	2	1	2
6	NE	MHD4394	Industry 4.0	2	0	0	2	1	2
Elective IV									
7	NE	MHD4481	Product Prototyping	2	0	0	2	1	2

SEMESTER VII

COURSE TITLE	NDT AND CONDITION MONITORING			CREDITS	3
COURSE CODE	MHB4407	COURSE CATEGORY	PC	L-T-P-S	3-0-0-2
Version	1.0	Approval Details	24th ACM, 30.05.2018	LEARNING LEVEL	BTL-3

ASSESSMENT SCHEME

First Periodical Assessment	Second Periodical Assessment	Seminar/ Assignments/ Project	Surprise Test / Quiz	Attendance	ESE
15%	15%	10%	5%	5%	50%

Course Description	This course intended to introduce various non-destructive testing and condition monitoring techniques practiced in industries. This course includes the introduction and selection of various NDT techniques and condition monitoring methods. This course also elaborates the interdisciplinary systems for engineering testing applications
Course Objective	The specific objectives of the Course enable the students to 1. To introduce the concepts of NDT and condition monitoring 2. To recognize the hardware aspects of inspection 3. To know the sensors and signal conditioning 4. To empathise the interfacing concepts through NDT methods 5. To know the capabilities of various monitoring systems
Course Outcome	Students will be able to: 1. Comprehend various techniques of condition monitoring and NDT methods and select the method for various defects flaws 2. Arrange the instrumentation for Vibration Monitoring. 3. Describe the materials and methods – UT, LPT, MPT, ECT and codes, standards, specifications. 4. Interpret the results using different analysis methods

Prerequisites: Knowledge in sensors and hardware

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	1	2	2	1	1	1	1	1	1	-	1	3
CO-2	3	3	2	2	3	1	1	1	1	1	2	-	1	3

CO-3	**3**	**3**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**-**	**1**	**3**
CO-4	**3**	**3**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**-**	**1**	**3**

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: INTRODUCTION (9L)	
Outline: vibration analysis, performance analysis, temperature monitoring , Fault diagnosis Introduction to various non-destructive methods- Visual Inspection, Optical aids, Applications. **Suggested Reading:** Case Study on selection of testing methods	**CO-1** **BTL-2**
MODULE 2: VIBRATION MONITORING (9L)	
Use of overall vibration level. Assessment of vibration severity. Frequency analysis, Monitoring of bearing - Case study **Suggested reading** Vibration monitoring of machine tools	**CO-2** **BTL-2**
MODULE 3: LIQUID PENETRANT AND MAGNETIC PARTICLETESTING (9L)	
Physical principles, procedure for penetrant testing, water washable, post – Emulsifiablemethods, Principle of MPT, procedure , Equipment , Applications **Demonstration** Liquid penetrant testing	**CO-3** **BTL-3**
MODULE 4: EDDY CURRENT TESTING (9L)	
Principles, Instrumentation for ECT, Absolute - differential probes, Techniques – High sensitivity Techniques, Applications **Suggested Reading** Fabrication of simple EM sensors	**CO-3** **BTL-2**
MODULE 5: ULTRASONIC TESTING (9L)	
Principle , Ultrasonic transducers ,Inspection Methods, Ultrasonic Flaw detection Equipment , Modes of display A- scan , B-Scan , C- Scan ,Applications **Suggested Reading** Study of Ultrasonic probes	**CO-4** **BTL-2**

TEXT BOOKS

1	Baldev raj, T Jeyakumar, M. Thavasimuthu. (2019). *Practical Non Destructive Testing*, Narosa Publishing House.
2	Amiya R. Mohanty .(2015). *Condition Monitoring Principles and Practices*, CRC Press, USA

REFERENCES

3	Krautkramer. J. (1996). *Ultrasonic Testing of Materials*, 2nd Edition, Springer Verlag Publication, New York, 1996.
4	Peter J. Shull. (2003). *Non Destructive Evaluation: Theory, Techniques and Application*, Marcel
Web Resource	
1	https://www.nde-ed.org/index_flash.html

COURSE TITLE	**ROBOTICS AND MACHINE VISION SYSTEMS**			**CREDITS**	**4**
COURSE CODE	**MHB4408**	**COURSE CATEGORY**	**PC**	**L-T-P-S**	**3-1-0-3**
Version	**1.0**	**Approval Details**	**24th ACM, 30.05.2018**	**LEARNING LEVEL**	**BTL- 4**
ASSESSMENT SCHEME					
First Periodical Assessment	**Second Periodical Assessment**	**Seminar/ Assignments/ Project**	**Surprise Test / Quiz**	**Attendance**	**ESE**
15%	**15%**	**10%**	**5%**	**5%**	**50%**
Course Description	Robotics is an interdisciplinary branch of engineering and science that includes mechanical engineering, electronics engineering, computer science, and others. Robotics deals with the design, construction, operation, and use of robots, as well as computer systems for their control, sensory feedback, and information processing. Robots are rapidly evolving from factory workhorses, which are physically bound to their work-cells, to increasingly complex machines capable of performing challenging tasks in our daily environment. The goal of this program is to introduce the hardware and programming concepts of industrial robots and their applications. Secondly, this course also introduces the fundamentals of vision systems and image processing that could be used along with the robots. Therefore, this course provides the basic concepts and algorithms required to develop mobile robots that act autonomously in complex environments integrating vision systems. The main emphasis is put on robot locomotion and kinematics, environment perception, vision system and motion planning. The lectures and exercises of this course introduce several types of industrial robots and their modelling, kinematics, path planning, various image processing and machine vision techniques along with application of vision system in robots.				

Course Objective	The specific objectives of the Course enable the students to 1. Learn the concepts of robot kinematics. 2. Learn the principles of robot drives and controls. 3. Learn the sensors used in robots. 4. Learn methods of developing solutions for Robot configurations. 5. Learn the concepts of various machine vision and image processing techniques
Course Outcome	Upon completion of this course, the students will be able to 1. Classify and discuss different robotic systems, their actuators, drives and controls. 2. Infer, Interpret and Develop Kinematic solutions for robots. 3. Classify, illustrate, and appreciate different gripping mechanisms and sensors for robotics. 4. Discuss the role of machine vision techniques in robotics. 5. Comprehend and discuss various image processing techniques in robotics

Prerequisites: NIL

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	3	3	1	0	0	2	2	0	0	2	2	2
CO-2	3	3	3	3	1	0	0	2	2	0	0	2	2	3
CO-3	3	3	3	3	0	0	0	2	2	0	0	2	2	3
CO-4	3	3	3	3	0	0	0	2	2	0	0	2	2	2
CO-5	3	3	3	3	0	0	0	2	2	0	0	2	2	2

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: INTRODUCTION (9L + 3T =12)

Introduction to robotics - Basic Structure– Classification of robot and Robotic systems –laws of robotics – robot motions – workspace, precision of movement – Drives and Actuators. **Suggested Readings:** ● Configurations of SCARA, PUMA 360, STANFORD arm ● Various Mechanical, Electric, Hydraulic and Pneumatic Actuators used for Robotic Applications.	**CO-1** **BTL-3**

MODULE 2: KINEMATICS OF ROBOTS (15L+5T=20)

Introduction, Matrix Representation, Robot Transformations - Homogeneous transformation, – Forward and Inverse Kinematics - Inverse Kinematics – D H Representation, Degeneracy, dexterity, Basics of Trajectory planning. **Suggested Readings:** ● Derive kinematic solutions of 2,3,4 and 6 DOF robotic and wrist configurations using Denavit – Hartenberg Matrix. ● Derive FK and IK solution for the 4 D.O.F GANTRY Robot considering the ACME Lead Screw transmission directly coupled with electric motor in X,Y, Z axis.	**CO-2** **BTL- 4**
MODULE 3: END EFFECTORS& SENSORS (9L+3T=12)	
Robot End Effectors: Types of end effectors – Mechanical grippers – Types of Gripper mechanisms – Gripper's force analysis – Other types of Grippers – Vacuum cups – Magnetic Grippers – Adhesive Grippers – Robot end effector interface – Sensors for Robotics – Design of Two and Three finger mechanical Grippers – Soft Grippers. **Suggested Readings:** ● Various Actuators used for design of robotic configurations. ● Study of Grasping Modes, Forces, and Stability ● Ultrasonic, Opto mechanical and Smart Tactile Sensors for gripper design.	**CO-3** **BTL-3**
MODULE 4: MACHINE VISION AND IMAGEPROCESSING (8L)	
Introduction – Image processing Vs image analysis, image Acquisition, digital Images – Sampling and Quantization – Image definition, levels of Computation. Data reduction – Windowing, digital conversion. Operation on images: Segmentation – Thresholding, Connectivity, Noise Reduction, Edge detection, Segmentation, Region growing and Region Splitting -Mondic – Diadic – Spatial – Morphology – Binary Morphology and grey morphology operations. Boundary detection – Hit and miss transform – Shape changing: Cropping – resizing – pyramids – warping. **Suggested Readings:** ● Various Image processing techniques used for object identification and detection.	**CO-4** **BTL-3**
MODULE 5: MULTIPLE IMAGES (8L)	

Object recognition by features, Depth measurement, specialized lighting techniques. Segmentation using motion – Tracking. Region Features: Classification – Representation – Description - Line Features – Point features - Feature correspondence – Geometry of multiple views – Stereo vision – Structure and motion, interfacing with industrial robots, Real time Image processing. **Suggested Readings:** ● Principles of Stereo Vision and its application in industrial robotics system.	**CO-5** **BTL-3**

TEXTBOOKS	
1.	Saeed B. Niku. (2019). *Introduction to Robotics: Analysis, Systems, Applications*, Wiley., 3rd edition, pp. 1 to 324
2.	Mikell P. Groover, Mitchel Weiss, Roger N Nagel, Nicholas G Odrey, Ashish Dutta. (2017).*Industrial Robotics: Technology, Programming, and Applications*, McGraw-Hill Companies.,2nd edition, 12th Reprint, pp. 1 to 183.
REFERENCE BOOKS	
1.	Davies, E.R. (2012).*Machine Vision: Theory, Algorithms, Practicalities*, Academic Press, London. pp. 1 to 487
2.	Peter Corke. (2017). *Robotics, Vision and Control: Fundamental Algorithms in MATLAB*, Springer, 2nd edition, pp. 1 to 683.
3.	K.S. Fu, R.C. Gonzalez, C.S.G Lee. (2017). *Robotics, Control, Sensing, Vision and Intelligence*, McGraw-Hill Education, pp. 1 to 571.
E BOOKS	
1.	https://robotacademy.net.au/lesson/principles-of-stereo-vision/
MOOC	
1.	https://www.coursera.org/specializations/modernrobotics
2.	https://nptel.ac.in/courses/107/106/107106090/

COURSE TITLE	**ARTIFICIAL INTELLIGENCE FOR MECHATRONICS**			**CREDITS**	**4**
COURSE CODE	**MHB4409**	**COURSE CATEGORY**	**PC**	**L-T-P-S**	**3-0-2-3**
Version	**1.0**	**Approval Details**	**24th ACM, 30.05.2018**	**LEARNING LEVEL**	**BTL-4**

ASSESSMENT SCHEME			
First Periodical Assessment	**Second Periodical Assessment**	**Practical Assessment**	**ESE**
15%	**15%**	**20%**	**50%**

Course Description	Artificial intelligence (AI) is a field that studies how to mimic the human intelligence on a computer. The goal of this course is to understand how to make a mechatronics system to learn, plan, and solve problems autonomously using AI. In this course, we will study the most fundamental knowledge for understanding AI. We will introduce some basic search algorithms for problem solving, knowledge representation and reasoning, neural networks, and scheduling.
Course Objective	The specific objectives of the Course enable the students to: 1. Provide the most fundamental knowledge to the students so that they can understand what AI is. 2. Enable the student to apply AI techniques in applications which involve perception, reasoning and learning 3. Provide a basic exposition to the goals and methods of various AI techniques
Course Outcome	Upon completion of this course, the students will be able to 1. Analyse the building block of Artificial Intelligence 2. Identify and apply proper decision-making techniques of AI in specific applications 3. Identify and apply different Searching algorithms of AI in specific applications 4. Design Neural networks for specific applications 5. Apply SLAM for automatic navigation and path planning in robotics

Prerequisites: MHB4220 – Statistics and Data Analytics

CO, PO AND PSO MAPPING

CO	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO -11	PO -12	PSO -1	PSO -2
CO-1	3	3	-	3	-	1	1	-	2	1	-	2	-	3
CO-2	3	3	3	2	3	-	-	-	2	1	-	2	2	3
CO-3	3	3	3	2	3	-	-	-	2	1	-	2	2	3
CO-4	3	3	3	2	3	-	-	-	2	1	2	2	2	3
CO-5	3	3	3	2	3	-	-	-	2	1	-	2	2	3

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1:INTRODUCTION (9L+6P)

Artificial Intelligence in Engineering – Strong and Weak AI – Intelligence in Machines – perception – cognition – execution – applications **Practical component:** Case study on Intelligent system in Engineering **Suggested Readings:** How Artificial Intelligence is transforming the world	**CO-1** **BTL-2**
MODULE 2: SEARCH	**(9L+6P)**
Artificial Intelligence in engineering – Applications – Tree search: Depth first, Breadth first, A* - Gradient Descent - Probabilistic Search **Practical component:** Apply searching algorithm for engineering applications 1. Informed search 2. Uninformed search 3. Probabilistic search **Suggested Readings:** How search engines use AI to power results	**CO-2, 3** **BTL-4**
MODULE 3: KNOWLEDGE AND REASONING	**(9L+6P)**
Adversarial search – Optimal and imperfect decisions – Alpha, Beta pruning – Logical agents **Practical component:** 1. Apply reasoning algorithm for decision making **Suggested Readings:** Representation of the world in Tesla	**CO-2, 3** **BTL-4**
MODULE 4: NEURAL NETWORKS	**(9L+6P)**
Artificial neural unit – Pattern classification – feed forward network – learning – feedback network – multi layer perceptron **Practical component:** Design Neural network for 1. Pattern classification 2. Prediction 3. Classification **Suggested Readings:** Deep Learning and Neural Networks	**CO-4** **BTL-3**
MODULE 5: SCHEDULING	**(9L+6P)**
Introduction – representation in scheduling – graphs and networks – shortest paths – critical path analysis – critical path activity scheduling **Practical component:** 1. Develop an intelligent robotic system using MATLAB **Suggested Readings:** Path planning algorithms in robots	**CO-5** **BTL-3**

TEXT BOOKS	
1.	Stuart Russel and Peter Norvig. (2003). *Artificial Intelligence: A Modern Approach*, Pearson Education, 2nd Edition.
REFERENCE BOOKS	
1.	George F.Luger. (2002). *Artificial Intelligence – Structures and Strategies for Complex Problem Solving*, Pearson Education, 4th Edition.
2.	David Allan Bradley, Derek Seward, David Dawson, Stuart Burge. (2000). *Mechatronics and the Design of Intelligent Machines and Systems*, CRC Press
E BOOKS	
1.	http://ciml.info/dl/v0_8/ciml-v0_8-all.pdf
MOOC	
1.	https://www.my-mooc.com/en/mooc/destination-ai-introduction-to-artificial-intelligence/
2.	https://www.coursera.org/learn/introduction-to-ai

COURSE TITLE	**FUNDAMENTALS OF SIGNAL PROCESSING**			**CREDITS**	**4**
COURSE CODE	**MHB4410**	**COURSE CATEGORY**	**PC**	**L-T-P-S**	**3-0-2-0**
Version	**1.0**	**Approval Details**	**24th ACM, 30.05.2018**	**LEARNING LEVEL**	**BTL-4**
ASSESSMENT SCHEME					
First Periodical Assessment	**Second Periodical Assessment**	**Practical Assessment**		**ESE**	
15%	**15%**	**20%**		**50%**	
Course Description	Signal processing focuses on analyzing, modifying, and synthesizing signals such as sound, images, and scientific measurements to improve transmission, storage efficiency and subjective quality and to also emphasize or detect components of interest in a measured signal				

Course Objective	1. Be able to describe signals mathematically and understand how to perform mathematical operations on signals. The operations should include operations on the dependent as well as independent variables. 2. Be familiar with commonly used signals such as the unit step, ramp, impulse function, sinusoidal signals and complex exponentials. 3. Be able to classify signals as continuous-time vs. discrete-time, periodic vs. non-periodic, energy signal vs. power signal, odd vs. even, conjugate symmetric vs anti-symmetric 4. Be able to compute the Fourier series or Fourier transform of a set of well-defined signals from first principles. Further, be able to use the properties of the Fourier transform to compute the Fourier transform (and its inverse) for a broader class of signals. 5. Be able to familiarize the application of Fourier transformations
Course Outcome	Upon completion of this course, the students will be able to 1. Outline the basic properties of signal & systems and the various methods of classification 2. Apply Fourier transform for Signals 3. Apply and analyse the techniques in fast Fourier transform 4. Apply the Z transform & DTFT and their properties 5. Illustrate the digital signal processing and its hardware architecture
Prerequisites:	

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	-	-	-	-	-	2	2	-	-	2	2	1
CO-2	3	3	3	3	3	-	-	2	2	-	-	2	2	1
CO-3	3	3	-	-	-	-	-	2	2	-	-	2	2	1
CO-4	3	3	-	-	-	-	-	2	2	-	-	2	2	1
CO-5	3	3	-	-	-	-	-	2	2	-	-	2	2	1

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: SIGNALS AND SYSTEMS (9L+6P)

Introduction to continuous, Discrete and Digital signals, Classification of continuous and Discrete Time signal – Periodic, Even and Odd, Energy and Power, Deterministic and Random, Complex exponential signlas, Elementary signals – UNIT step, Ramp, Impulse, Classification of systems: Linear, Time invariant, Causal, Stable, Invertible systems, BIBO Stability criterion. **Practical component:** Programs using mathematical computing tool for mathematical operations on CT, DT signals **Suggested Readings:** LTI Systems	**CO-1** **BTL-4**
MODULE 2: DISCRETE FOURIER SERIES (9L+6P)	
DFS Representation of Periodic Sequence, properties of Discrete Fourier Series. Discrete Fourier Transforms: Properties of DFT, Linear Convolution of Sequences using DFT. **Practical component:** ● Matlab program on linear convolution **Suggested Readings:** Circular Convolution	**CO-2** **BTL-4**
MODULE 3: FAST FOURIER TRANSFORMS (9L+6P)	
Fast Fourier Transforms (FFT) – Radi Decimation-in-Time and Decimation-in-Frequency FFT Algorithms, InverseFFT, and FFT with General Radix-N. **Practical component:** ● Implementing FFT algorithm in Matlab **Suggested Readings:** Application of FFT	**CO-3** **BTL-4**
MODULE 4: DISCRETE TIME SIGNALS AND Z TRANSFORM (9L+6P)	
DTFT – Properties of DTFT. Definition of Z transforms, Properties, Inverse Z transform. **Practical component:** ● Z transform to find zero pole and gain of transfer function **Suggested Readings:** Transfer function	**CO-4** **BTL-4**
MODULE 5: DIGITAL SIGNAL PROCESSOR (9L+6P)	
Introduction to Digital Signal Processing, DSP processor, architecture of DSP processors. Bus Architecture and Memory, Data Addressing Capabilities, Address Generation Unit, Programmability and Program Execution, Features for External Interfacing **Practical component:** ● Study of external interfacing with DSP processor **Suggested Readings:** Architecture & Implementation	**CO-5** **BTL-4**

TEXTBOOKS	
1.	John G. Proakis, Dimitris G. Manolakis. (2007). *Digital Signal Processing, Principles, Algorithms, and Applications*, Pearson Education / PHI.
REFERENCE BOOKS	
1	Li Tan. (2018). *Digital Signal Processing — Fundamentals and Applications —*, Elsevier – Academic Press.
2	Robert Schilling, Sandra L. Harris. (2013). Fundamentals of Digital Signal Processing using MATLAB, Cengage.
E BOOKS	
1.	http://www.fourierandwavelets.org/FSP_v1.1_2014.pdf
MOOC	
1	https://www.mooc-list.com /dsp

COURSE TITLE	ROBOTICS AND MACHINE VISION SYSTEMS LABORATORY			CREDITS	1
COURSE CODE	MHB4437	COURSE CATEGORY	PC	L-T-P-S	0-0-2-0
Version	1.0	Approval Details	24th ACM, 30.05.2018	LEARNING LEVEL	BTL - 4

ASSESSMENT SCHEME	
Continuous Internal Assessment	ESE
80%	20%

Course Description	The goal of this Laboratory course is to introduce the Modelling and Simulation of basic concepts of industrial robots and their applications in MATLAB. This course provides the basic concepts and algorithms required to develop robots that act autonomously in complex environments in MATLAB through Robotics Systems Toolbox and MOTOSIM. The main emphasis is put on robot locomotion and kinematics, and motion planning in simulation as well as in real time using MOTOMAN industrial robot. Little emphasis is given on understanding the basics of image acquisition and processing using MATLAB. The exercises of this course introduce several types of industrial robots and their modelling, kinematics and path planning in simulation as well as in real time.

Course Objective	The specific objectives of the Course enable the students to: 1. Learn the concepts of robot kinematics. 2. Learn the principles of robot drives and controls. 3. Learn methods of developing kinematic solutions for Robot configurations. 4. Learn methods of path planning for industrial robots. 5. Learn the concepts of various machine vision and image processing techniques.
Course Outcome	Upon completion of this course, the students will be able to 1. Recall the basics of Robots and elements of Industrial Robotic System. 2. Design and develop a Kinematic solution of Industrial robots and analyze its performance in Robotics System Toolbox, MATLAB as well as in real time for MOTOMAN Robot. 3. Apply methods of path planning and trajectory tracking for industrial robots and analyse its performance in Robotics System Toolbox, MATLAB. 4. Learn the concepts of basic image processing techniques for robotic applications by performing operations on digital images

Prerequisites: NIL

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	3	3	1	0	0	2	2	0	0	2	2	2
CO-2	3	3	3	3	1	0	0	2	2	0	0	2	2	3
CO-3	3	3	3	3	0	0	0	2	2	0	0	2	2	3
CO-4	3	3	3	3	0	0	0	2	2	0	0	2	2	2

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1 – ROBOTICS (18 P)

1. Build a robot using Robotics Systems Toolbox MATLAB 2. Forward Kinematics of Move Master RM 501 Robot 3. Forward Kinematics of PUMA 560 Robot 4. Inverse Kinematics of PUMA 560 Robot 5. Modelling and Simulation of a 2 D.O.F Jointed arm Robot using MATLAB – Forward Kinematics 6. Modelling and Simulation of a 3 D.O.F Jointed arm Robot using MATLAB – Forward Kinematics 7. Modelling and Simulation of a 2 D.O.F Jointed arm Robot using MATLAB – Inverse Kinematics 8. Modelling and Simulation of a 3 D.O.F Jointed arm Robot using MATLAB – Inverse Kinematics 9. 2-D Path Tracing of a Manipulator with Inverse Kinematics **Suggested Readings:** ● Forward and Inverse Kinematics of 2, 3, 4 and 5 DOF articulated robotic arm using Geometric and Analytical Method (D-H Method) ● Study of 4 D.O.F Gantry Robot in Motion Control Laboratory, Centre for Automation and Robotics, HITS. ● Study of 6 DOF Yaskawa robot and derive the kinematic solution.	**CO-1, CO-2 and CO-3 BTL- 4**
MODULE 2: INTERFACING	**(8 P)**
Real time experiments: 10. Sorting operation using MOTOSIM EG-VRC and Motoman MH Series Robot 11. Machining operation using MOTOSIM EG-VRC and Motoman MH Series Robot 12. PICK and PLACE Operation using 4 Axis GANTRY ROBOT **Suggested Readings:** ● MOVIAXIS CONTROLLER and 4 Axis GANTRY ROBOT ● ROBOT VISION USING MATLAB	**CO-2, CO-3 and CO-4 BTL-4**
MODULE 3: VISION	**(4 P)**
13. Acquiring and Basic operations on Images using MATLAB. **Suggested Readings:** ● Basic Operations on Images using MATLAB	**CO - 4 BTL - 4**
MATLAB ASSIGNMENT (SELF STUDY)	
1. Image Acquisition 2. Basic Image Processing Operations 3. Segmentation and Feature extraction 4. Object detection and Counting 5. Monocular Visual Odometry 6. Scene Change Detection 7. Motion Detection 8. Color-based object detection	**CO-4 BTL - 4**

VIRTUAL LABS
1. http://vlabs.iitkgp.ernet.in/mr/exp2/index.html 2. http://cse19-iiith.vlabs.ac.in/index.html

COURSE TITLE	NDT AND CONDITION MONITORING LAB			CREDITS	2
COURSE CODE	MHB4438	COURSE CATEGORY	PC	L-T-P-S	0-0-3-0
Version	1.0	Approval Details	24th ACM, 30.05.2018	LEARNING LEVEL	BTL-3

ASSESSMENT SCHEME	
Continuous Internal Assessment	ESE
80%	20%

Course Description	This course provides the attendee an introduction to vibration measurement and vibration measurement analysis, LPT, NDT concepts, FEMM, vibration characteristic values, time domain and spectrum analysis. The attendee will additionally familiarize oneself on guidelines, how to decide on mechanical condition of the rotating mechanical element. Practical exercises during the training complement to the theory of vibration measurement analysis.
Course Objective	The specific objectives of the Course enable the students to: 1. Impart basic knowledge and importance on Vibration Based Condition Monitoring in Engineering Fields among the students 2. Create the awareness on Vibration Based Condition Monitoring in Research and Application area 3. Know the usage of LPT and FEMM as per requirements
Course Outcome	Upon completion of this course, the students will be able to 1. Comprehend the Condition Monitoring Techniques and its interdisciplinary approach 2. Arrange the instrumentation for NDT and Condition Monitoring 3. Comprehend the standards and calibrate the instruments and Test the various defects flaws and monitor the different parameters 4. Interpret the results using different analysis methods

Prerequisites: Nil

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	2	3	2	2	2	2	3	2	2	1	3	3
CO-2	3	3	2	3	2	2	2	2	3	2	1	2	3	3

CO-3	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**3**	**3**	**2**	**1**	**3**	**3**
CO-4	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**3**	**3**	**1**	**2**	**3**	**3**

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: NON DESTRUCTIVE TESTING (30P)	
Practice in Ultrasonic Testing, Eddy Current and MPT for the detection of defects in various applications like welding, casting etc.	**CO-1-5 BTL-3**
MODULE 2: VIBRATION MONITORING (15P)	
Experiments in condition monitoring applications like shaft misalignment, bearing failure, looseness etc. 1. Condition Monitoring and Prognostics Using Vibration Signals 2. Tune PID Controller in Real Time Using Open-Loop PID Auto tuner Block 3. Fault Diagnosis of Centrifugal Pumps using Residual Analysis 4. Estimate Model Parameters and Initial States (GUI) 5. Fault Detection Using Data Based Models 6. Wind Turbine High-Speed Bearing Prognosis	**CO-1-5 BTL-3**

VLab Link	
1	http://vlabs.iitkgp.ac.in/mssp/exp6/index.html#

COURSE TITLE	**DESIGN PROJECT V**			**CREDITS**	**1**
COURSE CODE	**MHB4439**	**COURSE CATEGORY**	**PC**	**L-T-P-S**	**0-0-2-0**
Version	**1.0**	**Approval Details**	**24th ACM, 30.05.2018**	**LEARNING LEVEL**	**BTL-6**

ASSESSMENT SCHEME

First Review	**Second Review**	**Third Review**	**Project Report & Viva Voce**	**ESE**
20%	**30%**	**20%**	**30%**	**--**

Course Description	This course provides the student significant design experience and builds on the knowledge and skills acquired in earlier course work. This course provides an exposure to teamwork to emulate a typical professional design environment. Simulations are to be used both in the execution of the design methodology and the management of the design project.

Course Objective	The specific objectives of the Course enable the students to: 1. To develop skills in doing literature survey, technical presentation and report preparation. 2. To enable project identification and execution of preliminary works on 3. To enable students to work as team 4. To enable students to work on development of hardware
Course Outcome	Upon completion of this course, the students will be able to 1. To identify a problem, do survey, develop methodology and do the simulations and use them for major project 2. Prepare technical drawing, technical report and technicalpresentation

Prerequisites:

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	2	2	3	2	2	3	3	3	3	3	3	3
CO-2	3	3	2	2	3	2	2	3	3	3	3	3	3	3

1: Weakly related, 2: Moderately related and 3: Strongly related

NOTE

1	The students in convenient groups of not more than 4 members have to identify a product for design and fabrication. Every project work shall have a guide who is the member of the faculty of the institution.
2	To develop a mechatronic system with emphasis on electrical drives (Actuator) for different applications/Systems.
3	The students are required to design and fabricate the chosen system and demonstrate its working apart from submitting the project report. The report should contain assembly drawing, parts drawings, process charts relating to fabrication.

SEMESTER VIII

COURSE TITLE	PROJECT			CREDITS	8
COURSE CODE	MHB4448	COURSE CATEGORY	PC	L-T-P-S	0-0-24-0
Version	1.0	Approval Details	24th ACM, 30.05.2018	LEARNING LEVEL	BTL-6
ASSESSMENT SCHEME					
First Review	Second Review	Third Review, Project Report and Viva			ESE

20%	30%	30%	20%

Course Description	This course provides the student significant design experience and builds on the knowledge and skills acquired in earlier course work. This course provides an exposure to teamwork to emulate a typical professional design environment. Simulations are to be used both in the execution of the design methodology and the management of the design project.
Course Objective	The specific objectives of the Course enable the students to: 1. Design and fabricate a mechatronics system / conduct experimental investigations 2. Prepare technical drawing, technical report and acquire project management skills
Course Outcome	Upon completion of this course, the students will be able to 1. Design and fabricate a mechatronic system /Conduct experimental investigations 2. Modelling and simulation study of engineering systems/problem.
Prerequisites:	

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	3	2	3	2	2	3	3	3	3	3	2	3
CO-2	3	3	3	2	3	2	2	3	3	3	3	3	2	3

1: Weakly related, 2: Moderately related and 3: Strongly related

NOTE

1	The students in convenient groups of not more than 4 members have to identify a product/process for design and fabrication or experimental study. Every project work shall have a guide who is the member of the faculty of the institution.
2	Students will be exposed to lecture modules on Project and Thesis work followed by assignment of individual projects involving designing a mechatronics system for a real time problem with societal impact.
3	The students are required to design and fabricate/ conduct experiments and demonstrate its working apart from submitting the project report. The report should contain assembly drawing, parts drawings, process charts, programming, modelling and simulation, analysis relating to the project.

DEPARTMENTAL ELECTIVES – SEMESTER III

COURSE TITLE	BASICS OF ROBOTICS			CREDITS	3
COURSE CODE	MHC4251	COURSE CATEGORY	DE	L-T-P-S	3-0-0-1
Version	1.0	Approval Details	24th ACM, 30.05.2018	LEARNING LEVEL	BTL - 3

ASSESSMENT SCHEME

First Periodical Assessment	Second Periodical Assessment	Seminar/ Assignments/ Project	Surprise Test / Quiz	Attendance	ESE
15%	15%	10%	5%	5%	50%

Course Description	Robotics is an interdisciplinary branch of engineering and science that deals with the design, construction, operation, and use of robots, as well as computer systems for their control, sensory feedback, and information processing. The goal of this course is to introduce the basic concepts of industrial robots and their applications. This course provides the basic concepts, key elements and algorithms required to develop robots that act autonomously in complex environments. The main emphasis is on introducing various configuration of robots, its key elements such as sensors, actuators, and programming etc. Moderate emphasis is given on developing forward kinematic solution for robots used for various industrial applications. The lectures and exercises of this course introduce several types of industrial robots and their modelling, basics of kinematics along with their applications.
Course Objective	The specific objectives of the Course enable the students to understand: 1. The different robotic configurations, classification of end effectors, sensing and actuation. 2. The robotic drive systems and mechanical transmission methods. 3. Underlying principle and applications of various grippers and its design. 4. The Kinematics and dynamics of Robot. 5. Safety considerations of the robot and Applications of robot for material transfer, welding, assembly, Spray painting etc.
Course Outcome	Upon completion of this course, the students will be able to 1. Recall and identify the parts of robots, its configurations, D.O.F of Robots. 2. Illustrate and discuss the various drives and power transmission system in the design of robots. 3. Classify various end effectors and appraise the design of grippers. 4. Recall, Infer, Interpret and Develop Kinematic solutions for robots. 5. Discuss the various applications of robots, justification, and implementation of robots.

Prerequisites: Nil

CO, PO AND PSO MAPPING														
CO	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PO-7**	**PO-8**	**PO-9**	**PO-10**	**PO-11**	**PO-12**	**PSO-1**	**PSO-2**
CO-1	**3**	**3**	**3**	**3**	**1**	**2**	**2**	**1**	**1**	**1**	**1**	**2**	**2**	**2**
CO-2	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**2**	**2**	**2**
CO-3	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**2**	**2**	**2**
CO-4	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	**2**	**2**	**2**
CO-5	**3**	**3**	**3**	**3**	**1**	**2**	**2**	**1**	**1**	**1**	**1**	**2**	**2**	**2**
1: Weakly related, 2: Moderately related and 3: Strongly related														

MODULE 1: INTRODUCTION TO ROBOTICS (9L)	
An overview of Robotics — classification by coordinate system and control systems-Components of the Industrial Robotics: Degrees of freedom — End effectors: Mechanical gripper — Magnetic —Vacuum cup and other types of grippers —General consideration on gripper selection and design, Robot actuator and sensors. **Suggested Readings:** Model different configurations of robots using various joints and study its workspace, work volume and D.O.F.	**CO-1** **BTL-3**
MODULE 2 :ROBOT DRIVES AND POWER TRANSMISSION SYSTEMS (9L)	
Robot drive mechanisms, hydraulic – electric – servomotor- stepper motor – pneumatic drives, Mechanical transmission method - Gear transmission, Belt drives, cables, Roller chains, Link – Rod systems – Rotary-to-Rotary motion conversion, Rotary-to-Linear motion conversion, Rack and Pinion drives, Lead screws, Ball Bearing screws. **Suggested Readings:** Various Actuators used for design of robotic configurations.	**CO-2** **BTL - 4**
MODULE 3 : ROBOT END EFFECTORS (7L)	
Classification of End effectors – Tools as end effectors. Drive system for grippers-Mechanical Adhesive-Vacuum-Magnetic - Grippers, Hooks scoops. Gripper force analysis and gripper design. Active and passive grippers. **Suggested Readings:** ● Study of Grasping Modes, Forces, and Stability ● Ultrasonic, Optomechanical and Smart Tactile Sensors for gripper design.	**CO - 3** **BTL - 3**
MODULE 4 : ROBOT KINEMATICS AND DYNAMICS (11L)	

Positions, Orientations and frames, Mappings: Changing descriptions from frame to frame, Operators: Translations, Rotations and Transformations – Transformation Arithmetic – Forward and inverse Kinematics of Six Degree of Freedom Robot Arm **Suggested Readings:** ● Derive forward and Inverse kinematic solutions of 2 and 3 DOF robotic arm. ● Derive FK and IK solution for the 4 D.O.F GANTRY Robot ● Study of six axis YASKAWA robot.	**CO-4 BTL-3**
MODULE 5: APPLICATIONS OF ROBOTS (9L)	
Industrial Applications of Robots for material transfer, machine loading / unloading, welding, assembly and spray-painting operation. RGV, AGV, Implementation of Robots in Industries – Various Steps; Safety Considerations for Robot Operations **Suggested Readings:** ● Design and Development of AGV for industrial transportation	**CO-5 BTL-3**
TEXTBOOKS	
1.	Deb S. R. and Deb S. (2017). *Robotics Technology and Flexible Automation*, 2nd edition, Tata McGraw Hill Education Pvt.Ltd,.
2.	Mikell P. Groover, Mitchel Weiss, Roger N Nagel, Nicholas G Odrey, Ashish Dutta. (2017). *Industrial Robotics: Technology, Programming, and Applications*, 2nd edition, 12th Reprint, McGraw-Hill Companies.
REFERENCE BOOKS	
1.	Saeed B. Niku. (2019). *Introduction to Robotics: Analysis, Systems, Applications*, 3rd edition., Wiley.,
2.	K.S. Fu, R.C. Gonzalez, C.S.G Lee. (2017). *Robotics, Control, Sensing, Vision and Intelligence*, McGraw-Hill Education.
E BOOKS	
1.	http://wiki.ros.org/Events/ICRA2010Tutorial
MOOC	
1.	https://www.coursera.org/specializations/modernrobotics
2.	https://nptel.ac.in/courses/107/106/107106090/

COURSE TITLE	**MECHATRONICS SYSTEM APPLICATIONS**			**CREDITS**	**3**
COURSE CODE	**MHB4252**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3-0-0-1**
Version	**1.0**	**Approval Details**	**24th ACM, 30.05.2018**	**LEARNING LEVEL**	**BTL-4**
ASSESSMENT SCHEME					
First Periodical Assessment	**Second Periodical Assessment**	**Seminar/ Assignments/ Project**	**Surprise Test / Quiz**	**Attendance**	**ESE**

15%	15%	10%	5%	5%	50%

Course Description	In the Mechatronics system application students will be trained to develop, assemble, maintain and optimize products, systems, machines, installations or industrial processes integrating different functions and making use of different mechanical, electronic or automation tools.
Course Objective	The specific objectives of the Course enable the students to understand: 1. The key elements of Mechatronics system, representation into block diagram 2. The concept of transfer function, reduction and analysis 3. The principles of sensors, its characteristics, interfacing with DAQ microcontroller 4. The concept of PLC system and its ladder programming, and significance of PLC systems in industrial application 5. The system modeling and analysis in time domain and frequency domain. 6. The control actions such as Proportional, derivative and integral and study its significance in industrial applications
Course Outcome	Upon completion of this course, the students will be able to 1. Recall the modern mechatronics components. 2. Comprehend the principles and alternatives for mechatronics systems design 3. Apply the elements of mechatronics systems for various applications. 4. Analyze the system for the given mechatronics problem. 5. Evaluate the various applications of mechatronics systems, justification, and implementation of mechatronics system.

Prerequisites: Nil

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	3	3	3	3	3	3	3	3	2	2	3	2
CO-2	3	3	3	3	3	2	2	3	3	2	3	3	3	2
CO-3	3	3	3	3	3	3	3	3	2	2	3	3	3	2
CO-4	3	3	3	3	3	3	3	3	3	3	3	3	3	2
CO-5	3	3	3	3	3	3	3	3	3	3	3	3	3	2

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: INTRODUCTION (9L)

Introduction to basics mechatronics components - Sensors, Actuators, Micro-controllers, PLC's. **Suggested reading:** Read on how AI can be improved for our future upcoming Chandrayaan-3	**CO-1** **BTL-2**
MODULE 2: BIOMIMICRY USING MECHATRONICS (9L)	
Biomimicry – Introduction, Concept, Advantages. Bio-Inspired Robots – Mechanisms, Controls, Actuations. Case Studies - Wall-Climbing Caterpillar Robot, Hexapedal robot inspired by cockroach locomotion. **Suggested reading:** Read on the topic of heat-seeking missiles used in our Indian Air force	**CO-2** **BTL-2**
MODULE 3: MEDICAL APPLICATIONS (9L)	
Introduction to mechatronics for medical applications, Importance of Mechatronics in Medical Applications, Applications of Mechatronics in Medicine - Robotics in Medicine, Smart Instruments and Probes. Case Studies - Handheld Snake-Like Robots, 3D Printed Skull. **Suggested reading:** Read on the difference mechatronics application used in Chandrayaan-2 vs Chang'e 5-T1	**CO-3** **BTL-3**
MODULE 4: SAFETY, SECURITY AND DEFENCE APPLICATIONS (9L)	
Industrial safety systems, Smart security systems, Mechatronics in defence, Artificial Intelligence in security systems. Case Studies: Cobots (Collaborative Robots), Smart Doors, Heat-seeking missiles. **Suggested reading**: Read on the hexahedral robot which has been inspired by cockroach	**CO-4** **BTL-3**
MODULE 5: MANUFACTURING APPLICATIONS	**(9L)**
Introduction to manufacturing systems, Retrofitting, CNC machines, Rapid Prototyping, Industrial Robots. Case Studies – Laser cutting, Quality inspecting robots. **Suggested reading:** Read on EMG and EEG is recorded from patients for health diagnosis	**CO-5** **BTL-4**

TEXT BOOKS

1.	W Bolton. (2011). *Mechatronics*, Pearson Education, Fourth Edition

REFERENCE BOOKS

1	SiamakNajarian, JavadDargahi, Ph.D.,GoldisDarbemamieh, SiamakHajizadehFarkoush. (2012), *Mechatronics in Medicine: A Biomedical Engineering Approach*,McGraw-Hill Education.

2	David G. Alciatore& Michael B Histand.(2003). *Introduction to Mechatronics and Measurement systems*, Tata McGraw Hill.
E BOOKS	
1.	http://www.springer.com/in/book/9783642175305
MOOC	
1	www.mooc-list.com/course/me209x-thermodynamics-edx
2	www.class-central.com/tag/thermodynamics

COURSE TITLE	**MOBILE ROBOTS**			**CREDITS**	**3**
COURSE CODE	**MHC4253**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3-0-0-1**
Version	**1.0**	**Approval Details**	**24th ACM, 30.05.2018**	**LEARNING LEVEL**	**BTL-4 (ANALYZE)**
ASSESSMENT SCHEME					
First Periodical Assessment	**Second Periodical Assessment**	**Seminar/ Assignments/ Project**	**Surprise Test / Quiz**	**Attendance**	**ESE**
15%	**15%**	**10%**	**5%**	**5%**	**50%**
Course Description	Mobile Robot is an autonomous navigating device that can maneuver and reach the target in an environment. The autonomous robots are applied in many fields viz healthcare, industry, and environmental monitoring. The application of mobile robot requires a basic skill like the robot mechanisms, electronic circuits and array of sensors. A basic knowledge on sensor characteristics and selection of sensor for variety of applications. Fundamental programming knowledge of robots with Python and C language and to design the sensors interface to the controllers. Autonomous navigation of mobile robots with the help of Image based sensors, mapping and localisation of robots by various algorithms to avoid obstacles and find the optimal path for reaching the target location. Design and developing mobile robots for various applications by selecting sensors, navigation techniques and suitable controllers for the effective implementation is focused here.				

Course Objective	The course will enable the students to understand the: 1. Term of mobile robots and appreciate its use in industries 2. Working principle of the knowledge on sensors and actuators for robot applications 3. Apply vision based navigation in mobile robots 4. Various system integration for mobile robots 5. Learn the applications of mobile robots
Course Outcome	Upon completion of this course, the students will be able to 1. Recall the fundamentals of mobile robots 2. Apply knowledge on sensors and actuators for robot applications 3. Apply vision-based navigation in mobile robots 4. Perform system integration for mobile robots 5. Build Mobile Robots for specific applications

Prerequisites: Nil

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	3	2	2	-	-	-	-	-	1	1	2	3
CO-2	3	3	3	3	2	2	2	1	1	1	1	2	2	3
CO-3	3	3	3	3	2	2	2	1	1	1	1	2	2	3
CO-4	3	3	3	3	2	2	2	1	1	1	1	2	2	3
CO-5	3	3	3	3	2	2	2	1	1	1	1	2	2	3

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1 – INTRODUCTION
(9L)

Introduction to mobile Robots – Laws of Robots – Robot Anatomy – Basic Mechanics of Robots – Basic Electronics for Robots, Companion Robots – Robots for Agriculture Applications – Space Robots – Defense Robots. **Suggested reading:** Study of mechanical and electrical quantities in robot application Case study of mobile robots in various domains	**CO-1** **BTL-1,2**

MODULE 2 – SENSORS AND ACTUATORS
(9L)

Sensors for mobile robots – Sensor Characteristics – Classification of Sensors – Electric Actuators – DC Motors – Servo motor, stepper motor – Linear Actuators – Encoders – Motor Drives. **Suggested reading:** Study of calibration of sensors Study of electrical drives and controllers	**CO-2** **BTL-1,2**
MODULE 3 – VISION AND NAVIGATION (9L)	
Image Acquisition – Obstacle Detection and Avoidance – Localization – Path Planning Methods – Monte Carlo Methods. **Suggested reading:** Study of optimization algorithm for navigation Study of localization algorithm.	**CO-3** **BTL-2,3**
MODULE 4 – PROGRAMMING AND INTERFACING (9L)	
Robot Programming using Python – Basic Embedded C Programming for Robots – Data Acquisition – Interfacing Sensors and Actuators with Robot Controller – Program for Interfacing. **Suggested reading:** Study of interfacing programming of sensors and actuators Study of python programming for interfacing	**CO-4** **BTL-3,4**
MODULE 5 – BUILDING OF MOBILE ROBOTS (9L)	
Building of various types of mobile robots – Use of various Sensing methods, Navigation and Vision-Demonstration and Exercises **Suggested reading:** Study of sensing methods in mobile robots Study of mobile robots for variable applications	**CO-5** **BTL-3,4**
LAB / MINI PROJECT / FIELD WORK	
1. Design and develop a mobile robot for a specific application	
TEXT BOOKS	
1.	Ulrich Nehmzow. (2003). *Mobile Robots - A practical introduction*, Springer, second edition.
2.	S.R. DEB, S. DEB. (2011). *Robotics Technology and Flexible Automation*, McGraw-Hill, 2nd Edition
3.	Mikell P. Groover, Roger N. Nagel (2012). *Industrial Robotics: Technology, Programming, and Applications*, McGraw-Hill Companies. .
REFERENCE BOOKS	
1.	Woo-Kyung Choi, Hong-Tae Jeon, Seong-Joo Kim. (2007). *Multiple Sensor Fusion and Motion Control of Snake Robot Based on Soft-Computing*, INTECH Open Access Publisher.

2.	S.R. DEB, S. DEB. (2011). *Robotics Technology and Flexible Automation*, Mc-GrawHill, 2nd Edition.
3.	Katsuhiko Ogata. (2011). *Modern Control Engineering*, Pearson Education.
E BOOKS	
1.	http://home.deib.polimi.it/gini/robot/docs/siegwart.pdf
2.	https://mitpress.mit.edu/books/introduction-autonomous-mobile-robots
MOOC	
1.	https://www.coursera.org/learn/mobile-robot
2.	https://www.open2study.com/courses/mobile-robotics

DEPARTMENTAL ELECTIVES – SEMESTER IV

COURSE TITLE	**INDUSTRIAL ROBOTS**			**CREDITS**	**3**
COURSE CODE	**MHC4266**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3-0-0-1**
Version	**1.0**	**Approval Details**	**24th ACM, 30.05.2018**	**LEARNING LEVEL**	**BTL-3**

ASSESSMENT SCHEME					
First Periodical Assessment	**Second Periodical Assessment**	**Seminar/ Assignments/ Project**	**Surprise Test / Quiz**	**Attendance**	**ESE**
15%	**15%**	**10%**	**5%**	**5%**	**50%**

Course Description	The course is aimed at providing concepts and skills in the industrial automation domain related to mechatronics, robotics, electrical machines and drives. Students will learn, in the first module, fundamental concepts and methodologies for understanding and modelling mechatronic systems and industrial robots; then, they will acquire fundamental knowledge and competences on how to simulate and program industrial robots. In the second module the course discusses the theoretical basis and the practical applications of the electrical drives technology applied to automation and mechatronic systems. At first, the theory of electrical motors (actuators) is introduced. Then, the drive system is analyzed considering all of its components and the various control strategies that can be adopted. Emphasis is given to practical applications, especially considering the advantages achievable with the latest technologies.

Course Objective	The specific objectives of the Course enable the students to: 1. Recognize the basics of robots. 2. Calculate kinematics of industrial robots. 3. Identify actuators and sensors used in industrial robots 4. Create industrial robot programming 5. Discuss about various applications in industries
Course Outcome	Upon completion of this course, the students will be able to 1. Comprehend the basics of robots. 2. Derive the kinematics of robots. 3. Identify actuators and sensors used in industrial robots. 4. Apply industrial robot programming. 5. Describe applications of industrial robots

Prerequisites: Nil

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	2	2	1	-	-	-	-	1	-	1	2	2
CO-2	3	3	2	2	1	-	-	-	1	1	-	-	2	2
CO-3	3	3	2	2	2	-	-	-	1	1	-	-	2	2
CO-4	3	3	2	2	2	-	-	-	1	1	-	-	3	3
CO-5	2	2	3	2	2	-	-	-	-	-	-	-	3	3

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1:INTRODUCTION	**9L**
History of Robots – Robot Anatomy – Robot Configurations – Work Volume – Robot Safety. **Suggested Readings:** History of Robots	**CO-1** **BTL-3**

MODULE 2: KINEMATICS **9L**	
Robot Transformations – Rotation Matrix – Forward and Inverse Kinematics – DH Representation **Suggested Readings:** Study of forward and inverse geometrics	**CO-2** **BTL-3**

MODULE 3: DRIVES, ACTUATORS SENSORS AND END EFFECTORS 9L	
Functions of Drive Systems – AC, DC Motors – Pneumatic and Hydraulic Actuators – Selection of Sensors – Classification of Sensors – Data Acquisition – Mechanical, Vacuum and Adhesive Grippers. **Suggested Readings:** Balancing of Simple mechanisms	**CO-3** **BTL-2**
MODULE 4: ROBOT LANGUAGES AND PROGRAMMING 9L	
Robot Languages – Classification of Languages –VAL II- Motosim, Computer Control and Robot Software. **Suggested Readings:** Robot languages	**CO-4** **BTL-2**
MODULE 5: APPLICATIONS 9L	
Robot Applications – Welding, Palletizing, Deburring, Assembly- Hands on training in material handling and processing applications, recent trends in industrial robots- Building of grippers – Exercises **Suggested Readings:** Study of Robots applications in industries	**CO-5** **BTL-3**

TEXT BOOKS	
1.	Mikell P. Groover, Roger N. Nagel. (2012). *Industrial Robotics: Technology, Programming, and Applications*, McGraw-Hill Companies.
2.	Rao. P.N. (2003). *Manufacturing Technology - Metal Cutting and Machine Tools*, Tata McGraw-Hill.
REFERENCE BOOKS	
1.	S.R. DEB, S. DEB. (2011*). Robotics Technology and Flexible Automation*, Mc-GrawHill, 2nd Edition, 2011.
2.	Roy. A.Lindberg. (2006). *Process and Materials of Manufacture,* Fourth Edition, PHI/Pearson Education.
3.	Edquist. (1988). *Flexible Automation: The Global Diffusion of New Technology*, Wiley-Blackwell.
E BOOKS	
1.	http://onlinelibrary.wiley.com/book/10.1002/9780470172506
MOOC	
1.	https://www.coursera.org/specializations/robotics

COURSE TITLE	MACHINING TECHNOLOGY	CREDITS	3

COURSE CODE	MHC4267	COURSE CATEGORY	DE	L-T-P-S	3-0-0-1
Version	1.0	Approval Details	23 ACM, 06.02.2021	LEARNING LEVEL	BTL-4

ASSESSMENT SCHEME

First Periodical Assessment	Second Periodical Assessment	Seminar/ Assignments/ Project	Surprise Test / Quiz	Attendance	ESE
15%	15%	10%	5%	5%	50%

Course Description	Machining is a process in which a material (often metal) is cut to a desired final shape and size by a controlled material-removal process. Machining is a part of the manufacture of many metal products, but it can also be used on other materials such as wood, plastic, ceramic, and composite material.
Course Objective	**The specific objectives of the Course enable the students to** 1. Comprehend the metal cutting theories and concepts 2. Present various turning machining methods 3. Familiarize different finishing operations. 4. Describe non-traditional methods and show their superiority of process. 5. Describe the Laser and Plasma arc machining.
Course Outcome	**Upon completion of this course, the students will be able to:** 1. Comprehend the fundamental concepts of metal cutting. 2. Select the machining methods. 3. Describe turning and finishing operations. 4. Comprehend the different types of non-traditional machining, operation and its characteristics. 5. Describe the operation of Laser beam & plasma arc machining.

Prerequisites: NIL

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	2	3	2	1	1	1	1	2	1	-	1	3	2
CO-2	3	2	3	2	1	1	1	1	2	1	-	1	3	2
CO-3	3	2	3	2	1	1	1	1	2	1	-	1	3	2
CO-4	3	2	3	2	1	1	1	1	2	1	-	1	3	2
CO-5	3	2	3	2	1	1	1	1	2	1	-	1	3	2

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: THEORY OF METAL CUTTING	9L
Mechanics of chip formation, single point cutting tool, forces in machining, Types of chip, cutting tools – nomenclature, orthogonal metal cutting, thermal aspects, cutting tool materials, tool wear, tool life, surface finish, cutting fluids and Machinability. **Suggested Readings** Advances in Theory Of Metal Cutting	**CO-1** **BTL-4**
MODULE 2:TURNING MACHINES	**9L**
Centre lathe, constructional features, specification, operations – taper turning methods, thread cutting methods, special attachments, machining time and power estimation. Capstan and turret lathes- tool layout – automatic lathes: semi-automatic – single spindle : Swiss type, automatic screw type – multi spindle **Suggested Readings:** Advances in Turning Machines	**CO-2** **BTL-2**
MODULE 3: ABRASIVE PROCESS AND BROACHING	**9L**
Abrasive processes: grinding wheel – specifications and selection, types of grinding process– cylindrical grinding, surface grinding, centreless grinding and internal grinding- Typical applications – concepts of surface integrity, broaching machines: broach construction – push, pull, surface and continuous broaching machines **Suggested Readings:** Best practices for Abrasive Process and Broaching	**CO-3** **BTL-2**
MODULE 4 :NON-TRADITIONAL MACHINING	**9L**
Introduction, need, Abrasive Jet Machining , Parametric Analysis, Process capabilities, Ultrasonic Machining –Mechanics of cutting, models, Parametric Analysis. Water Jet Machining –principle, equipment ,process characteristics , performance, EDM – principles, equipment, generators, analysis of R-C circuits, MRR , Surface finish, WEDM. **Suggested Readings:** Evolution of Non-Traditional Machining	**CO-4** **BTL-3**
MODULE 5: LASER BEAM & PLASMA ARC MACHINING	**9L**
Laser Beam Machining – Principle of working, equipment, Material removal rate, Process parameters, performance characterization, Applications. Plasma Arc Machining – Principle of working, equipment, Material removal rate, Process parameters, performance characterization, Applications **Suggested Readings:** Next-generation LASER BEAM & PLASMA ARC Techniques.	**CO-5** **BTL-4**

TEXT BOOKS	
1.	H.A. Taha (2003). *Operations Research - An Introduction*, Prentice Hall of India./Pearson Education

2.	J.K. Sharma(2006). *Operations Research*, Macmillan
REFERENCE BOOKS	
1.	F S Hiller and G J Leiberman(2000), *Introduction to Operations Research*
2.	Gupta Prem Kumar and Hira D S (2010).*Operations Research*
MOOC	
1	https://onlinecourses.nptel.ac.in/noc17_mg10/preview

COURSE TITLE	**APPLIED PNEUMATICS FOR INDUSTRIAL AUTOMATION**			**CREDITS**	**3**
COURSE CODE	**MHC4268**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3-0-0-1**
Version	**1.0**	**Approval Details**	**24th ACM, 30.05.2018**	**LEARNING LEVEL**	**BTL-3**
ASSESSMENT SCHEME					
First Periodical Assessment	**Second Periodical Assessment**	**Seminar/ Assignments/ Project**	**Surprise Test / Quiz**	**Attendance**	**ESE**
15%	**15%**	**10%**	**5%**	**5%**	**50%**
Course Description	This course covers how work, force and energy are applied to principles of pneumatics. It shows operating principles of reciprocating, positive displacement, rotary and dynamic air compressors. It covers primary and secondary treatment which includes valves, logic devices, cylinders and air motors. A centrally located and electrically powered compressor, power cylinders, air motors and other pneumatic devices. A pneumatic system controlled through manual or automatic solenoid values is selected when it provides a lower cost, more flexible or safer alternative to electric motors and actuators.				
Course Objective	**The course should enable the student to,** 1. Learn the concepts of governing equations of fluid power 2. Learn the operation of simple circuits 3. Learn development of the electro pneumatic circuits 4. Learn the fundamentals of PLC and its elements 5. Learn about the low cost automation and troubleshoots				

Course Outcome	**Upon completion of this course, the students will be able to** 1. Infer the fundamental theoretical concepts of governing fluid power 2. Interpret the operation of basic circuits for directional, speed, pressure, and force and flow control. 3. Develop the electro pneumatic circuits for controlling multi cylinders 4. Comprehend the fundamentals of PLC and other elements 5. Appraise low cost automation and troubleshoots.

Prerequisites: NIL

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	-	-	2	-	-	-	-	-	-	2	2	0
CO-2	3	3	-	-	2	-	-	-	-	-	-	2	2	0
CO-3	3	3	-	-	2	-	-	-	-	-	-	2	2	0
CO-4	3	3	-	-	-	-	-	-	-	-	-	2	2	0
CO-5	3	3	-	-	-	-	-	-	-	-	-	2	2	0

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: INTRODUCTION (9L)

Merits of Fluid power & its utility for increasing productivity through Low Cost Automation, Transmission of Fluid Power through various types of Cylinders, Symbolic representation of Pneumatic elements, Compressors and Air supply and conditioning system including airline installations,Distribution System - ring rails systems Suggested Readings: Basic components of Pneumatic power systems and component descriptions	**CO-1 BTL-1, 2**

MODULE 2: BASIC PNEUMATIC CIRCUITS (9L)

Pneumatic control elements (control valves & remote control system), Basic pneumatic circuits for controlling single & double acting cylinder, Basic pneumatic circuits, advanced pneumatic circuits forcontrolling multi cylinders- Simulation -Autosim **Suggested Readings:** Development of automatic pneumatic cylinder reciprocating system	**CO-2 BTL-1,2,3**

MODULE 3: ADVANCED PNEUMATIC CIRCUITS (9L)	
Advanced pneumatic circuits for controlling multicylinders, Electro pneumatics with relay logic,Pneumatics system with PID controls, Simulation -Autosim **Suggested Readings:** Design of Pneumatic Logic circuits by Cascade method	**CO-3 BTL-2, 3,5**
MODULE 4: PROGRAMMABLE LOGIC CONTROLLERS (9L)	
Programmable logic controllers, introduction, architecture hardware. Components basics of PLC programming –Programming timers counters-master and jump controls-data manipulations and instructions, Programmable sequential control using pneumatic modular elements **Suggested Readings:** **PLC applications in Fluid power control**	**CO-4 BTL-1,2,3**
MODULE 5: LOW COST AUTOMATION (9L)	
Low cost Automation using pneumatics, FMS – Assembly, disassembly, inspection and fault diagnosis,Maintenance of pneumatics systems **Suggested Readings:** **Fault finding using Troubleshooting charts**	**CO-5 BTL-1,2, 3**

TEXTBOOKS	
1.	Anthony Esposito, Fluid Power with application, Prentice Hall, 2013
REFERENCE BOOKS	
1.	MajumdarS.R.,OilHydraulics,Tata McGraw-Hill, New Delhi 2009
2.	Anderson, J.D., "Modern Compressible flow", 3rd Edition, McGraw Hill, 2003
3.	A text book of Basic Pneumatics, SMC Pneumatics, 2012
4.	A text book of Electro Pneumatics, SMC Pneumatics, 2012
5.	Harry StevartD.B,Practical guide to fluid power, Taraoealasons and Port Ltd. Broadey,1976
6.	Michael J, Prinches and Ashby J. G, Power Hydraulics, Prentice Hall, 1989
E BOOKS	
1.	https://www.powermotiontech.com/learning-resources/ebooks
MOOC	
1.	https://www.mooc-list.com/course/hydraulics&pneumatics
2.	https://nptel.ac.in/courses/112/105/112105046/

COURSE TITLE	PRODUCT DEVELOPMENT			CREDITS	3
COURSE CODE	MHC4269	COURSE CATEGORY	DE	L-T-P-S	3-0-0-1
Version	1.0	Approval Details	24th ACM, 30.05.2018	LEARNING LEVEL	BTL- 4
ASSESSMENT SCHEME					
First Periodical Assessment	Second Periodical Assessment	Seminar/ Assignments/ Project	Surprise Test / Quiz	Attendance	ESE
15%	15%	10%	5%	5%	50%

Course Description	This course immerses students in the new product development process with the objective of learning modern key tools, techniques and methods. This course will help them to gain thorough understanding in the entire new product development process from consumer need identification, product ideation, concept development, concept evaluation, product design to marketing of any product. Since every industry develop new products in order to be successful in the business market this course is important for the students to be familiar and use latest technology tools for designing any product and efficiently handle whole project management cycle.
Course Objective	**The course should enable the student to,** 1. Learn terms in the new product development process. 2. Learn how to integrate the customer and end-consumer into this process. 3. Learn and apply the concepts and tools necessary through case examples and assignments. 4. Use the new product development process by conceiving your own new product or service and an introductory launch plan. 5. Participate in group work sessions and teams to become acquainted with the importance of teamwork and collaboration that is critical to new product success.
Course Outcome	**Upon completion of this course, the students will be able to** 1. Describe the nature and techniques of new product development process 2. Discuss the market opportunities, develop an understanding of customer and user needs, and assess the competitive landscape 3. Competent with a set of tools and methods for product design and development. 4. Demonstrate the best level of practice in each problem situation within the context of innovation and new product development 5. Work collaboratively on a team to successfully complete a design project and to effectively communicate the results of projects and other assignments in a written and oral format

Prerequisites: NIL

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	1	1	-	2	-	-	-	1	-	-	1	2
CO-2	3	3	2	1	-	2	1	-	-	1	-	2	1	2
CO-3	3	3	2	2	3	2	-	-	-	1	-	2	1	2
CO-4	3	3	3	3	3	2	1	-	-	1	-	2	1	2
CO-5	3	3	3	3	1	2	0	2	2	1	2	2	1	2

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: INTRODUCTION (9L)

Research and new product development –Need for developing new products -relevance of product lifecycle issues in design-Generic New Product Development Process- Intellectual property rights (IPR)-Patents - Patent search - Patent laws - International code for patents.

Suggested Readings: Intellectual property rights(IPR), patent laws

CO-1
BTL-2

MODULE 2: CONSUMERS AND OPPORTUNITIES (9L)

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

Suggested Readings: Customer need gathering methods

CO-2
BTL- 3

MODULE 3: NEW PRODUCT DEVELOPMENT PROCESS – I (9L)

Idea generation- Collection of ideas and purpose of project - Selection criteria - screening ideas for new products - Principal, Point Forward Developing and Selecting Product Concepts- concept development- Concept evaluation techniques.

Suggested Readings: Concept development and evaluation techniques

CO-3
BTL-3

MODULE 4: NEW PRODUCT DEVELOPMENT PROCESS – II (9L)

Design process- Different stages in design and their significance - Design detailing- Material selection, Design visualization- Solid modeling; Detailed 2D drawings; Tolerance; Use of standard items in design; Research needs in design- Designing and branding a product. Selecting a brand name, packaging

Suggested Readings: Designing and branding a product

CO-4
BTL-4

MODULE 5: STRATEGIC MARKETING (9L)

Sales Forecasting and Financial Analysis- Marketing Plan-Secrets of New Product Success- Strategic Launch Planning -Implementation of the Strategic Plan-Cases Examples of New Innovative Product Forecasting Before Launching- Open innovation; User innovation; Crowd sourcing; Free innovation-Continuous innovation and creating a culture of innovation **PROJECT:** Creative design - Model Preparation - Testing - cost evaluation **Suggested Readings:** Sales forecasting and financial analysis	**CO-5** **BTL-3**
TEXTBOOKS	
1.	Anita Goyal, Karl T Ulrich, Steven D Eppinger. (2009). *Product Design and Development*, 4th Edition, Tata McGraw-Hill Education, ISBN-10-007-14679-9
REFERENCE BOOKS	
1.	Isaacson, Walter. (2014). *The Innovators: How a Group of Hackers, Geniuses, and Geeks Created the Digital Revolution*, Simon and Schuster, New York, NY.
2.	Gladwell, Malcolm. (2000). *The Tipping Point: How Little Things Can Make a Big Difference*, Little, Brown, and Co.: New York, NY.
3.	Norman, Donald A. (2004). *Emotional Design: Why We Love (or Hate) Everyday Things*, Basic Books: New York, NY.
4.	Christensen, Clayton M. (1997). The Innovator's Dilemma, Harper Collins: New York, NY.
5.	Urban, Glen L. and John R. Hauser. (1993). *Design and Marketing of New Products,* Revised Edition, Prentice-Hall, Inc.: Englewood Cliffs, NJ.
6.	Moore, Geoffrey. (1991). *Crossing the Chasm*, Harper Collins Publishers, New York.
E BOOKS	
1.	https://www.designbetter.co/principles-of-product-design
MOOC	
1.	https://www.coursera.org/learn/new-product-development
2.	https://www.edx.org/course/new-product-development

DEPARTMENTAL ELECTIVES – SEMESTER V

COURSE TITLE	**BUILDING AUTOMATION**			**CREDITS**	**3**
COURSE CODE	**MHC4355**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3-0-0-1**
Version	**1.0**	**Approval Details**	**24th ACM, 30.05.2018**	**LEARNING LEVEL**	**BTL-4**
ASSESSMENT SCHEME					
First Periodical Assessment	**Second Periodical Assessment**	**Seminar/ Assignments/ Project**	**Surprise Test / Quiz**	**Attendance**	**ESE**

15%	15%	10%	5%	5%	50%

Course Description	Building automation is an automatic centralized control system that provides automated control and monitoring within a building. A building automation system (BAS) is an intelligent system of both hardware and software connecting heating, venting and air conditioning system (HVAC), lighting, security, and other systems to communicate on a single platform. The automation system is used to deliver the crucial information on the operational performance of a building. Security of the building and safety of personal are becoming important aspects now a day and in near future, it will be in a great demand. The objectives of building automation were to enhance the safety and comfort of the occupants, efficient operation of building systems, reduction in energy consumption and operating costs, and improved life cycle of utilities. Complex infrastructure requires a variety of building automation and control Systems. This subject will help the students to understand the various aspects of different systems seen in well structured building.
Course Objective	**The course should enable the student to,** 1. Study the current values, technology, terminology and practices used in building automation system 2. Analyze and choose the suitable hardware and software for HVAC system and various applications 3. Appraise the concept of energy management system and techniques adopted 4. Evaluate different safety standards and features of integrated systems
Course Outcome	**Upon completion of this course, the students will be able to** 1. Select and evaluate the different transducers, actuators, AC, refrigeration systems in modern Buildings. 2. Identify the importance and techniques of energy conservations in BAS for simple applications 3. Design and installation methods of safety sensors for simple application 4. Describe the procedure for integrated and secure smart building techniques

Prerequisites: Nil

CO, PO AND PSO MAPPING

CO	PO -1	PO-2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO-9	PO -10	PO -11	PO -12	PSO-1	PSO-2
CO-1	2	1	1	-	-	2	1	2	2	1	2	3	3	2
CO-2	2	2	1	1	-	2	2	2	2	1	2	3	3	2
CO-3	3	2	3	1	1	1	1	1	1	1	2	3	3	2

CO-4	**2**	**1**	**1**	**2**	**1**	**2**	**2**	**1**	**1**	**1**	**2**	**3**	**3**	**3**

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: INTRODUCTION (9L)	
Introduction to Building Automation System, Features, Characteristics, Drawbacks of Building Automation system. Various Systems of Building Automation – Building Management System, Energy Management System, Security System, Safety System, Video Management System. **Practical component:** Building parameter control using basic sensors and actuators **Suggested Readings:** Level of Vulnerabilities	**CO-1** **BTL-2**
MODULE 2: BUILDING MANAGEMENT SYSTEM(9L)	
Qualitative study- Introduction, HVAC, Sensors & Transducers – Temperature, Pressure, Level, Flow, RH. Meaning of Analog & Digital Signals, Valves and Actuators, Valve & Actuator Selection, Various Controllers, Job IO Summary Calculation, Controller Sizing, AI to DI Conversion, Cable Selection, Earthing – Meaning, Importance, Panel Earthing, EMI & Tackling EMI. Logic Examples, CL Programming. **Practical component:** Heating, Ventilation and Air-conditioning (HVAC) **Suggested Readings:** Building automation communication standards	**CO-2** **BTL-3**
MODULE 3: ENERGY MANAGEMENT SYSTEM(9L)	
Concept, Energy Meters, Types, Meter Networking, Monitoring Energy Parameters, Analysis of Power Quality – Instantaneous Power, Active Power, Reactive Power, Power Factor, Voltage, Current. Effect of Power Quality on Energy Consumption, Energy Reports, Energy Conservation, Importance of Energy Saving. **Practical component:** Illumination (lighting) control **Suggested Readings:** Concept of Green building (LEED)	**CO-3** **BTL-3**
MODULE 4: SAFETY SYSTEMS (9L)	

Introduction, Fire –Meaning, Fire Development Stages, Fire Sensors & Detectors, Detector Placement, Detectors Required For Various Applications. Fire Extinguishing Principles, Fire Extinguishers & Its Classification. Fire Alarm System – Controllers, Components, Features, Concept of Fire Loop & Fire Devices, 2-Wire & 4-Wire Loops, Working Principle, System Description, Pre-alarm, Alarm, Trouble, Fault, Differences, Cable Selection, Installation Guidelines Best Installation Practices, Logic Example. NFPA and IS2189 Stds, System Programming **Practical component:** Fire detector & alarm system **Suggested Readings:** Design aspects and components of PA system	**CO-4** **BTL-3**
MODULE 5: INTEGRATED SYSTEMS (9L)	
Introduction, Integration of Building Management System, Energy Management System, Safety System, Security Systems & Video Management, Benefits of Integrated Systems, Challenges, Future Prospects of Integrated Systems. **Practical component:** Access control **Suggested Readings:** Intelligent Building	**CO-5** **BTL-3**

TEXT BOOKS	
1	You Lin Xu & Jia He. (2017). *Smart Civil Structures*, CRC Press.
2	Nancy G. Leveson. (2011). *Engineering a Safer World: Systems Thinking Applied to Safety (Engineering Systems)*, 1st Edition, The MIT Press.
REFERENCE BOOKS	
1	Geoff Levermore. (2000). *Building Energy Management Systems: An Application to Heating, Natural Ventilation, Lighting and Occupant Satisfaction,* 2nd Edition, Routledge.
2	Haralick, R.M. and Shapiro, L.G. (1990). *Computer and Robot Vision (Volumes I and II),* Addison Wesley, Reading Massachusetts.
3	Reinhold A. Carlson, Robert A. Di Giandomenico. (1991) *Understanding Building Automation Systems: Direct Digital Control, Energy Management, Life Safety, Security Access Control, Lighting, Building*, 1st edition, R.S. Means Company Ltd.
MOOC	
1	https://www.ed2go.com/courses/construction-and-trades/trades/ctp/hvacr-controlsbuilding-automation-systems

COURSE TITLE	**ELECTRONIC DEVICES & CIRCUITS**	**CREDITS**	**3**

COURSE CODE	MHC4356	COURSE CATEGORY	DE	L-T-P-S	3-0-0-1
Version	1.0	Approval Details	24th ACM, 30.05.2018	LEARNING LEVEL	BTL-3

ASSESSMENT SCHEME

First Periodical Assessment	Second Periodical Assessment	Seminar/ Assignments/ Project	Surprise Test / Quiz	Attendance	ESE
15%	15%	10%	5%	5%	50%

Course Description	Electronic Devices and Circuits deals with the design and applications of electronic devices and circuits such as passive components, diodes, triodes and transistors, rectification and power supplies, amplifying circuits, electronic instruments, and oscillators.
Course Objective	**The course should enable the student to,** 1. learn about the semiconductor devices 2. comprehend the concept of different diodes 3. know the concept of BJT, FET 4. design oscillator circuits 5. design diode, transistor applications
Course Outcome	**Upon completion of this course, the students will be able to** 1. Describe the fundamental concepts of electronic devices 2. Explain and Analyse the different types of diodes, operation and its characteristics 3. Describe the operation of BJT and FET, its biasing and input-output characteristics of different configurations 4. Differentiate the different type of negative feedback amplifiers and oscillator circuits with their design equations. 5. Design diode application circuits, amplifier circuits and oscillators employing BJT, FET devices.
Prerequisites:	

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	-	-	-	-	-	2	2	-	-	2	2	2
CO-2	3	3	3	3	3	-	-	2	2	-	-	2	2	2
CO-3	3	3	-	-	-	-	-	2	2	-	-	2	2	2
CO-4	3	3	-	-	-	-	-	2	2	-	-	2	2	2

CO-5	**3**	**3**	**-**	**-**	**-**	**-**	**-**	**2**	**2**	**-**	**-**	**2**	**2**	**2**

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: SEMICONDUCTORS & DIODES (6L+6P)	
Semiconductor fundamentals –Energy Band diagram – Intrinsic and Extrinsic Semiconductors PN j unction diode-Qualitative Theory of P-N Junction, P-N Junction as a Diode, Diode Equation, Volt- Ampere Characteristics, Temperature dependence of VI characteristic, Breakdown Mechanisms in Semiconductor Diodes, Zener Diode. **Suggested Readings:** Semiconductor	**CO-1** **BTL-2**
MODULE 2: RECTIFIERS AND FILTERS (6L+6P)	
P-N junction as a Rectifier, Half wave Rectifier, Full wave Rectifier, Bridge Rectifier, Harmonic components in a Rectifier Circuit, Inductor Filters, Capacitor Filters, L-Section Filters, π- Section Filters, , Voltage Regulation using Zener Diode. **Suggested Readings:** Comparison of Filters	**CO-2** **BTL-2**
MODULE 3: BIPOLAR JUNCTION TRANSISTOR (6L+6P)	
Principle of transistor action – Cut off, Active and saturation regions of a transistor – CE,CB,CC Configurations – Comparison -Transistor as a switch and amplifier- Classification of amplifiers– Distortion in amplifiers– frequency response of an amplifier. **Suggested Readings:** BJT Hybrid Model	**CO-3** **BTL-3**
MODULE 4: FIELD EFFECT TRANSISTOR (6L+6P)	
Junction Field Effect Transistor (Construction, principle of operation, symbol) – Pinch-off Voltage - Volt-Ampere characteristics, FET Amplifiers MOSFET (Construction, principle of operation, symbol), MOSFET Characteristics in Enhancement and Depletion modes **Suggested Readings:** JFET Small Signal Model	**CO-4** **BTL-2**
MODULE 5: OSCILLATORS & MULTI VIBRATORS (6L+6P)	
Classification of oscillators – Barkhausen criterion operation and analysis of RC phase shift – Hartely and colpitts oscillators – Multivibrators – astable, monostable and bistablemultivibrators **Suggested Readings:** Schmitt Trigger	**CO-5** **BTL-2**

TEXT BOOKS	
1.	Boylestad&Nashelsky, (2001), Electronic Devices & Circuit Theory, Eighth edition, Prentice Hall Of India (P) Ltd.
REFERENCE BOOKS	
1	Millman and Halkias, (2015), Electronic devices and Circuits, Tata McGraw Hill International, Edition.
2	Thomas L. Floyd, (2010), Electron Devices, Charles &Messil Publications.
MOOC	
1	https://www.mooc-list.com/course/electronic-materials-and-devices-edx
2	https://www.mooc-list.com/course/04832430x-electronic-circuits-edx

COURSE TITLE	INDUSTRIAL INSTRUMENTATION			CREDITS	3
COURSE CODE		COURSE CATEGORY	DE	L-T-P-S	3-0-0-1
Version	1.0	Approval Details	24th ACM, 30.05.2018	LEARNING LEVEL	BTL5
ASSESSMENT SCHEME					
First Periodical Assessment	Second Periodical Assessment	Seminar/ Assignments/ Project	Surprise Test / Quiz	Attendance	ESE
15%	15%	10%	5%	5%	50%
Course Description	Industrial Instrumentation delivers the automation tools required for the Real time application. The knowledge of programmable logic controller basics, design for software and hardware requirements for a successful deployment. The different methods of programming the PLC and instructions used to program PLC are dealt with. The exposure to SCADA tools gives a cutting-edge deployment of effective management of resources available in plant or networked zones. The Distributed control system plays a vital role in industry scenario to monitor and control the day to day operations of the plant.				
Course Objective	The course will enable the students to understand: 1. The basics Industrial instrumentation systems 2. The fundamental operation of PLC and DCS 3. The real time interface of sensor and actuators in various applications				

Course Outcome	Upon completion of this course, the students will be able to 1. Comprehend and gain knowledge about industrial controllers 2. Describe PLC and DCS 3. Design automation system and develop PLC ladder logic for systems.
Prerequisites:	

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	3	2	2	-	-	-	-	-	1	1	2	2
CO-2	3	3	3	2	2	-	-	-	-	-	1	1	2	2
CO-3	3	3	3	2	2	-	-	-	-	-	1	1	2	2

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1 – INTRODUCTION	**(9L)**
Introduction to automation tools – PLC, SCADA, DCS, Hybrid DCS-PLC	**CO-1** **BTL-1,2**
MODULE 2 – PROGRAMMABLE LOGIC CONTROLLERS	**(9L)**
Hardware, selection, I/O devices and programming **Suggested reading:** Study of Digital data systems Study of data acquisition devices.	**CO-2** **BTL-1,2**
MODULE 3 – AUTOMATION SPECIFICATIONS	**(9L)**
Functional design specifications for automation tool, Development of user requirement specifications. **Suggested reading:** Study of key components of automation systems Study of various types of automation systems	**CO-2** **BTL-3,4**
MODULE 4 – DISTRIBUTED CONTROL SYSTEM	**(9L)**
Architecture, specifications, sensor interfacing **Suggested reading:** Study of key components of distributed control systems Study of data interfacing and communication from field devices	**CO-3** **BTL-4,5**
MODULE 5 – APPLICATIONS	**(9L)**
Case Study – Industrial process monitoring and automation **Suggested reading:** Study of redundant systems and history servers Study of DCS implementation for industries	**CO-3** **BTL-5**

LAB / MINI PROJECT / FIELD WORK	
1. Study of automation systems	
2. PLC programming for motor control	
3. Study of DCS for industrial process applications	
TEXT BOOKS	
1.	William C Dunn.(2005). *Fundamentals of Industrial Instrumentation and Process Control*, McGraw Hill, 2005.
2	Donald P. Eckman. (2009). *Industrial Instrumentation*, CBS Publishers & Distributors, second edition
REFERENCE BOOKS	
1	Chennakesava R. Alavala, (2011). *Principles of Industrial Instrumentation and Control Systems,* CENGAGE Learning Asia.
2	S K Singh. (2010). *Industrial Instrumentation & Control*, Tata McGraw Hill Education.
3	C. R. Venkataramana. (2010). *Mechatronics*, Sapna Book house, Bangalore.
MOOC	
1	https://ocw.mit.edu/courses/chemical-engineering/10-450-process-dynamics-operations-andcontrol-spring-2006/
2	http://www.eit.edu.au/cms/courses/industrial-automation-instrumentation-processcontrol/professional-certificate/in-instrumentation-automation-and-process-control

DEPARTMENTAL ELECTIVES – SEMESTER VI

COURSE TITLE	OPERATIONS RESEARCH			CREDITS	3
COURSE CODE	MHC4371	COURSE CATEGORY	DE	L-T-P-S	3-0-0-1
Version	1.0	Approval Details	24th ACM, 30.05.2018	LEARNING LEVEL	BTL-3
ASSESSMENT SCHEME					
First Periodical Assessment	Second Periodical Assessment	Seminar/ Assignments/ Project	Surprise Test / Quiz	Attendance	ESE
15%	15%	10%	5%	5%	50%
Course Description	Operations Research nowadays are widely used in the area of decision making for the real life problems. Managers and decision makers get idea for optimizing and approximating industrial problems. They not only strive to devise appropriate measures for problem solving but also apply scientific techniques to monitor the organizations ongoing activities such as production mix, transportation, queuing, assignment, dynamic, Integer, goal and game problem.				

Course Objective	The course will enable the students to: 1. Familiarize with decision making concepts and tools. 2. Practice various Transportation models. 3. Master CPM and PERT techniques and to adopt them suitably for the projects. 4. Assign the resources in an optimum manner. 5. Familiarize with inventory controls.
Course Outcome	Upon completion of this course, the students will be able to 1. Differentiate the types of decision making environmental and appropriate decision making approaches and tools to be used in each type. 2. Build and solve Transportation models and assignment models. 3. Design simple models like CPM and PERT to improve decision making 4. Develop critical thinking and objective analysis decision making. 5. Determine EOQ in factory live situations and the inventories effectively.

Prerequisites:

CO, PO AND PSO MAPPING

CO	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO-9	PO-10	PO-12	PO-12	PSO -1	PSO -2
CO-1	3	2	3	2	1	1	1	1	2	1	-	1	3	2
CO-2	3	2	3	3	1	1	1	1	2	1	-	1	3	2
CO-3	3	2	3	2	1	1	1	1	2	1	-	1	3	2
CO-4	3	2	3	2	1	1	1	1	2	1	-	1	3	2
CO-5	3	2	3	2	1	1	1	1	2	1	-	1	3	2

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: PROGRAMMING PROBLEM (9L)	
Graphical Solution – Bounded and Unbounded Solutions – Simplex Method – Big M method-Duality - Two phase Method – Dual Simplex method.	**CO-1 BTL-2**
MODULE 2: SEQUENCING AND GAME THEORY (9L)	
Algorithm – Two Machine and three Machine problem – Game theory with saddle point and without saddle point – Dominance properties – Graphical Solutions. Dynamic Programming **Suggested Readings:** Advances in Sequencing And Game Theory	**CO-2 BTL-2**
MODULE 3: ASSIGNMENT ANDTRANSPORTATIONPROBLEM 9L	

Purchase Model with and without Shortages – Manufacturing Model with and without Shortages, Probabilistic Model. **Suggested Readings:** Next-generation INVENTORY CONTROL techniques.	**CO-3** **BTL-3**
MODULE 4: PERT - CPM -DECISIONTHEORY 9L	
Concepts of feedback – Classification of feedback amplifiers – General characteristics of negative feedback amplifiers – Effect of Feedback on Amplifier characteristics. Condition for oscillations. RC and LC type Oscillators – Generalized analysis **Suggested Readings:** Schmitt Trigger	**CO-4** **BTL-2**
MODULE 5: DETERMINATIONOFEOQ &INVENTORY CONTROL 9L	
Class A Power Amplifier, Push Pull and Complimentary Symmetry Class B and Class AB Power Amplifiers – Principle of operation of class C and D Amplifier, Transistor Power Dissipation, Heat Sinks, Tuned Amplifiers **Suggested Readings:** Tuned Amplifiers	**CO-5** **BTL-2**
TEXT BOOKS	
1.	H.A. Taha. (2003). *Operations Research - An Introduction*, Prentice Hall of India./Pearson Education
REFERENCE BOOKS	
1	F S Hiller and G J Leiberman.(2000), *Introduction to Operations Research*
2	Gupta Prem Kumar and Hira D S.(2010).*Operations Research*
MOOC	
1	https://onlinecourses.nptel.ac.in/noc17_mg10/preview

COURSE TITLE	**ANALOG ELECTRONICS**			**CREDITS**	**3**
COURSE CODE	**MHC4370**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3-0-0-1**
Version	**1.0**	**Approval Details**	**24th ACM, 30.05.2018**	**LEARNING LEVEL**	**BTL-3**
ASSESSMENT SCHEME					
First Periodical Assessment	**Second Periodical Assessment**	**Seminar/ Assignments/ Project**	**Surprise Test / Quiz**	**Attendance**	**ESE**

15%	15%	10%	5%	5%	50%

Course Description	Analog electronics deals with a continuously variable signal and is widely used in radio and audio equipment along with other applications where signals are derived from analog sensors before being converted into digital signals for subsequent storage and processing.
Course Objective	1. To introduce circuit realizations with components such as diodes, BJTs and transistors studied earlier. 2. To give understanding of various types of amplifier circuits such as small signal, cascaded, large signal and tuned amplifiers. 3. To familiarize the Concept of feedback in amplifiers so as to differentiate between negative and positive feedback.
Course Outcome	Upon completion of this course, the students will be able to 1. Comprehend the small signal amplifier circuits applying the biasing techniques. 2. Describe the transistor models at high frequencies 3. Design FET and MOSFET amplifier circuits 4. Design and realize different classes of Power Amplifiers and tuned amplifiers useable for audio and Radio applications. 5. Utilize the Concepts of negative feedback to improve the stability of amplifiers and positive feedback to generate sustained oscillations.

Prerequisites:

CO, PO AND PSO MAPPING

CO	PO -1	PO-2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO-9	PO-10	PO -11	PO -12	PSO-1	PSO -2
CO-1	3	3	-	-	-	-	-	2	2	-	-	2	2	2
CO-2	3	3	3	3	3	-	-	2	2	-	-	2	2	2
CO-3	3	3	-	-	-	-	-	2	2	-	-	2	2	2
CO-4	3	3	-	-	-	-	-	2	2	-	-	2	2	2
CO-5	3	3	-		-	-	-	2	2	-	-	2	2	2

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: INTRODUCTION TO ELECTRONIC DEVICES &CIRCUITS (6L+6P)

Diodes, BJT, FET, MOSFET – Principle of operation, Characteristics, Applications, Rectifiers, Amplifiers, Oscillators. **Suggested Readings:** Semiconductors Theory	**CO-1** **BTL-2**
MODULE 2: BJT AMPLIFIERS (6L+6P)	
Review of transistor biasing, Classification of Amplifiers – Distortion in amplifiers, Frequency response of BJT Amplifiers, effect of coupling and bypass capacitors, Design of single stage RC coupled amplifier, Cascode amplifier, Darlington pair. **Suggested Readings:** Hybrid- pi (π Embedded Systems - Design challenges, optimization of design metrics. Processor Technology: General purpose Processor, Single-purpose processor, Application specific processor. Introduction to microprocessor & microcontroller-8085 Architecture- 8051 Architecture 8085 Instruction Set: Addressing modes; Data transfer, arithmetic, logical, branch, stack and machine control groups of instruction set, 8051 Instruction set, Addressing modes – Assembly language programming.) – Common Emitter transistor model	**CO-2** **BTL-2**
MODULE 3: FET AMPLIFIERS (6L+6P)	
CS, CD, CG JFET Amplifiers, Basic Concepts of MOS Amplifiers, MOS Small signal model, Cascode and Folded Cascode Amplifier. **Suggested Readings:** Common source amplifier with resistive, Diode connected and Current source loads, Source follower.	**CO-3** **BTL-3**
MODULE 4: FEEDBACK AND OSCILLATOR CIRCUITS (6L+6P)	
Concepts of feedback – Classification of feedback amplifiers – General characteristics of negative feedback amplifiers – Effect of Feedback on Amplifier characteristics. Condition for oscillations. RC and LC type Oscillators – Generalized analysis **Suggested Readings:** Schmitt Trigger	**CO-4** **BTL-2**
MODULE 5: LARGE SIGNAL AMPLIFIERS (6L+6P)	
Class A Power Amplifier, Push Pull and Complimentary Symmetry Class B and Class AB Power Amplifiers – Principle of operation of class C and D Amplifier, Transistor Power Dissipation, Heat Sinks, Tuned Amplifiers **Suggested Readings:** Tuned Amplifiers	**CO-5** **BTL-2**

TEXT BOOKS	
1.	David A. Bell. (2010).*Electronic Devices and Circuits*, 5th Edition, Oxford.
REFERENCE BOOKS	
1	Jacob Millman, Christos C Halkias. (2017). *Integrated Electronics*, McGraw Hill Education.
2	Thomas L. Floyd. (2015). *Electronic Devices Conventional and current version*, Pearson.
MOOC	
1	https://www.coursera.org/learn/electronics

COURSE TITLE	**ROBOTIC OPERATING SYSTEM**			**CREDITS**	**3**
COURSE CODE	**MHC4372**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3-0-0-1**
Version	**1.0**	**Approval Details**	**24th ACM, 30.05.2018**	**LEARNING LEVEL**	**BT L- 4**
ASSESSMENT SCHEME					
First Periodical Assessment	**Second Periodical Assessment**	**Seminar/ Assignments/ Project**	**Surprise Test / Quiz**	**Attendance**	**ESE**
15%	**15%**	**10%**	**5%**	**5%**	**50 %**
Course Description	The Robot Operating System (ROS) enables to quickly build robotic applications through access to a large set of open-source software and tools. Over the years, ROS has become the essential tool for roboticists. A large community surrounds ROS and there has been extensive input from industrial users in the development of these tools. In this course, the students will learn to use different ROS tools to create a complete robotic application. Students will be working with their own standalone Ubuntu-Linux installation and with industrial and mobile robots on the physics-based simulation engine, Gazebo/webots. Students will learn to program and configure basic robotic tasks such as pick-and-place objects, and navigate through obstacles.				

Course Objective	**The course should enable the student to** 1. Use ROS communication tools (topics, services, actions) to exchange information between functional modules 2. Visualization and creation of a custom environment with a robot 3. Mapping of the robot environment and navigation with a mobile robot 4. How to implement a pick-and-place function with industrial robot arms 5. Design of a complete robotic application with state machines
Course Outcome	**Upon completion of this course, the students will be able to** 1. Comprehend the ROS architecture 2. Model a robot in ROS 3. Simulate a mobile robot 4. Plan movement of a robot by avoiding collisions 5. Interface sensors and actuators with ROS

Prerequisites: NIL

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	1	1	1	2	1	-	-	-	-	-	-	2	3
CO-2	3	3	3	1	3	1	-	-	2	1	-	1	2	3
CO-3	3	3	3	1	3	1	-	-	2	1	-	1	2	3
CO-4	3	3	2	1	3	1	-	-	2	1	-	1	2	3
CO-5	3	2	2	1	3	1	-	-	2	1	1	1	2	3

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: INTRODUCTION (9L)

Introduction to ROS - ROS file system level - ROS computation graph level - ROS community level **Practical component:** Working with ROS packages, nodes & messages **Suggested Readings:** Applications of ROS	**CO-1** **BTL-2**

MODULE 2: 3D ROBOT MODELING IN ROS (9L)

ROS packages for robot modelling - Creating ROS package for robot description - Visualizing robot in 3D model **Practical component:** Creating URDF model, using RVIZ for visualizing 3 D model & robot description **Suggested Readings:** URDF	**CO -2 BT L- 3**
MODULE 3: SIMULATING ROBOTS (9L)	
Understanding Gazebo - Robotic arm simulation - Simulating joints - Interfacing with ROS controllers **Practical component:** Simulating robotic arm, moving joints using Gazebo & moving mobile robot **Suggested Readings:** ROS Gazebo	**CO -3 BT L-4**
MODULE 4: MOTION PLANNING (9L)	
Configuration Space - Collision matrix - Motion planning methods - Motion planning using ROS - ROS Controllers **Practical component:** Movelt configuration package setup & motion planning **Suggested Readings:** Forward kinematics and inverse kinematics of robotic manipulators	**CO -4 BT L-4**
MODULE 5: INTERFACING I/O BOARDS, SENSORS & ACTUATORS (9L)	
ROS Serial package – ROS and Microcontroller - Interfacing Sensors & Actuators **Practical component:** ROS serial package – ROS and microcontroller – Interfacing sensors and actuators **Suggested Readings:** ROS communication in real-time with sensors and actuators	**CO -5 BT L-4**

TEXTBOOKS	
1.	Lentin Joseph. (2015). *Mastering ROS for Robotic Programming*, Packt Publishing.
2.	Morgan Quigley, Brian Gerkey, William D. Smart. (2015). *Programming Robots with ROS: A Practical Introduction to the Robot*, O'Reilly.
REFERENCE BOOKS	
1.	Anis Koubaa. (2016).*Robot Operating System (ROS): The Complete Reference – Volume 1.* Springer.
2.	R. Patrick Goebel. (2012). *ROS by Example: A Do-It-Yourself Guide to the Robot Operating System.* Lulu.
MOOC	
1.	https://www.udemy.com/course/ros-for-beginners/
2.	https://robocademy.com/2021/01/19/advanced-ros-programming-live-course-by-lentin-joseph/

COURSE TITLE	VIRTUAL REALITY			CREDITS	3
COURSE CODE	MHC4373	COURSE CATEGORY	DE	L-T-P-S	3-0-0-1
Version	1.0	Approval Details	24th ACM, 30.05.2018	LEARNING LEVEL	BTL-6

ASSESSMENT SCHEME

First Periodical Assessment	Second Periodical Assessment	Seminar/ Assignments/ Project	Surprise Test / Quiz	Attendance	ESE
15%	15%	10%	5%	5%	50%

Course Description	This course is designed to provide students with an overview of the basic principles of virtual reality, scripting and rendering virtual environments. The goal is to learn enough about the strengths and limitations of VR technology to be able to construct simple immersive environments. Students in the course will be given an opportunity to interact directly with immersive virtual environment technology and will gain experience by developing a VR-based application
Course Objective	1. To provide an understanding on the fundamental concepts relating to Virtual Reality such as presence, immersion, and engagement 2. To introduce students to the field of virtual reality (VR) and provide students with hands-on experience developing applications for modern virtual 3. To enable students to explore libraries and tools for creating VR experiences such as Unity
Course Outcome	Upon completion of this course, the students will be able to 1. Discuss Virtual reality concepts 2. Develop VR applications using Unity3D 3. Move around the 3D world 4. Run Unity 3D application in VR on a smart phone.

Prerequisites: Nil

CO, PO AND PSO MAPPING

CO	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO-9	PO -10	PO-11	PO-12	PSO -1	PSO -2
CO -1	2	3	3	1	3	2	2	1	2	2	2	2	-	-
CO -2	2	3	3	1	3	1	1	1	1	1	1	1	-	-
CO -3	2	3	3	1	3	1	1	1	1	1	1	1	-	-
CO -4	2	3	3	1	3	1	1	1	1	1	1	1	-	-

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: INTRODUCTION TO VIRTUAL REALITY (9L)

Virtual Reality – Types – Virtual Reality Vs Augmented Reality – Applications – Technical skills required Suggested Readings: Immersive technologies: VR, AR, MR and XR	CO-1 BTL-2
MODULE 2: BUILDING SIMPLE SCENES	**(9L)**
Introduction to Unity IDE – Objects and Scale – Creating a simple diorama – VR Device integration Practical component: Working with Unity 3D with scene and objects Suggested Readings: Computer Graphics and Virtual Reality	CO-2 BTL-3
MODULE 3: GAZE BASED CONTROL (9L)	
First person Controller – Third person controller – Navigation in VR application – World space User Interface Practical component: Create an application where user can navigate around the scene Suggested Readings: Augmented reality navigation systems	CO-3 BTL-6
MODULE 4: PHYSICS & ENVIRONMENT (9L)	
Physics component – physics materials – Raycast – particle effects Practical component: Create an application 1. where the user can interact with the objects in the scene using a raycast 2. demonstrate particle effects upon interaction 3. create physics materials and apply the same to objects Suggested Readings: Development of Haptic virtual reality systems	CO-4 BTL-6
MODULE 5: WALK-THROUGHS (9L)	
Assembling scenes – Adding photos – Animated walkthrough – optimizing for performance – Using all 360 degrees Practical component: Create a virtual reality application for a walkthrough Suggested Readings: Game engines and VR in film making	CO-4 BTL-6
TEXT BOOKS	
1.	Tony Parisi. (2016). *Learning Virtual Reality*, O'Reilly Media
REFERENCE BOOKS	
1.	Jason Jerald. (2015). *The VR Book – Human Centered Design for Virtual Reality*, Morgan & Claypool
2.	John Williamson, Charles Palmer. (2018). *Virtual Reality Blueprints: Create compelling VR experiences for mobile and desktop*, Packt Publishing
MOOC	

1.	https://in.udacity.com/course/introduction-to-virtual-reality--ud1012
2.	https://www.edx.org/course/creating-virtual-reality-vr-apps-uc-san-diegox-cse190x

DEPARTMENTAL ELECTIVES – SEMESTER VII

COURSE TITLE	ROBOTIC PROCESS AUTOMATION			CREDITS	3
COURSE CODE	MHC4459	COURSE CATEGORY	DE	L-T-P-S	3-0-0-1
Version	1.0	Approval Details	24th ACM, 30.05.2018	LEARNING LEVEL	BTL-6

ASSESSMENT SCHEME

First Periodical Assessment	Second Periodical Assessment	Seminar/ Assignments/ Project	Surprise Test / Quiz	Attendance	ESE
15%	15%	10%	5%	5%	50%

Course Description	Robotic Process Automation (RPA) can transform business processes by eliminating the mundane, time-consuming, manual tasks that professionals complete; enabling them more time to focus on critical thinking. This course will help students to understand the characteristics, benefits, risks, and challenges of RPA. This course will also enable students to develop RPA solutions for simple applications.
Course Objective	1. To introduce robotics process automation to participants 2. To impart basic proficiency in RPA tools so that they are able to write their own RPA solutions 3. To create bots to automate common work processes
Course Outcome	Upon completion of this course, the students will be able to 1. recognize robotic process automation 2. create different types of workflows 3. create control flow and record events 4. perform scraping 5. Perform image and text automation

Prerequisites: Nil

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	1	2	-	-	-	-	-	-	-	-	2	1	-	-
CO-2	3	3	3	-	3	-	-	-	3	3	-	-	-	-
CO-3	3	3	3	-	3	-	-	-	3	3	-	-	-	-

CO-4	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**3**	**3**	**3**	**3**	**3**	**3**	**3**
CO-5	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: INTRODUCTION TO ROBOTIC PROCESS AUTOMATION (9L)	
Introduction to Business process automation – Robotic process automation – RPA Tools and Technology **Practical component:** Working with UIPath Studio and StudioX **Suggested Readings:** Trends in RPA	CO-1 BTL-2
MODULE 2: ROBOTIC PROCESS AUTOMATION WORKFLOW (9L)	
Types of Workflow – Sequences – Flowcharts – State Machines – Variables – Arguments - Namespaces **Practical component:** Create RPA workflow using UIPath **Suggested Readings:** Workflow automation Vs RPA	CO-2 BTL-3
MODULE 3: CONTROL FLOW & RECORDING (9L)	
Control flow – Control flow activities. Recording: Types – Automatic Recording Interface **Practical component:** Develop RPA solution for a given problem using appropriate control flows Myths in RPA recorder	CO-3 BTL-6
MODULE 4: UI ELEMENTS & SCRAPING(9L) **Suggested Readings:**	
UI elements – UI activities properties – Input Methods. Scraping: Data Scraping – Screen Scraping – Relative Scraping **Practical component:** Scrap data from various UI elements- Perform screen scraping **Suggested Readings:** Scraping, Data Extraction and Automation in Help systems	CO-4 BTL-6
MODULE 5: IMAGE AND TEXT AUTOMATION (9L)	
Introduction – Mouse and keyboard activities – Text activities – OCR activities – Image activities **Practical component:** Perform image and text automation **Suggested Readings:** RPA and intelligent automation	CO-5 BTL-6
TEXT BOOKS	

1.	Tom Taulli. (2020). *The Robotic Process Automation Handbook: A Guide to Implementing RPA Systems*, Apress
REFERENCE BOOKS	
1	Nandan Mullakara, Arun Kumar Asokan. (2020). *Robotic Process Automation Projects: Build real-world RPA solutions using UiPath and Automation Anywhere*, Packt Publishing Ltd.
MOOC	
1	https://www.udemy.com/robotic-process-automation/
2	https://academy.uipath.com/landing

COURSE TITLE	**INDUSTRIAL ENGINEERING**			**CREDITS**	**3**
COURSE CODE	**MHC4460**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3-0-0-1**
Version	**1.0**	**Approval Details**	**24th ACM, 30.05.2018**	**LEARNING LEVEL**	**BTL-4**
ASSESSMENT SCHEME					
First Periodical Assessment	**Second Periodical Assessment**	**Seminar/ Assignments/ Project**	**Surprise Test / Quiz**	**Attendance**	**ESE**
15%	**15%**	**10%**	**5%**	**5%**	**50%**
Course Description	Industrial Engineering covers a broad spectrum including production planning and control, manufacturing systems and processes, facilities design, human factors, occupational safety, quality control, systems reliability, and systems analysis and design with a strong emphasis on advanced computing.				
Course Objective	The objectives of the industrial engineering are to produce graduates who: 1. Contribute to the success of companies through effective problem solving. 2. Design, develop, implement, and improve integrated systems that include people, materials, information, equipment, and environments. 3. Achieving Maximum results with minimum efforts. 4. Increasing the Efficiency of factors of Production. 5. Maximum Prosperity for Employer & Employees				

Course Outcome	Upon completion of this course, the students will be able to 1. Conduct market research, demand forecasting and costing 2. Demonstrate the knowledge of designing plants and controlling production 3. Optimize the resources of an organization and improve productivity. 4. An understanding of the impact of industrial engineering solutions 5. Evaluate the production planning and control

Prerequisites: Nil

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	2	2	3	2	3	3	2	2	3	3	3	3	3
CO-2	3	2	2	3	2	2	2	3	3	3	3	2	3	3
CO-3	3	2	2	3	2	3	3	3	3	3	3	2	3	3
CO-4	3	2	2	3	2	3	3	3	3	3	3	2	3	3
CO-5	3	2	3	3	2	3	3	3	3	3	3	2	3	3

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: DEMAND FORECASTING AND ELEMENTS OF COST (9L)

Demand Forecasting and Elements of Cost Macro and micro economics - Demand and supply – Factors influencing demand – Elasticity of demand – Demand forecasting – Time series - Exponential smoothing casual forecast - Delphi method – Correlation and Regression - Barometric method – Long run and Short run forecast. Elements of cost – Determination of Material cost - Labour cost - Expenses – Types of cost. **Suggested Reading:** Read on how the Delphi method helps in improving the taste quality of Dominos Indi Tandoori Paneer Pizza.	**CO-1** **BTL-2**

MODULE 2: INDUSTRIAL ORGANISATION (9L)

Introduction to Industrial Engineering – Concepts - History and Development of Industrial engineering – Roles of Industrial Engineer – Applications – Productivity – Factors affecting productivity – Increasing productivity of resources – Kinds of productivity measures. **Suggested Reading:** Read on how the iPhone's elasticity of demand creates a huge impact on the mobile market	**CO-2** **BTL-2**
MODULE 3: WORK DESIGN (9L)	
Introduction to work study – Method study – Time study – stopwatch time study – Standard data - Method Time Measurement (M-T-M) – Work sampling – Ergonomics. **Suggested Reading:** Read on the factors that affect the productivity of the tyre industry	**CO-3** **BTL-3**
MODULE 4: PLANT LAYOUT AND GROUP TECHNOLOGY (9L)	
Plant location - Factors - Plant layout - Types - Layout design process – Computerized Layout Planning – Construction and Improvement algorithms -ALDEP - CORELAP and CRAFT. Group technologyProblem definition - Production flow analysis - Heuristic methods of grouping by machine matrices – Flexible Manufacturing System - FMS work stationsMaterial handling and Storage system-Cellular Manufacturing System. **Suggested Reading:** Read on the concept of a flexible manufacturing system with an application	**CO-4** **BTL-3**
MODULE 5: PRODUCTION PLANNING AND CONTROL (9L)	
Types of productions, Production cycle-Process planning, Forecasting, Loading, Scheduling, Dispatching, Routing- Simple problems. Materials Planning – ABC analysis – Incoming materials control – Kanban system – Just in time. MRP systems- Master Production Schedule – Bill of Materials – MRP calculations **Suggested Reading:** Read on how the thermal power plant layout process was carried out along with its design process.	**CO-5** **BTL-4**
TEXT BOOKS	
1.	Buffa E.S. (2009). Modern Production / Operational Management, John Wiley & Sons, 2009
REFERENCE BOOKS	
1	Nigel Slack, Stuart Chambers, Robert Johnston., (2010). Operation Management, Pearson Education.

2	R.Danreid& Sanders., (2009). Operations Management, John Wiley & Sons, 2009
MOOC	
1	http://engineering.nyu.edu/academics/online/masters/industrial-engineering
2	https://online.engineering.arizona.edu/online-programs/industrial-engineering/master-of science-in-industrial-engineering/

COURSE TITLE	**TOTAL QUALITY MANAGEMENT**			**CREDITS**	**3**
COURSE CODE	**MHC4461**	**COURSE CATEGORY**	**PC**	**L-T-P-S**	**3-0-0-0**
Version	**1.0**	**Approval Details**	**24th ACM, 30.05.2018**	**LEARNING LEVEL**	**BTL-2**
ASSESSMENT SCHEME					
First Periodical Assessment	**Second Periodical Assessment**	**Seminar/ Assignments/ Project**	**Surprise Test / Quiz**	**Attendance**	**ESE**
15%	**15%**	**10%**	**5%**	**5%**	**50%**
Course Description	Total quality management (TQM) is the continual process of detecting and reducing or eliminating errors in manufacturing, streamlining supply chain management, improving the customer experience				
Course Objective	1. To diagnose problems in the quality improvement process. 2. To identify ethical and unethical behavior in Quality Management. 3. To Utilize Statistical Process Control techniques as a means to diagnose, reduce and eliminate causes of variation 4. To perform process capability and specification studies. 5. To propose how business leaders might plan and execute quality management strategies to gain and sustain a competitive advantage in today's global business arena.				
Course Outcome	Upon completion of this course, the students will be able to 1. Discuss the overview of quality and TQM 2. Comprehend customer Focus, Employee Focus and their involvement, continuous process improvement and Supply chain Management. 3. Describe the basic and new seven management tools, Quality concepts like Six sigma, Failure mode effect analysis. 4. Describe industrial applications of Quality function deployment Taguchi quality concepts and TPM 5. Discuss various quality systems like ISO and its standards				

Prerequisites: NIL

CO, PO AND PSO MAPPING

CO	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO-9	PO -10	PO -11	PO-12	PSO -1	PSO -2
CO-1	1	2	-	2	1	-	-	-	-	-	2	1	-	-
CO-2	1	-	2	-	2	-	-	-	2	2	1	1	-	-
CO-3	2	1	2	1	-	1	-	-	3	3	-	1	-	-
CO-4	2	2	-	2	-	1	2	2	-	-	-	1	-	-
CO-5	1	2	3	1	-	3	3	2	1	-	-	2	-	-

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: INTRODUCTION	**(9L)**
Introduction - Need for quality - Evolution of quality - Definitions of quality - Dimensions of product and service quality - Basic concepts of TQM - TQM Framework - Contributions of Deming, Juran and Crosby - Barriers to TQM - Quality statements - Customer focus - Customer orientation, Customer satisfaction, Customer complaints, Customer retention - Costs of quality. **Suggested Readings:** Product & service Quality Management.	**CO-1** **BTL-1**
MODULE 2: TQM PRINCIPLES	**(9L)**
Leadership - Strategic quality planning, Quality Councils - Employee involvement - Motivation, Empowerment, Team and Teamwork, Quality circles Recognition and Reward, Performance appraisal - Continuous process improvement - PDCA cycle, 5S, Kaizen - Supplier partnership – Partnering. **Suggested Readings:** Quality Management, Organizational structure	**CO-2** **BTL-1**
MODULE 3: TQM TOOLS AND TECHNIQUES I	**(9L)**
The seven traditional tools of quality - New management tools - Six sigma: Concepts, Methodology, applications to manufacturing, service sector including IT - Bench marking - Reason to bench mark, Bench marking process - FMEA - Stages, Types. **Suggested Readings:** Strategic and systematic approach, Fact-based decision making.	**CO-3** **BTL-2**
MODULE 4: TQM TOOLS AND TECHNIQUES II	**(9L)**

Control Charts - Process Capability - Concepts of Six Sigma - Quality Function Development (QFD) - Taguchi quality loss function - TPM - Concepts, improvement needs - Performance measures. **Suggested Readings:** Management commitment, Continuous improvement	**CO-4** **BTL-2**
MODULE 5: QUALITY SYSTEMS	**(9L)**
Need for ISO 9000 - ISO 9001-2008 Quality System - Elements, Documentation, Quality Auditing - QS 9000 - ISO 14000 - Concepts, Requirements and Benefits - TQM Implementation in manufacturing and service sectors. **Suggested Readings:** Quality Management Standards, Business Process.	**CO-5** **BTL-2**

TEXT BOOKS	
1.	Dale H. Besterfiled, et al. (2016). *Total quality Management*, Pearson Education Asia.
REFERENCE BOOKS	
1	Oakland J. (2003). *TQM – Text with Cases*, A Butterworth-Heinemann Title.
E BOOKS	
1.	http://psbm.org/Ebooks/Total%20Quality.pdf
MOOC	
1	https://onlinecourses.nptel.ac.in/noc17_mg18/preview

COURSE TITLE	**FINITE ELEMENT ANALYSIS**			**CREDITS**	**3**
COURSE CODE	**MHC4462**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**3-0-0-1**
Version	**1.0**	**Approval Details**	**24th ACM, 30.05.2018**	**LEARNING LEVEL**	**BTL-3**

ASSESSMENT SCHEME					
First Periodical Assessment	**Second Periodical Assessment**	**Seminar/ Assignments/ Project**	**Surprise Test / Quiz**	**Attendance**	**ESE**
15%	**15%**	**10%**	**5%**	**5%**	**50%**

Course Description	The Finite Element Analysis (FEA) is the simulation of any given physical phenomenon using the numerical technique called Finite Element Method (FEM). Engineers use FEA software to reduce the number of physical prototypes and experiments and optimize components in their design phase to develop better products, faster while saving on expenses. It is necessary to use mathematics to comprehensively understand and quantify any physical phenomena such as structural or fluid behavior, thermal transport, wave propagation, the growth of biological cells, etc. Most of these processes are described using Partial Differential Equations (PDEs). However, for a computer to solve these PDEs, numerical techniques have been developed over the last few decades and one of the prominent ones, today, is the Finite Element Analysis.
Course Objective	1. To understand the Mathematical Modeling of field problems in Engineering 2. To solve the 1D problems 3. To discuss about the various Galarkin approach, Temperature effects stress strain relations, plane problems of elasticity and element equations 4. To solve Axi-symmetric formulation , Element stiffness matrix and force vector , Galarkin approach and Problems 5. To discuss about Numerical integration and application to plane stress problems, Matrix solution techniques Solutions Techniques to Dynamic problems, Introduction to Analysis Software
Course Outcome	1. Comprehend the Mathematical Modeling of field problems in Engineering 2. Solve the One Dimensional Second Order Equations 3. Describe Galarkin approach, Temperature effects stress strain relations, plane problems of elasticity and element equations 4. Solve Axi-symmetric formulation , Element stiffness matrix and force vector , Galarkin approach and Problems 5. Solve Numerical integration and application to plane stress problems, Matrix solution techniques Solutions Techniques to Dynamic problems.
Prerequisites: Nil	

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	-	3	2	2	1	-	-	-	-	1	-	1	-	-
CO-2	-	3	2	-	1	-	-	-	1	1	-	-	-	-
CO-3	-	-	2	-	2	-	-	-	1	1	-	-	-	-
CO-4	-	-	2	-	2	-	-	-	1	1	-	-	-	-

CO-5	**2**	**2**	**3**	**-**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1:INTRODUCTION **9L**	
Historical Background – Mathematical Modelling of field problems in Engineering – Governing Equations – Discrete and continuous models – Boundary, Initial and Eigen Value problems– Weighted Residual Methods – Variational Formulation of Boundary Value Problems – Ritz Technique – Basic concepts of the Finite Element Method. **Suggested Readings:** Application to bar element, Application to the continuum.	**CO-1 BTL-3**
MODULE 2: ONE DIMENSIONAL PROBLEMS **9L**	
One Dimensional Second Order Equations - Derivation of Shape functions and Stiffness matrices and force vectors- Galarkin approach - Assembly of stiffness matrix and load vector - Solution of problems from solid mechanics and heat transfer-Finite element equations - Longitudinal vibration frequencies and mode. **Suggested Readings:** Applications to plane trusses, Quadratic shape functions.	**CO-2 BTL-3**
MODULE 3: TWO DIMENSIONAL CONTINUUM **9L**	
Introduction - Finite element modelling - Scalar valued problem - Poisson equation -Laplace equation - Triangular elements - Element stiffness matrix - Force vector - Galarkin approach - Temperature effects - stress strain relations – plane problems of elasticity – element equations – assembly – need for quadrature formulae – transformations to natural coordinates – Gaussian quadrature – example problems in plane stress, plane strain using MATLAB and Abaqus. **Suggested Readings:** Structural mechanics applications.	**CO-3 BTL-3**
MODULE 4: AXISYMMETRIC CONTINUUM **9L**	
Axisymmetric formulation - Element stiffness matrix and force vector - Galarkin approach - Body forces and temperature effects - Stress calculations - Boundary conditions - Applications to cylinders under internal or external pressures - Rotating discs - Plate and shell elements. **Suggested Readings:** Axisymmetric applications.	**CO-4 BTL-3**
MODULE 5: ISOPARAMETRIC FORMULATION **9L**	
Natural co-ordinate systems – Isoparametric elements with mat lab coding – Shape functions for iso parametric elements – One and two dimensions– Numerical integration and application to plane stress problems - Matrix solution techniques – Solutions Techniques to Dynamic problems – Introduction to Analysis Software. **Suggested Readings:** Application of four node quadrilateral.	**CO-5 BTL-3**

TEXT BOOKS	
1.	C Krishnamoorthy. (2017). *Finite Element Analysis: Theory and Programming*, McGraw Hill Education.
2.	Anand V. Kulkarni. (2017). *A Primer On Finite Element Analysis*, Laxmi Publications.
REFERENCE BOOKS	
1	Randy Shih. (2016). *Introduction to Finite Element Analysis Using SOLIDWORKS Simulation*, SDC Publications.
2	Daryl L. Logan. (2016). *A First Course in the Finite Element Method CL Engineering*; Oxford, 6th edition, 2016.
MOOC	
1	https://www.coursera.org/learn/finite-element-method
2	http://www.open.edu/openlearn/science-maths-technology/introduction-finite-elementanalysis/content-section-0

NON-DEPARTMENTAL ELECTIVES – SEMESTER III

COURSE TITLE	BUILDING OF MOBILE ROBOTS			CREDITS	2
COURSE CODE	MHD4281	COURSE CATEGORY	NE	L-T-P-S	2-0-0-1
Version	1.0	Approval Details	24th ACM, 30.05.2018	LEARNING LEVEL	BTL- 4

ASSESSMENT SCHEME					
First Periodical Assessment	Second Periodical Assessment	Seminar/ Assignments/ Project	Surprise Test / Quiz	Attendance	ESE
15%	15%	10%	5%	5%	50%

Course Description	Robots are rapidly evolving from factory workhorses, which are physically bound to their work- cells, to increasingly complex machines capable of performing challenging tasks in our daily environment. The objective of this course is to provide the basic concepts and algorithms required to develop mobile robots that act autonomously in complex environments. The main emphasis is put on mobile robot locomotion and kinematics, environment perception, probabilistic map based localization and mapping, and motion planning. The lectures and exercises of this course introduce several types of robots such as wheeled robots, legged robots. *This course is offered as Project Based Learning and Assessment

Course Objective	**The course should enable the student to,** 1. Remember, Recall and Identify basic mechanisms of Mobile Robots 2. Comprehend various sensors and actuators used in the design of mobile robots. 3. Design a simple controller / program for the control of mobile robot 4. Design and Develop a mobile robot integrating sensor – actuator – controller for simple applications
Course Outcome	**Upon completion of this course, the students will be able to** 1. Apply knowledge about sensors and actuators forselection for a typical application. 2. Use vision system for navigation of the mobile robot. 3. Write program for various applications of mobile robots. 4. Design mobile robot for simple applications.

Prerequisites: NIL

CO, PO AND PSO MAPPING

CO	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO -9	PO -10	PO-11	PO-12	PSO -1	PSO -2
CO-1	3	3	-	-	-	-	-	-	-	-	2	2	1	-
CO-2	3	3	2	2	1	1	1	1	1	2	2	2	1	-
CO-3	3	3	3	2	3	1	1	2	3	3	2	2	1	-
CO-4	3	3	3	3	3	1	1	2	3	3	2	2	3	-

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: INTRODUCTION (9L)

Introduction to mobile Robots – Laws of Robots – Robot Anatomy – Basic Mechanics of Robots– Basic Electronics for Robots, Robot Applications - Companion Robots – Robots for Agriculture Applications – Space Robots – Defense Robots. **Suggested Readings:** ● Mobile robots applications	**CO-1** **BTL-2**

MODULE 2: SENSORS (9L)

Sensors for mobile robots – Need – Types & Classification of Sensors- Sensor Characteristics – Sensors for Navigation, Motion, Position, Force, Range, Tactile and Vision – Selection of Sensors **Suggested Readings:** ● Sensors interfacing with mobile robot controllers	**CO-2** **BTL- 3**
MODULE 3: ACTUATORS (9L)	
Actuation mechanism for robots – Mechanical Actuators and drive trains, Electric Actuators – DC Motors – Servo motor, stepper motor – Linear Actuators – Grippers – Motor drives. **Suggested Readings:** ● Actuators interfacing with mobile robot controllers	**CO-3** **BTL-3**
MODULE 4: CONTROLLERS (9L)	
Analog Controller –design of simple controller by basic electronic devices – Digital controller – design of simple controller using logic gates – Introduction to Microcontroller – Arduino – simple program for Obstacle Detection and Avoidance – Localization **Suggested Readings:** ● Arduino interfacing with motor drive	**CO-4** **BTL-4**
MODULE 5: BUILDING OFMOBILE ROBOTS (Project)(9L)	
Building of simple mobile robot – Use of various Sensing methods - Interfacing Sensors and Actuators with Robot Controller – Design of simple programs for Interfacing. **PROJECT:** Build simple mobile robot **Suggested Readings:** ● Arduino programming	**CO-5** **BTL-4**

TEXTBOOKS	
1.	Ulrich Nehmzow. (2003). *Mobile Robots - A practical introduction*, Springer.
REFERENCE BOOKS	
1.	S.R. DEB, S. DEB. (2011). *Robotics Technology and Flexible Automation*, McGraw-Hill.
E BOOKS	
1.	http://www.robotshop.com/blog/en/how-to-make-a-robot-lesson-1-3707
MOOC	
1.	http://www.nptelvideos.in/2012/12/robotics.html
2.	http://nptel.ac.in/courses/112108093/

NON-DEPARTMENTAL ELECTIVES – SEMESTER IV

COURSE TITLE	AI IN ROBOTICS			CREDITS	2
COURSE CODE	MHD4292	COURSE CATEGORY	NE	L-T-P-S	2-0-0-1
Version	1.0	Approval Details	23 ACM, 06.02.2021	LEARNING LEVEL	BTL - 4

ASSESSMENT SCHEME					
First Periodical Assessment	Second Periodical Assessment	Seminar/ Assignments/ Project	Surprise Test / Quiz	Attendance	ESE
15%	15%	10%	5%	5%	50%

Course Description	Robotics is a programmable system able to perform multipurpose activities and finds applications in industries, surveillance, disaster management and defense sectors. Mobile robots are robots that are designed on hardware platforms with suitable software tool with tight coupling between perception to actions in the environment of interest. Mobile robotics technology is becoming popular in various sectors such agricultural, medical and defense. Farmers use mobile robots to perform different tasks, including harvesting, collecting crop data, and weeding. The mobile robotics market is mainly driven by growing application sectors and increasing in popularity among end users. Decreasing cost of sensors, actuators and simplicity in functioning of mobile robot systems is one of the key factors driving the growth mobile robotics market. This course is designed as a project-based learning course, where the outcome is to develop controllers incorporating the AI for mobile robot applications in Webots simulation environment. The assessment is based on evaluation of the outcomes of the exercises that are planned to be carried out at the end of each unit. *This course is offered as Project Based Learning and Assessment
Course Objective	The objective of this course is to enable the students to understand 1. Physical structure, sensing/actuation and programming required to develop an intelligent robot. 2. Comprehend the sensory techniques that are used to produce intelligent behaviours in robot system 3. Capability of Identifying and Applying suitable robot navigation and control techniques appropriate for a range of different robotic applications 4. By considering case studies they will be able to critically appraise robot systems developed by others.

Course Outcome	Upon completion of this course, the students will be able to 1. Acquire the fundamental concepts behind Intelligent Robotic systems and differentiate various intelligent control techniques. 2. Identify and Apply Intelligent algorithms, navigation and control techniques appropriate for a range of different robotic applications 3. Comprehend the sensory techniques that are used to produce intelligent behaviours in robot system 4. Design, Develop and Program an artificially intelligent robot for applications involving the basic modalities of sensing, path planning and navigation.

Prerequisites: NIL

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2
CO-1	3	3	1	1	1	-	-	-	-	-	-	2	-	-
CO-2	3	3	2	2	2	1	1	2	2	2	-	2	-	-
CO-3	3	3	2	2	1	-	-	-	-	-	-	2	-	-
CO-4	3	3	3	3	3	1	1	2	2	2	-	2	-	-

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: INTRODUCTION (6L)

Artificial Intelligence – Introduction – History – State of the Art – Agents and Environments – Role and Applications in Robotics, Automation and Manufacturing. Robot Paradigms – History – Need of Intelligence – Social Implications – Telepresence and Semi-Autonomous control – Seven Areas of AI – classifications **Practical component:** ● Study of Webots – Environment, Physical Model, Nodes and Controllers **Suggested Readings:** ● Webots Curriculum and Technical Manual	**CO-1** **BTL-3**

MODULE 2: CONTROL METHODS (9L)

Hierarchical, Deliberative and Reactive Paradigms – Attributes - Closed world assumptions – advantages & disadvantages – Reactive Paradigms – Biological Foundations – Behaviours – reflexive, coordination and perception in behaviours- Schema Theory – Transferring Insights to robots. Attributes of Reactive Paradigm - Subsumption Architecture – Potential Field Methodologies - Implementation of reactive systems - Designing a Reactive Implementation – Case studies **Suggested Readings:** ● Study of kinematic model for Differential drive mobile robots	**CO - 2** **BTL - 4**
MODULE 3: SENSORS AND SENSING TECHNIQUES FOR ROBOTS (6L)	
Overview- Sensors – Transducers – Attributes - Sensors for Motion, Force, Position, Light, Vision - Tactile sensing – Advanced Sensors – Applications; Hybrid Control Paradigms and its architectural attributes **Suggested Readings:** ● Various Actuators used for design of robotic configurations.	**CO - 3** **BTL - 3**
MODULE 4: PATH PLANNING AND NAVIGATION (9L)	
Introduction to Path planning and Navigation – Landmarks – Relational and associative methods; Metric Path planning – Configuration Space – Graph based path planners. Localization – continuous localization – feature based localization – exploration. **Suggested Readings:** ● Study of Braitenberg controller model for mobile robots and its behaviors	**CO-4** **BTL-3**
MODULE 5: Design of Robotic Applications using AI in Webots (15L)	
Webots – Introduction – design of differential drive mobile robot – Teleoperation – Braitenberg control - Path Planning and Navigation **Practical component: -** ● Build simple tele-operative differential drive mobile robots in “Webots” environment. Tele-operation can be performed using Keyboard control. ● Integrate sensors in the previously build model and make the robot to navigate the environment using braitenberg control. ● Modify the controller designed by implementing behaviours for a robot to navigate the environment by avoiding obstacles ● Modify the controller designed by making the robot to plan its path using any navigational methods to reach the goal by avoiding the obstacle. **Suggested Readings:** ● Study of Robot Behaviors	**CO 1-4** **BTL-3**
TEXTBOOKS	
1.	Robert R Murphy. (2001). Introduction to AI Robotics, MIT Press, 2nd edition.

2.	Roland Siegwart and I. Nourbaksh. (2011). Introduction to Mobile Robots, MIT Press, 2nd edition.
REFERENCE BOOKS	
1.	Igor Skrjanc, Andrej Zdesar, SasoBlazic and Gregor Klancar. (2017). Wheeled Mobile Robotics From Fundamentals Towards Autonomous Systems, ELSEVIER.
MOOC	
1.	https://www.coursera.org/specializations/modernrobotics
SOFTWARE	
WEBOTS (OPEN SOURCE) ● https://cyberbotics.com/#download ● https://cyberbotics.com/doc/guide/tutorials ● https://en.wikibooks.org/wiki/Category:Book:Cyberbotics%27_Robot_Curriculum ● https://en.wikibooks.org/wiki/Cyberbotics%27_Robot_Curriculum	

COURSE TITLE	**ROBOTICS AND IoT, SENSORS FOR AUTONOMOUS VEHICLES**			**CREDITS**	**2**
COURSE CODE	**MHD4293**	**COURSE CATEGORY**	**NE**	**L-T-P-S**	**3-0-0-1**
Version	**1.0**	**Approval Details**	**23 ACM, 06.02.2021**	**LEARNING LEVEL**	**BTL-3**
ASSESSMENT SCHEME					
First Periodical Assessment	**Second Periodical Assessment**	**Seminar/ Assignments/ Project / Practical**	**Surprise Test / Quiz**	**Attendance**	**ESE**
15%	**15%**	**10%**	**5%**	**5%**	**50%**
Course Description	Robotics systems in modern era have penetrated in to aspects of commercial and societal scenario. The basic analogy to human systems is described through anatomy and configuration. Various types of sensors and actuators for efficient functioning of robots are essential. Mathematical modeling of Robots – transformations, rotation matrix through forward and inverse kinematic analysis. The programming languages used in operation of various Robots. Internet of Things has been exploited in the area of Robotics and interfacing real time systems to cloud servers. The efficient function of autonomous vehicles require a fusion of sensors to function in an orderly fashion to help in navigation and path planning.				

Course Objective	**The course should enable the students to** 1. Understand the basic concepts of a Robotic System. 2. Comprehend the mathematical modeling and transformation in representing the position of manipulators. 3. Understand and Perform basic programming of Robot functions with Robot software. 4. Program Internet of Things for communication and control of Robots. 5. List a variety of sensors for autonomous vehicles.
Course Outcome	**Upon completion of this course, the students will be able to** 1. Recognize and associate basic structure and components of robots 2. Describe the Robot movements and mathematical models in position control. 3. Write and interpret the basic programming sequences used in Robot systems. 4. Implement IoT application for robotic and various real-time applications. 5. Select sensors and construct sensor interface for various Robotic applications.
Prerequisites:	

CO, PO AND PSO MAPPING

CO - PO	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO-9	PO -10	PO-11	PO-12	PSO-1	PSO -2
CO-1	3	3	-	-	-	-	-	-	-	-	-	-	2	-
CO-2	3	3	3	-	-	-	-	-	-	-	-	2	2	-
CO-3	3	3	3	-	-	-	-	-	-	-	-	2	2	-
CO-4	3	3	-	-	-	-	-	-	-	-	-	2	2	-
CO-5	3	3	3	3	-	3	-	-	-	-		2	2	-

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: INTRODUCTION
(9 L)

History of Robots – Robot Anatomy – Robot Configurations – Work Volume – Robot Safety- Sensors and Actuators. **Practical component:** ● Case study Robot system **Suggested Readings:** ● Evolution of Robots	**CO-1** **BTL-1,2**

MODULE 2: KINEMATICS

(9 L)	
Robot Transformations – Rotation Matrix – Forward and Inverse Kinematics – DH Representation. **Practical component:** ● Robot transformations **Suggested Readings:** ● Mathematical modeling of Robot.	**CO-2** **BTL-2**
MODULE 3: ROBOT LANGUAGES AND PROGRAMMING (9 L)	
Robot Languages – Classification of Languages –Motosim, Computer Control and Robot Software. **Practical component:** ● Moto Sim simulation and programming on Robot software **Suggested Readings:** ● Robot Programming languages.	**CO-3** **BTL-2,3**
MODULE 4: INTERNET OF THINGS PROGRAMMING AND INTERFACING (9 L)	
Robot Programming– Basic Embedded C Programming for Robots – Data Acquisition – Interfacing Sensors and Actuators with Robot Controller – Program for Interfacing. **Practical component:** ● Programming – basic programming for sensor and actuator interface. ● IoT programming basics. **Suggested Readings:** ● **Programming for Sensor Interfacing,** Reading Analog Value, Converting an Analog Value to Digital Value and vice versa, communication to cloud servers.	**CO-4** **BTL-2, 3**
MODULE 5:SENSOR FOR AUTMONOMOUS SYSTEMS (9 L)	
SENSORS- Various sensor for autonomous systems like sonar, ultrasonic, infra-red, lidar and their interface to robots. **Practical component:** ● Case study of autonomous systems. **Suggested Readings:** ● How to connect and work with different sensors, such as Humidity, Proximity, IR Motion, Accelerometer, Sound, Light Distance, Pressure, Temperature.	**CO-5** **BTL-1,2**
TEXT BOOKS	
1	Mikell P. Groover, Roger N. Nagel, Industrial Robotics: Technology, Programming, and Applications‖ McGraw-Hill Companies, 2020.
2	S.R. DEB, S. DEB, Robotics Technology and Flexible Automation, Mc-GrawHill, 2nd Edition, 2011.

3	Edquist, Flexible Automation: The Global Diffusion of New Technology, Wiley-Blackwell, 1988.
REFERENCE BOOKS	
1	G.K. Dubey, Fundamental Electrical Drives, second edition 2002, Narosa Publications, Second edition, 2002.
2	Pillai, S.K., A Seish course on Electrical Drives, Wilay Eastern Ltd., New Delhi, 2014
E BOOKS	
1	https://mitpress.mit.edu/books/introduction-autonomous-mobile-robots
MOOC	
1	http://www.rsl.ethz.ch/education-students/lectures/ros.html
2	https://www.coursera.org/specializations/robotics

NON-DEPARTMENTAL ELECTIVES – SEMESTER V

COURSE TITLE	**MACHINE VISION**			**CREDITS**	**2**
COURSE CODE	**MHD4382**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**1-1-0-0**
Version	**1.0**	**Approval Details**	**23 ACM, 06.02.2021**	**LEARNING LEVEL**	**BTL-5**
ASSESSMENT SCHEME					
First Periodical Assessment	**Second Periodical Assessment**	**Seminar/ Assignments/ Project**	**Surprise Test / Quiz**	**Attendance**	**ESE**
15%	**15%**	**10%**	**5%**	**5%**	**50%**
Course Description	This course helps to gain a basic understanding of machine vision and image analysis for 2D machine vision. The course will focus on problem solving based on this technology and industrial applications. Students will use Matlab to implement machine vision algorithms to solve industrial problems.				
Course Objective	To introduce the student to machine vision algorithms, methods and concepts which will enable the student to implement computer vision systems with emphasis on applications and problem solving.				

Course Outcome	Upon completion of this course, the students will be able to 1. Demonstrate awareness on usage of machine vision techniques for industrial applications 2. Perform image segmentation to extract information from digital image 3. Perform filtering operations in the time and frequency domains to achieve desired image enhancement 4. Apply morphological operations for shape recognition and template matching

Prerequisites:

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	
CO-1	3	3	3	3	3								-	-	
CO-2	3	3	3	3	3				3	2	2	3	-	-	
CO-3	3	3	3	3	3				3	2	2	3	-	-	
CO-4	3	3	3	3	3				3	2	2	3	-	-	

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: IMAGE FORMATION PROCESS	**(6L)**
Introduction – Elements of machine vision system – Image model: perspective geometry, image function – Radiometrical model	**CO-1** **BTL-2**
MODULE 2: SEGMENTATION	**(6L)**
Gray level thresholding – locally adaptive thresholding – edge detection – Connected component labelling – Crack and border following – Region based segmentation – Morphological Image processing: Binary erosion – dilation – opening – closing operations – hit or miss transform – Gray scale morphology	**CO-2** **BTL-3**
MODULE 3: ENHANCEMENT	**(6L)**
Gray scale modification – Histogram modification – convolution - Image filtering: Smoothing – Sharpening – average - median	**CO-3** **BTL-3**
MODULE 4: RECOGNITION	**(6L)**
Blob analysis – Hough transform techniques – Geometric constraints – Texture - matching - classification	**CO-4** **BTL-2**
MODULE 5: CASE STUDY	**(6L)**
Inspection – Gauging – Guidance – Identification, Dimensional Checking, Color Sorting, Shape Recognition applications **Suggested Readings:** Industrial case studies using machine vision	**CO-1** **BTL-5**

TEXT BOOKS

1.	González, Rafael C. and Woods, Richard Eugene, Digital Image Processing, 3rd Edition, Prentice Hall, 2008

REFERENCE BOOKS

1	Davies, E.R., Machine Vision: Theory, Algorithms, Practicalities , Academic Press, London, 1990
2	Haralick, R.M. and Shapiro, L.G., *Computer and Robot Vision (Volumes I and II)*, Addison-Wesley, Reading Massachusetts, 1990
E BOOKS	
1.	http://freecomputerbooks.com/Programming-Computer-Vision-with-Python.html
MOOC	
1	https://www.mooc-list.com/course/robotic-vision-processing-images-futurelearn

NON-DEPARTMENTAL ELECTIVES – SEMESTER VI

COURSE TITLE	**IMMERSIVE TECHNOLOGIES**			**CREDITS**	**2**
COURSE CODE	**MHD4392**	**COURSE CATEGORY**	**DE**	**L-T-P-S**	**1-1-0-0**
Version	**1.0**	**Approval Details**	**23 ACM, 06.02.2021**	**LEARNING LEVEL**	**BTL-5**
ASSESSMENT SCHEME					
First Periodical Assessment	**Second Periodical Assessment**	**Seminar/ Assignments/ Project**	**Surprise Test / Quiz**	**Attendance**	**ESE**
15%	**15%**	**10%**	**5%**	**5%**	**50%**
Course Description	Due to its potential benefits, immersive technologies such as augmented reality, virtual reality, mixed reality and 360 VR are increasingly incorporated in various applications. These technologies can provide a platform for increased engagement, immersion, interaction, enjoyment, and experience. This course aims to provide an understanding of this technology and its capabilities. Also, this course will enable to develop content using immersive technologies.				
Course Objective	1. To establish a broad and comprehensive understanding immersive applications 2. To work in collaborative group projects and develop working prototypes 3. To experiences different immersive technologies that can be used in various applications,				
Course Outcome	Upon completion of this course, the students will be able to 1. Distinguish between the various immersive technologies and available resources 2. Reflect on the experience with immersive technologies 3. Identify a suitable immersive technology for a given application 4. Evaluate a use case and identify the important considerations when designing an application using immersive technology.				
Prerequisites:					

CO, PO AND PSO MAPPING

CO	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO-10	PO-11	PO-12	PSO-1	PSO-2	
CO-1	2	3	3	1	3	2	2	1	2	2	2	2	2	-	
CO-2	2	3	3	1	3	1	1	1	1	1	1	1	2	-	
CO-3	2	3	3	1	3	1	1	1	1	1	1	1	2	-	
CO-4	2	3	3	1	3	1	1	1	1	1	1	1	2	-	

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: INTRODUCTION TO IMMERSIVE TECHNOLOGIES	**(4L)**
Introduction to Immersive Technologies – History – Types - Interactions **Suggested Readings:** Immersive Technology: What is it and How can we Use it Today?	**CO-1** **BTL-2**
MODULE 2: BUILDING IMMERSIVE ENVIRONMENTS	**(7L)**
Working with Unity 3D, Objects and Scale – Creating a simple diorama – VR Device integration - Experiencing virtual reality **Suggested Readings:** Creating Immersive Virtual Environments with Unity	**CO-2** **BTL-3**
MODULE 3: USER INTERACTIONS	**(7L)**
Interactions with virtual environments – Controllers – Raycast – Particle effects **Suggested Readings:** Gesture Interaction in Virtual Reality	**CO-2** **BTL-3**
MODULE 4: AUGEMNTED REALITY AND MIXED REALITY	**(7L)**
Introduction to Augmented Reality , Mixed reality – AR Toolkit **Suggested Readings:** Virtual Reality Vs Augemented Reality Vs Mixed Reality	**CO-3** **BTL-2**
MODULE 5: CASE STUDY	**(5L)**
A case study on design of an application using immersive technologies **Suggested Readings:** Industrial case studies using immersive technologies	**CO-4** **BTL-5**

TEXT BOOKS

1.	Lawrence, C. (2016). Cyber security for Dummies,John Wiley & Sons Inc., 2nd Edition, pp.213--432.

REFERENCE BOOKS	
1	Jason Jerald. (2015), The VR Book – Human Centered Design for Virtual Reality, Morgan & Claypool
2	Tony Parisi. (2016), *Learning Virtual Reality*, O'Reilly Media, 2016
E BOOKS	
1.	https://profs.info.uaic.ro/~avitcu/FII%202015-2016/Animatie%203D_Documentatie/ VR.pdf
MOOC	
1	https://in.udacity.com/course/introduction-to-virtual-reality--ud1012
2	https://www.edx.org/course/creating-virtual-reality-vr-apps-uc-san-diegox-cse190x

COURSE TITLE	DESIGN THINKING AND PRODUCT DEVELOPMENT			CREDITS	2
COURSE CODE	MHD4393	COURSE CATEGORY	NE	L-T-P-S	3-0-0-2
Version	1.0	Approval Details	23 ACM, 06.02.2021	LEARNING LEVEL	BTL-3
ASSESSMENT SCHEME					
First Periodical Assessment	Second Periodical Assessment	Seminar/ Assignments/ Project / Practical	Surprise Test / Quiz	Attendance	ESE
15%	15%	10%	5%	5%	50%
Course Description	Design thinking is a process for solving problems by prioritizing the consumer's needs It relies on observing, with empathy, how people interact with their environments, and employs an iterative, hands-on approach to creating innovative solutions. Product development is the complete process of taking an idea from concept to delivery and beyond. Whether you are delivering a brand-new offering or enhancing an existing product, the product development cycle begins long before anything gets built.				
Course Objective	**The course should enable the students to** 1. Understand the concepts of design thinking process 2. Recall the process of product development 3. Apply the various concepts of Product design 4. Analyze the different types of Additive Manufacturing Process.				

	5. Analyze the concepts of design thinking and product development.
Course Outcome	**Upon completion of this course, the students will be able to** 1. Illustrate the steps involved design thinking process. 2. Organizing the process of product development in an organization. 3. Describe the concepts of 3D modeling, Product Architecture and Industrial design. 4. Examine the concepts of Additive Manufacturing for Manufacturing new prototypes 5. Select the suitable product development process for various Applications.
Prerequisites:	

CO, PO AND PSO MAPPING

CO – PO	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO-9	PO -10	PO -11	PO-12	PSO -1	PSO -2	PSO -3
CO-1	3	3	1	-	-	-	-	2	2	-	-	2	2	-	
CO-2	3	3	3	3	3	-	-	2	2	-	-	2	2	-	
CO-3	3	3	1	-	-	-	-	2	2	-	-	2	2	-	
CO-4	3	3	1	-	-	-	-	2	2	-	-	2	2	-	
CO-5	3	3	3	2	2	-	-	2	2	-		2	2	-	

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: I DESIGN THINKING	**(9L)**
Introduction, the process - Explore, Empathize, Experiment, Engage, prototyping, testing, Evolve.	**CO-1BTL-3**
MODULE 2: BASICS OF PRODUCT DEVELOPMENT	**(9L)**
Development processes and organization, Product planning, Identifying Customer needs, Product Specifications, concept – Generation, selection & testing.	**CO-2 BTL - 3**
MODULE 3: PRODUCT DESIGN	**(9L)**
Product architecture, Industrial design, Design for manufacturing, 3D CAD Modeling	**CO – 3BTL - 3**
MODULE 4: PROTOTYPING	**(9 L)**
Understanding prototypes, Principles of prototyping, Planning of prototypes, Rapid prototyping technologies - SLA, SLS & FDM.	**CO-4BTL - 4**

MODULE 5: CASE STUDIES	(9L)
Review of success and failure models, Activities	CO – 5BTL - 4

TEXT BOOKS	
1.	Thomke, Stefan H., and Ashok Nimgade. "IDEO Product Development." Harvard Business School Case 600-143, June 2000.
2.	Tim Brown, Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation, 2009

REFERERENCE BOOKS	
1.	Thomas Lockwood and Edgar Papke, Innovation by Design: How Any Organization Can Leverage Design Thinking to Produce Change, Drive New Ideas, and Deliver Meaningful Solutions
2.	Ulrich, Karl, and Steven Eppinger. Product Design and Development. 3rd Edition. McGraw-Hill, 2003.
3.	Groover, CAD/CAM: Computer-Aided Design and Manufacturing, Pearson Education India, 1984.
4.	Chee Kai Chua, Kah Fai Leong, Chu Sing Lim. Rapid Prototyping: Principles and Applications, World Scientific 2003.
5.	A. K. Chitale, R. C. Gupta. Product Design And Manufacturing. PHI India Publications, 2013.

COURSE TITLE	INDUSTRY 4.0			CREDITS	2
COURSE CODE	MHD4394	COURSE CATEGORY	PC	L-T-P-S	2-0-0-2
Version	1.0	Approval Details	23 ACM, 06.02.2021	LEARNING LEVEL	BTL- 4

ASSESSMENT SCHEME

First Periodical Assessment	Second Periodical Assessment	Seminar/ Assignments/ Project / Practical	Surprise Test / Quiz	Attendance	ESE
15%	15%	10%	5%	5%	50%

Course Description	Fourth Industrial revolution is very much driven by the smarts in automating decision making and processes. Industry 4.0 concerns the transformation of industrial processes through the integration of modern technologies such as sensors, communication, and computational processing. Technologies such as Cyber Physical Systems (CPS), Internet of Things (IoT), Cloud Computing, Machine Learning, and Data Analytics are considered to be the different drivers necessary for the transformation. Advancements in technology has resulted in immense improvements in computational power across nearly all electronic devices and enhanced capabilities in connecting the dots in an increasingly networked society. Industrial Internet of Things (IIoT) is an application of

	IoT in industries to modify the various existing industrial systems. IIoT links the automation system with enterprise, planning and product lifecycle.
Course Objective	**The course should enable the students to** 1. Explore various sensors, peripheral devices and networking protocol applied in industries. 2. Realize the challenges faced for the effective implementation of Industry 4.0 in industrial applications. 3. Gain good depth of fundamental knowledge in designing Industrial IOT Systems for various application. 4. Identify the underlying principle of various systems and models to solve engineering problems by using Industrial IoT . 5. Develop solution for Real time problems using acquired skills of Industrial applications with IoT capability.
Course Outcome	**Upon completion of this course, the students will be able to** 1. Infer knowledge in the basics of sensors, communication and networks commercialized in industries. 2. Analyze the challenges and opportunities brought about by Industry 4.0 and appreciate the smartness in Smart Factories, Smart cities, smart products and smart services. 3. Comprehend the fundamentals of Industrial processes, Business model and architecture deploying industrial IoT. 4. Outline the various systems and models used in a Industries and their role in an Industry 4.0 world. 5. Illustrate the applications of Industry 4.0 with real-time case studies.
Prerequisites : Basic knowledge of computer network and internet	

CO, PO AND PSO MAPPING

CO - PO	PO -1	PO -2	PO -3	PO -4	PO -5	PO -6	PO -7	PO -8	PO-9	PO -10	PO -11	PO-12	PSO -1	PSO -2	PSO -3
CO-1	3	3	3	3	2	-	1	-	2	3	3	-	-	-	
CO-2	3	3	3	3	2	-	1	-	2	3	3	2	-	-	
CO-3	3	3	3	3	2	-	1	-	2	3	3	-	-	-	
CO-4	3	3	3	3	2	-	1	-	2	3	3	-	-	-	
CO-5	3	3	3	3	2	-	1	-	2	3	3	2	-	-	

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: INTRODUCTION (9L)

Introduction – Sensing and Actuation – Communication – Networking – Globalization and Emerging Issues – The Fourth Revolution – LEAN Production Systems **Suggested Readings:** ● Comparison of Industry 4.0 Factory and Today's Factory	**CO-1** **BTL-2**

MODULE 2: SMART INDUSTRY	(9L)
Smart and Connected Business Perspective – Smart Factories – Cyber Physical Systems and Next Generation Sensors – Collaborative Platform and Product Lifecycle Management – Cyber security **Suggested Readings:** ● Augmented Reality and Virtual Reality, Artificial Intelligence	**CO-2** **BTL-3**
MODULE 3: INDUSTRIAL IOT	**(9L)**
Introduction –Industrial Sensing and Actuation – Industrial Processes – Business Model and Architecture - Industrial IoT Layers - Communication - Networking – Processing **Suggested Readings:** ● Industrial Internet Systems	**CO-3** **BTL-3**
MODULE 4: IIoT ANALYTICS AND DATA MANAGEMENT	**(9L)**
Introduction – Machine Learning and Data Science - Cloud and Fog Computing - Programming -Data Management with Hadoop -Data center Networks – SDN - Security **Suggested Readings:** ● R and Julia Programming	**CO-4** **BTL-4**
MODULE 5: APPLICATIONS AND CASE STUDIES	**(9L)**
Application Domains : Factories and Assembly Line - Food Industry - Inventory Management & Quality Control-Plant Safety and Security-Facility Management- Oil, chemical and pharmaceutical industry-Applications of UAVs in Industries Case Studies : Milk Processing and Packaging Industries – Manufacturing Industries – Virtual Reality Lab– Steel Technology Lab **Suggested Readings:** ● Smart home Applications	**CO-5** BTL-4

TEXT BOOKS	
1	Alasdair Gilchrist (2016). *Industry 4.0: The Industrial Internet of Things*, Apress
2	Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat (2017). *Industrial Internet of Things: Cyber manufacturing Systems*, Springer
REFERENCE BOOKS	
1	*Ovidiu Vermesan, Peter Friess (2013).* Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems*, River Publishers Series in Communications and Networking*
2	Christoph Jan Bartodziej (2017). The Concept Industry 4.0: An Empirical Analysis of Technologies and Applications in Production Logistics, Springer Gabler
E BOOKS	

1	https://link.springer.com/book/10.1007/978-1-4842-2047-4?noAccess=true
2	https://link.springer.com/book/10.1007/978-3-319-57870-5?noAccess=true
MOOC	
1	https://nptel.ac.in/courses/106105195
2	https://www.edx.org/course/industry-40-how-to-revolutionize-your-business

COURSE TITLE	**PRODUCT PROTOTYPING**			**CREDITS**	**2**
COURSE CODE	**MHD4481**	**COURSE CATEGORY**	**NE**	**L-T-P-S**	**2-0-2-1**
Version	**1.0**	**Approval Details**	**23 ACM, 06.02.2021**	**LEARNING LEVEL**	**BTL- 4**
ASSESSMENT SCHEME (Everything is based on Projects)					
First Periodical Assessment	**Second Periodical Assessment**	**Seminar/ Assignments/ Project / Practical**	**Surprise Test / Quiz**	**Attendance**	**ESE**
15%*	**15%***	**20%***	**--**	**--**	**50%***
Course Description	Course is Project based learning (PBL).3D Printing uses software that slices the 3D model into layers (0.01mm thick or less in most cases). Each layer is then traced onto the build plate by the printer, once the pattern is completed, the build plate is lowered and the next layer is added on top of the previous one. Typical manufacturing techniques are known as 'Subtractive Manufacturing' because the process is one of removing material from a preformed block. Processes such as Milling and Cutting are subtractive manufacturing techniques. This type of process creates a lot of waste since; the material that is cut off generally cannot be used for anything else and is simply sent out as scrap. 3D Printing eliminates such waste since the material is placed in the location that it is needed only, the rest will be left out as empty space.				
Course Objective	**The course should enable the students to** 1. Apply the concept of design and process optimization. 2. Select suitable materials for 3D Printing. 3. Explain the concept of photo polymerization and extrusion process system. 4. Explain the concept of Powder bed fusion and direct energy system. 5. Apply the architecture of IoT in 3D Printing.				

Course Outcome	**Upon completion of this course, the students will be able to** 1. Apply the concept of design and process optimization for 3D printing. 2. Select suitable materials in additive manufacturing for various applications. 3. Explain the concept of photo polymerization and extrusion process system 4. Explain the concept of Powder bed fusion and direct energy system. 5. Apply the architecture of IoT in various 3D Printing process and application

Prerequisites:

CO, PO AND PSO MAPPING

CO - PO	PO -1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8	PO-9	PO -10	PO-11	PO-12	PSO-1	PSO-2	PSO-3
CO-1	1	1	1	1	1	-	-	2	1	2	-	1	-	-	
CO-2	1	1	1	1	1	-	-	2	1	2	-	1	-	-	
CO-3	1	1	1	1	1	-	-	2	1	2	-	1	-	-	
CO-4	1	1	1	1	1	-	-	2	1	2	-	1	-	-	
CO-5	1	1	1	1	1	-	-	2	1	2	-	1	-	-	

1: Weakly related, 2: Moderately related and 3: Strongly related

MODULE 1: DESIGN FOR 3D PRINTING	**(9L)**
Introduction of AM – Basic Principle-Generic 3D Printing process – DFAM concepts and objectives-3D printing unique capabilities –Exploring design freedoms – Design tools for 3D Printing- Guidelines for process selection.	**CO-1** **BTL-3**
MODULE 2: MATERIALS FOR 3D PPRINTING	**(9L)**
Classification of polymer and metallic materials –Properties of AM materials – Application of AM material – Atomic structure and bonding-ceramics – polymer- powdered materials- composites- Multiple materials in AM – Multiple – discrete – porous – blended.	**CO-2** **BTL-3**
MODULE 3:PHOTOPOLYMERIZATION PROCESSES AND EXTRUSION BASED SYSTEM	**(9L)**
Photopolymerization materials – Reaction Rates – Vector scan SL - SL Resin Curing Process - SL Scan Patterns - Vector Scan Microstereolithography - Mask Projection Photopolymerization Technologies and Processes - Two-Photon SL - Extrusion-Based Systems – Basic Principles - Plotting and Path Control - Fused Deposition Modeling – Materials – Limitation – Bio extrusion - FDM of Ceramics	**CO-3** **BTL-3**
MODULE 4: POWDER BED FUSION AND DIRECT ENERGY SYSTEM	**(9L)**

SLS process - Powder Fusion Mechanisms - Powder Handling – Process parameters – Materials – Application – SLM Process – Process parameters – Materials – Application – DMLS process – Process parameters – materials – application – EBM process – process parameters – materials – application – LENS process – process parameters – materials – application.	**CO-4** **BTL-3**
MODULE 5:ARTIFICIAL INTELLIGENT IN ADDITIVE MANUFACTURING	**(9L)**
Overview of AI – Types of intelligent agents – AI model – AI enabled 3D Printing–3D Printing-based product development - Intelligent agents for product design - Intelligent agents for process design - Intelligent agents for production - Global methods - Framework of smart AM - Artificial Intelligence Applications in 3D Printing.	**CO-5** **BTL-4**

TEXT BOOKS	
1	*Ian Gibson, David W.Rosen, Brent Stucker, "Additive Manufacturing Technologies", Springer, 3rd edition, 2020.*
2	*Patri.K.Venuvinod and Weiyin Ma. "Rapid Prototyping" Springer science+ business Media, LLC, 2004.*
REFERENCE BOOKS	
1	*Andreas Gebhardt, Hanser "Rapid Prototyping", Gardener Publications, 2003*
2	*.LiouW.Liou, Frank W.Liou, "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2007.*
3	*. Chua C.K. Leong K.F., and Lim C.S., "Rapid prototyping: Principles and application", Second edition, World Scientific Publishers, 2010*
MOOC	
1	https://nptel.ac.in/courses/112/104/112104265/
2	https://www.coursera.org/specializations/3d-printing-additive-manufacturing