Academic Document for the Programme

M Tech in Robotic Engineering

Program Code – 074

Batch – 2022 - 2024

RAMAIAH UNIVERSITY OF APPLIED SCIENCES

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Faculty	Engineering and Technology
Department	Mechanical and Manufacturing Engineering
Name of the Programme	M Tech in Robotic Engineering
Programme Code	074
Mode of Study	Full Time
Date of Commencement of the Programme	August 2022
Date of Programme Approval by the Academic Council of MSRUAS	June 2019

1. Programme Objective

The aim of the programme is to produce postgraduates with advanced knowledge and understanding of contemporary Robotics systems development; higher order critical, analytical, problem solving and transferable skills; ability to think rigorously and independently to meet higher level expectations of industry, academics, research or take up entrepreneurial route.

2. Programme Outcomes (POs) / Graduate Attributes

PO 1. Discuss the importance of robots in various applications
PO 2. Design, develop geometric models of robots and perform kinematic and dynamic analysis
PO 3. Select sensors, actuators, drives, end effectors and control systems for robots based on application
PO 4. Develop on board real-time decision making capabilities in robots through image and signal processing
PO 5. Design, develop and simulate robotic systems to meet varied functional and operational Requirements
PO 6. Develop a career in Robotics and Automation
PO 7. Practice Teamwork, lifelong learning and continuous improvement

3. Programme Specific Outcomes (PSOs)

The programme specific outcomes are listed under four headings:

1. Knowledge and Understanding
2. Cognitive skills
3. Practical skills and
4. Capability/Transferable skills

Knowledge and Understanding: After undergoing this programme, a student will be able to:

PSO1: Explain the design and working of robotic systems, principles of sensors and its use in controlling robotic motion
PSO2: Infer robotic system requirement for an application
PSO3: Explain the kinematics and dynamics of robots and their effect
PSO4: Discuss significance of sensors, actuators, end effectors, drives and control systems, image processing algorithms in robot design

Cognitive Skills: After undergoing this programme, a student will be able to:

PSO5: Plan and arrive at conceptual configuration of a robot system for a given set of functional requirements
PSO6: Develop an image processing flow diagram and appropriate algorithms for robotic system hardware platform for a specific application
PSO7: Design, model and simulate appropriate control systems for robotic operation

PSO8: Synthesise spatial mechanism for a robot to the defined application

Practical Skills: After undergoing this programme, a student will be able to:

PSO9: Create virtual models and analyse robotic systems

PSO10: Use commercially available tools for modelling, simulation and analysis of robot mechanisms and controls

PSO11: Develop program for robotic systems

PSO12: Build robot using subsystems

Capability Skills / Transferrable Skills: After undergoing the programme, a student will be able to:

PSO13: Manage information, develop technical reports and make presentations

PSO14: Build, Manage and Lead a team to successfully complete a project and communicate across teams and organizations to achieve professional objectives

PSO15: Work under various constraints to meet project targets

PSO16: Adopt to the chosen profession by continuously upgrading his/her knowledge and understanding through Life-long Learning philosophy

4. Eligibility for Admission:

4.1. Eligibility for students seeking admission under Government of Karnataka quota (for 40% seats):

i. A candidate seeking admission to postgraduate programme must have passed graduate level in Engineering and Technology in a related discipline with at least 50% marks in aggregate or equivalent CGPA.

ii. A candidate belonging to SC/ST category will be entitled to a relaxation in the qualifying marks in accordance with the related government notification in this regard.

4.2. Eligibility for Indian students seeking admission under the university quota:

Students seeking admission under University quota must have passed graduate level degree in Engineering in a related discipline with at least 50% marks in aggregate or equivalent CGPA.

4.3. Eligibility for foreign students seeking admission under University quota:

i.Foreign students should have Association of Indian Universities recognized first degree qualification in the Engineering related discipline of equivalent

ii. Should have proof of proficiency in English.

4.4: Selection of Students

Selection of students for admission under Government of Karnataka will be based on Karnataka

Government notified admission tests.

Selection of students for admission to University quota of seats is based on admission policy of the University notified from time to time.

Selection of foreign students for admission to University quota of seats is based on the admission policy of the University notified from time to time.

4.4.1: Admission to Programme

Selected candidates shall complete the admission procedure within the prescribed date by paying the prescribed fees and completing all other admission formalities notified by the University. Failure to do so may lead to cancellation of the selection.

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4.4.2: Annual Programme Fee
Details of the fees payable for each Programme will be notified well in advance to the commencement of the programme.

The fees, once paid, will not be refunded under any circumstances.
The continuation of a student's registration in subsequent academic years is subject to payment of the prescribed programme and registration fees for each of those years.

4.4.3: Free-ship and scholarships
The Board of Management, in consultation with the Board of Governors, may consider offering free ships / scholarships to deserving students who maintain a minimum level of academic performance on a yearly basis.

5. Programme Duration

5.1. Normal Duration: The normal duration of the M.Tech. postgraduate programme is:

a. Two years in the Full-Time Route
b. Three years in the Part-Time Route

5.2. Maximum Duration: The maximum period a student is allowed to complete the M.Tech Programme shall be double the normal duration of the programme, i.e., Four Years for Full-Time students and Six years for Part-Time students.

5.3. Duration for Lateral Entry Scheme: N/A

6. Medium of Instruction

English is the medium of instruction for the programme.

7. Programme Structure

The programme structure is presented in **Appendix A**.

8. Programme Curriculum

The programme curriculum is presented in **Appendix B**.

9. Attendance Requirement

A student is required to have a minimum attendance of 80% to be eligible to appear for the examination and for assignment submission. Students who fail to achieve the minimum attendance will be declared as "FAIL". A failed student is required to re-register, attend the course and take up all the components of assessment at the next offering.

10. Assessment

10.1. Achievement Testing: During each semester, students' performance is assessed through two components, Continuous Evaluation (CE) and a Semester-End Examination (SEE). Both CE and SEE carry equal weight.

10.1.1. Continuous Evaluation (CE): This includes term tests, assignments, viva-voce, quiz, seminars, mini projects and other such evaluation methods designed for specific courses and conducted as per the norms of the University for Assessment.

10.1.2. Semester End Examination (SEE): This includes a written/laboratory examination conducted as per the norms of the University for Assessment.

The attainment of student in all COs are evaluated. A typical evaluation template in a theory course is presented in Table 1. A student is required to score a minimum of 40% marks in each course, scoring a minimum of 40% in each of CE and SEE.

Table 1: Typical evaluation template for a theory course

Course Outcome	CE (Weightage: 50 %)				SEE (Weightage: 50 %) Semester End Exam
	Component	Component	Component	Component	
	XX Marks	XX Marks	XX Marks	XX Marks	50 Marks
CO-1					
CO-2					
CO-3					
CO-4					
CO-5					
CO-6					

In the case of a laboratory course, there are two components: Component-1 and Component-2. Component-1 (CE) carries a weight of 50% and Component -2 (SEE) carries a weight of 50%.

The template for weightage of CE and SEE in percentages for each course is indicated in Table 2.

Table 2: Typical evaluation template for a laboratory course

Course Outcome		CE (Weightage: 50 %) 25 Marks				SEE (Weightage: 50 %): 25 Marks
	Assessment Type	Conduction of Lab Exercises	Viva-Voce	Lab Record Submission	Lab Test	SEE
	Component Weightage	10 Marks	05 Marks	05 Marks	05 Marks	25 Marks
CO-1						
CO-2						
CO-3						
CO-4						
CO-5						
CO-6						

10.1.2: Second Assessment and External Review

Each student's work is first assessed by the Course teaching team. All the answer scripts of a given course are to be assessed by a second examiner. 10% of the evaluated scripts will be further reviewed by an examiner who is external to the University. An External examiner will have tenure of 2 years which can be renewed for a further period of 2 years. The first assessor or assessing team is required to fill in the evaluation data and write the Post Module Assessment Report (PMAR).

10.1.2.2: Feedback on Assessed work

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The awarded marks and distribution pattern will be reviewed by the Dean of the Faculty before scheduling a face-to-face feedback session with the student. After completing assessment of the course, the course teaching team along with the concerned Head of the Department should provide face-to-face feedback to the student regarding his/her performance after handing over the assessed documents on a prescheduled day. After the feedback, the assessed documents are collected and deposited with the Examination and Assessment Unit of the Faculty.

10.3. Credits not earned in a Course and Opportunities for Make-up:
A minimum of 40 % marks in the assignment and a minimum of 40% marks in the written examination are required for successful completion of a course. A student failing in any one of the components will be declared 'FAILED' in the course. A failed student who has fulfilled the attendance criterion is eligible to re-sit under the fast track scheme.

There is no provision for a re-examination or re-submission of any of the assessment components for a failed course.

A maximum of 3 attempts, including the first attempt, are permitted for successful completion of a course.

11. Academic Awards

Award of Grades: Students will be awarded grades based on the marks scored. The basis for awarding grades is shown in Table 3.

Table 3: Grade Definition and Grade Points

Sl. No.	Marks Scored	Grading	GPA Grade Points
1.	91-100	O (Outstanding)	10
2.	75-90	A+ (Excellent)	9
3.	61-74	A (Very Good)	8
4.	55-60	B+ (Good)	7
5.	50-54	B (Above Average)	6
6.	45-49	C (Average)	5
7.	40-44	P (Pass)	4
8.	Below 40	F (Fail/Absent) RS – Re-sit RR – Re-registration	0
'RS' and 'RR' to be considered as 'F' for SGPA and CGPA calculations.			

The SGPA is indicated in the transcript only if all credits prescribed for the semester are earned by the student.

Computation of CGPA:

$$\text{CGPA} = \frac{\sum_1^N \text{Grade points scored in a given course} \times \text{Number of credits for that course}}{\text{Total number of registered credits}}$$

Here, N is the total number of courses registered for in a semester.

Example: Typical SGPA and CGPA calculations for two semesters are shown in Table 4.

Table 4: SGPA and CGPA calculations for two semesters					
SGPA and CGPA: Sem-1 (All courses excluding 'Consideration Courses')					
Course	**Grade**	**Grade Point (GP)**	**Credit**	**GP * Credit**	
C1	A	8	4	32	**SGPA** = 129/18 = 7.166 = 7.17
C2	B+	7	4	28	
C3	C	5	3	15	
C4	B	6	4	24	
C5	O	10	3	30	
		Total	**18**	**129**	
Cumulative Credits and Grade Point * Credits			**18**	**129**	**CGPA** = 129/18 = 7.17
SGPA and CGPA: Sem-2 (All courses excluding 'Consideration Courses')					
Course	**Grade**	**Grade Point (GP)**	**Credit**	**GP * Credit**	
C10	O	10	3	30	**SGPA = 97/14 = 6.93**
C11	A+	9	3	27	
C12	C	5	4	20	
C13	C	5	4	20	
		Total	**14**	**97**	
Cumulative Credits and Grade Point * Credits			**18 + 14 = 32**	**129 + 97 = 226**	**CGPA** = 226/32 = 7.0625 = 7.10

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Appendix A

Programme Structure

The Programme consists of four semesters as shown below. A student is required to successfully complete the following courses and earn credits for the award of the degree.
Complete details of each of the courses such as ILO's, content, resources, teaching-learning processes and other related information are outlined in Course Specification of the respective programme.

SEMESTER 1

Sl.No.	Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Total Credits	Max. Marks
1	19MME501A	Computer Aided Design and Engineering	3	1	2	5	100
2	19RBC501A	Robotic Systems and Applications	4			4	100
3	19RBC502A	Robot Kinematics and Dynamics	3	1	2	5	100
4	19RBC503A	Mechatronics -1	3	1		4	100
5	19RBC504A	Mechatronics -2	3	1		4	100
6	19FET508A	Research Methodology & IPR	2	--	--	2	50
7	19FET509A	Professional Communication	1	--	--	0	
		Total	**19**	**2**	**4**	**24**	**550**
	25 hours						
	Minimum			**19**		**Maximum**	**24**

SEMESTER 2

Sl.No.	Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Total Credits	Max. Marks
1	19RBC505A	Control Systems for Robots	3	1		4	100
2	19RBE5X1A	*Refer Elective Course Table*	3	1		4	100
3	19RBE5X2A	*Refer Elective Course Table*	3	1		4	100
4	19RBE5X3A	*Refer Elective Course Table/ MOOC*	3	1		4	100
5	19RBE5X4A	*Refer Elective Course Table/ MOOC*	3	1		4	100
9	19FET510A	Value Education	1			0	
			16	**5**	**X**	**20**	**500**
			21 hours				
			Minimum	**16**		**Maximum**	**20**

SEMESTER 3

Sl.No.	Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Total Credits	Max. Marks
X	19RBP521A	*Internship*			10	4	100
	19RBP522A	Group project			15	8	200
	19RBP523A	Dissertation – Phase -1					
Total					25	12	300
Total number of contact hours per week			XX hours				
Number of credits can be registered			Minimum	XX		Maximum	XX

SEMESTER 4

Sl.No.	Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Total Credits	Max. Marks
	19RBP523A	Dissertation and Publication – Phase - II			24	24	400
Total					24	24	400
Total number of contact hours per week			24 hours				
Number of credits can be registered			Minimum	24		Maximum	24

Elective Course List			
Stream / Specialization	**S. No.**	**Course Code**	**Course Title**
Stream-1: Robotic System Design	E11	**19RBE511A**	Image Processing for Robotics
	E12	**19RBE512A**	Embedded Systems and programming for Robots
	E13	**19RBE513A**	Machine Learning and Applications
	E14	**19RBE514A**	Robot System Design and Development
Stream-2: Industrial Robotics	E21	**19RBE521A**	Industrial Robotics and Automation
	E22	**19RBE522A**	Computer Vision
	E23	**19RBE523A**	Design of End Effectors
	E24	**19RBE514A**	Robot System Design and Development

Note:
The Vacations and other activities shall be as per the Timetable for the corresponding batch.

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Course Title	Computer Aided Design and Engineering
Course Code	19MME501A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The course deals with creation of geometric models and performing finite element analysis of engineering components/assemblies as part of product development cycle. Students are taught the principles of geometric modeling and engineering analysis and are trained to use commercial 3D modeling, discretisation and finite element analysis tools. They will also be trained to carry out reverse engineering and rapid prototyping processes to create engineering components.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Specify and evaluate tools and techniques of CAE and their role in product development cycle
- **CO 2.** Create geometric models and generate manufacturing drawings of engineering components
- **CO 3.** Create rapid prototype model of a reverse engineered engineering component
- **CO 4.** Develop finite element model for different types of analysis using Hyper-Mesh software
- **CO 5.** Perform discretisation and engineering analysis using geometric modelling tools like CATIA and ANSYS software

Course Contents

Unit 1: CAE Systems:
Need and role of CAE systems in product realisation process, Emerging trends in CAE systems, Fundamental geometric modelling and computer graphics techniques, algorithms connected with geometric modelling. Considerations for selection of Computer Aided Design/CAM hardware and software

Unit 2: Geometric Modelling:
CAD techniques for generating three-dimensional, wire frame, surface, and solid models, Preparation of design documents according to current ISO and ANSI standards, GD and T, Preparation of production drawing

Unit 3: Reverse Engineering and Rapid Prototyping:
Reverse Engineering, Rapid Prototyping, Rapid tooling, Virtual Reality applications in product development

Unit 4: Finite Element Modelling:
Modelling consideration: Types of elements, element selection (kind, type size and order), meshing techniques, representation of geometry, material models, application of loads, representation of and application of boundary condition, Grid independence study, Post processing of results and discussions

Unit 5:
Demonstration of different types of Finite Element Analysis examples / case studies

Unit 6:
Laboratory Practice:

Geometric Modelling exercises using CATIA Finite Element Modelling using ANSYS
Reverse Engineering practice using 3D laser scanner and RP practice using FDM

Course Resources

a. Essential Reading

1. Class Notes
2. Chris McMahon and Jimmie Browne, (2005), CAD-CAM Principles, Practice and Manufacturing Management, 2nd Edition, Pearson Education.
3. Ibrahim Zeid, (2008), Mastering CAD/CAM, Tata McGraw-Hill.
4. O.C. Zienkiewicz, (2005), The Finite Element Method, Tata McGraw-Hill.

b. Recommended Reading

1. K.J. Bathe, (1997), Finite Element Procedures, 1st Edition, PHI, New Delhi.
2. Robert D. Cook, David S. Malkus, Michael E. Plesha and Robert J. Witt, (1998), Concepts and Applications of Finite Element Analysis, 4th Edition, Wiley Publications
3. Ibrahim Zeid and R. Sivasubramanian, (2008), CAD/CAM Theory and Practice, Tata McGraw-Hill.
4. Cornelius Leondes, (2000), Computer-Aided Design, Engineering, and Manufacturing: Systems Techniques and Applications, (Volume 1-7), CRC Press.
5. Kunwoo Lee, (1999), Principles of CAD/CAM/CAE Systems, Addison Wesley.

c. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Robotic Systems and Applications
Course Code	19RBC501A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The course deals with evolution of robot and its future application in varied fields. Anatomy of robots will be taught, applications and limitations of using robotic solutions will be discussed. System approach towards robotic solution will be explained. Applications of robots across different sectors will be explained and significant contributions will be analyzed.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the evolution and future of robotic systems and applications
- **CO 2.** Develop general idea of robot technology
- **CO 3.** Analyse the anatomy of given robotic system
- **CO 4.** Recognise the scope of robots in various applications
- **CO 5.** Select robotic solutions for varied domains

Course Contents

Unit 1: Introduction to robotic system:
Definition of robotic systems, Evolution of robotic systems and future of robotic systems; Global robotic industry; Challenges faced in both service and manufacturing sectors: health care, defence, agriculture, production, waste management etc.; Relevance of robotic systems and solutions for current and future social needs; socioeconomic impact

Unit 2: Overview of Robot Technology:
Definitions, standards and terminology; Robot and its peripherals, control systems and components, robot motion analysis and control, robot end effectors, sensors in robotics, machine vision

Unit 3: Anatomy of robotic systems:
Robot physical configurations; Basic robot motions; Different parts and functions in a robotic systems, manipulator, actuators, power sources, terminologies in robotics

Unit 4: Robotic Applications:
General considerations in robot applications; Robotic systems in general manufacturing; Robotic systems in electronics manufacturing; Robotic systems in Agriculture and forestry; Robotic in Construction; Medical Robotics and computer integrated surgery; Robots in rehabilitation and health care; Robotics in Hazardous Environments; Robots in defense; Domestic Robots; Humanoids; Biologically inspired robots

Unit 5: Industry 4.0:
Concepts and framework of Industry 4.0 and its developments

Course Resources

a. Essential Reading

1. Class Notes
2. Siciliano Bruno and Oussama Khatib (2008) Handbook of Robotics, Springer, Berlin.

3. Harry H. Poole (1989) Fundamentals of Robotics Engineering, 1st edition, Van Nostrand Reinhold, New York

b. Recommended Reading

1. Mikell P. Groover (2012) Specifications of Industrial Robotics: Technology, Programming, and Applications, 2nd Ed., Mcgraw Hill Education
2. Anthony DiGioia (2014) Computer and Robotic Assisted Hip and Knee Surgery, OUP Oxford, New York
3. Karl Mathia (2010) Robotics for Electronics manufacturing, Cambridge University Press
4. Russel A. Faust (2007) Robotics in Surgery: History, Current and Future Applications, Nova Publishers, New York
5. Y Baudoin, M K Habib (2010) Using Robots in Hazardous Environments, Elsevier, New Delhi
6. Shuuji Kajita (2014) Introduction to Humanoid Robotics, Springer, Berlin

c. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Robot Kinematics and Dynamics
Course Code	19RBC502A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The course deals with kinematic and dynamic analysis of robots. Students are taught basics of kinematics and dynamics of robotic manipulators. They are able to analyse rigid body motion and carry out forward and inverse kinematics of articulated arms. Students are able to perform dynamic analysis and estimate the forces and torque required to motion. Students are trained in using appropriate software tools to carry out manipulator kinematics and dynamics.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss basics of planar and spatial description, transformation, kinematics, dynamics and their importance in robotics
- **CO 2.** Apply D-H parameters for any robotic system
- **CO 3.** Perform forward and inverse kinematics on a manipulator
- **CO 4.** Evaluate forces and torque required to operate manipulators
- **CO 5.** Simulate kinematic and dynamic behaviour of robots using appropriate software tools

Course Contents

Unit 1: Introduction:
Basics of mechanisms – link, joints, rigid body, degrees of freedom; Principles of spatial mechanisms; Kutzbach's equation; Robotic manipulators; Robotic systems; Common robotic arrangements

Unit 2: Spatial description and transformation:
Position, orientation and frames; mappings; operators; translation, rotation and transformation; Composition of transformation, Compound transformation, Inverting a transform, transform equations; Euler angle representation

Unit 3: Manipulator Kinematics:
Link description, link connection description; frames to link fixing conventions; Denavit-Hartenberg parameters; Forward kinematics; workspace; Inverse kinematics; solvability; algebraic solution methods

Unit 4: Velocity and Acceleration:
Time varying position and orientation; linear and rotational velocity, angular velocity; Motion of a link; velocity propagation; Acceleration of a rigid body; Jacobians; singularities;

Unit 5: Static and Dynamic analysis:
Understanding the concepts of dynamic model, equivalent system, free body diagrams, mass distribution, mass moment of inertia; Force and moments; D'Alembert's principle; Static forces in manipulators; static force / torque relationships; Newton's and Euler's equations; Iterative Newton-Euler Dynamic Formulation, Closed form dynamic equations; Structure of Manipulator Dynamic Equations, Lagrangian Formulation, Manipulator Dynamics in Cartesian Space

Unit 6: Trajectory planning and generation:
General considerations in path description and generation, joint-space schemes, Cartesian-space schemes, geometric problems with cartesian paths, path generation at run time; collision-free path planning

Unit 7: Biomimetic:
Simulation of various biological inspired motions like crab, grasshopper, frog, lantern, etc.

Course Resources

a. Essential Reading

1. Class Notes
2. J. J. Craig (2005) Introduction to Robotics: Mechanics and Controls, 3rd edition,
3. Pearson Education Inc., Harlow.
4. R. L. Norton (2004) Design of Machinery, 3rd edition, McGraw-Hill.

b. Recommended Reading

1. K. S. Fu, R. C. Gonzalez and C. S. Lee (1987) Robotics: Control, Sensing, Vision and Intelligence, McGraw-Hill.
2. Mark W. Spong, Seth Hutchinson and M. Vidyasagar (2005) Robotic modeling and control, First edition, John Wiley and Sons, New York.
3. Robert J. Schilling (2003) Fundamentals of Robotics: Analysis and Control, Prentice-Hall, Inc., New Delhi.
4. J. M. Selig (1992) Introductory Robotics, Prentice Hall, New York.
5. Ashitava Ghosal (2006) Robotics: Fundamental Concepts and Analysis, Oxford University Press.
6. Jorge Angeles (2007) Fundamentals of Robotic Mechanical Systems: Theory, Methods and Algorithms, 3rd edition, Springer, New York.

c. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Mechatronics-I
Course Code	19RBC503A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with the concepts and application of electro-mechanical systems. Students are taught the principles of analog, digital and mixed signal circuits and their applications in the design and development of electromechanical subsystems. The standard device libraries used in the design of CMOS and OP-Amp circuits are emphasised. Students will be trained to design, implement and validate analog, digital and mixed signal circuits using software tools. The concepts of sensors and actuators are also emphasised in this course.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the theory of analog, digital and mixed signal circuits
- **CO 2.** Evaluate and analyse the stability performance of feedback amplifiers
- **CO 3.** Identify and select the appropriate Op-amp for the design of signal conditioning circuits
- **CO 4.** Apply mixed signal concepts in development of data converters
- **CO 5.** Apply microcontroller concepts to interface sensors and actuators
- **CO 6.** Design, integrate and demonstrate working of a mechatronic system for a robot

Course Contents

Unit 1: Introduction to Mechatronics:
Key elements of a mechatronic system, Examples of mechatronic systems

Electronic Components and Circuits:
Resistive Networks, Diode characteristics and its applications, Zener diode characteristics and its applications, Transistors-BJT, FET and MOSFET and their applications, ICs

Unit 2: Digital Electronics:
Logic functions and gates, Flip-flops, Combinational logic functions, sequential logic, Digital counters, Memory, Oscillators and clock generators, ICs

Unit 3: Analog Electronics and Feedback Amplifiers:
Loading effects – Impedance Matching, Op-amp as an amplifier, Ideal operational amplifier model, General Feedback Techniques and Circuits, Negative Feedback techniques (Nonlinear Distortion, Noise Reduction, Bandwidth Extension, Gain De-sensitivity), Inverting amplifier, Non- inverting amplifier, Unity-gain buffer, Summing amplifier, Difference amplifier, Instrumentation amplifier, Integrator amplifier, Differentiator amplifier, Current Amplifiers, Trans-conductance Amplifiers, Trans-resistance Amplifiers, Series- Shunt Feedback Amplifier, Comparator, Active filters, Op-amp Characteristics (Input bias, Input offset current, Input offset voltage, Thermal Drift)

Unit 4: Introduction to Microcontroller:
Introduction to Microprocessors and Microcontrollers, and their architectures, Van-Neumann and Harvard architecture, Instruction set architectures, Memory organizations and Memory Maps, Vector table, Registers, Stacks, Interrupts, Oscillators and Reset configurations, Instruction sets and Assembler Directives, Introduction to microcontroller Programming and peripherals Interfacing (Timer, UART, LCD,LED, KEYPAD, SPI,USB,I2C,Ethernet etc.), ARDUINO board

Unit 5: Data Acquisition:
Introduction to DAQ and its components, Sampling and aliasing, Quantization theory, Digital-to-analog conversion circuits, Analog-to-digital conversion circuits

Unit 6: Sensors:
Characteristics of a sensor, Classification of Sensor, Selection of Sensors, Distance sensors, Movement sensors, Proximity sensors, Electrical strain and stress measurement, Force measurement, Encoders, Temperature measurement, Pressure measurement , Accelerometer

Unit 7: Electrical actuator systems:
Electromagnetic transducers, Solenoids, Relays, Electric motors, Direct current motors, DC motors, servomotor, stepper motor and BLDC motor, Energy storage elements

Unit 8: Interfacing microcontrollers with Transducers:
Interfacing: relays, solenoids, stepper motors, permanent magnet motors, sensors and DAC

Course Resources

a. Essential Reading

1. Class Notes
2. Sendra Smith (2004) Microelectronic Circuits, Oxford University Press.
3. Godfrey Onwubolu (2002) Mechatro nics - Principles and Applications, Second edition, Elsevier

b. Recommended Reading

1. Lawrence T. Pillage, Ronald A. Rohrer and Chandramouli Visweswariah (1998) Electronic Circuit and System Simulation Methods, First edition, TMH Publications
2. M. H. Rashid (2011) Microelectronic Circuits: Analysis and Design, Second edition, Cengage Learning
3. Mark N. Horenstein (1996) Microelectronic Circuits and Devices, Prentice Hall.

c. Other Electronic Resources

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M.S. Ramaiah University of Applied Sciences

Course Title	Mechatronics-II
Course Code	19RBC504A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with implementation of mechanical, hydraulic and pneumatic actuators and end effectors in robotic applications. Students are taught basic principles of various mechanical, hydraulics and pneumatics drives and actuators, and their applications. Knowledge will be imparted on types of mechanical, hydraulic and pneumatic drives available for use in various applications and their selection procedures. Students are taught different types of end effectors, drives and actuators associated with end effectors and their design considerations. Students are trained to evaluate the dynamic response of hydraulic and pneumatic circuits through software.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss various mechanical, hydraulic and pneumatic control devices as applied to robotics
- **CO 2.** Analyze the robotic application for selecting appropriate end effector
- **CO 3.** Evaluate various mechanical, hydraulic and pneumatic component options and select the appropriate component for a robotic application
- **CO 4.** Design control circuit for robotic motion control and identify appropriate drive system
- **CO 5.** Create a drives circuit to achieve desired robot motion and to meet the specifications
- **CO 6.** Model and simulate hydraulic and pneumatic circuits using software for a robotic application

Course Contents

Unit 1: Mechanical drives, actuator and sensors:
Different types of mechanical sensors; characteristics of sensors; working of different feedback systems; types of gears and their applications, gear trains, rails, pulleys, cams, power screw; bearings and their selection; gear drives, belt and chain drives;

Unit 2: Hydraulics system:
Basic principles of hydraulic transmission system, pumps and motors; actuators; control valves; pressure valves; performance analysis; different types of hydraulic drives and their applications; component selection and circuit design

Unit 3: Pneumatic system:
Functions of the major components of pneumatic systems, compressors; pneumatic actuators; valves; selection of compressors and valves; different types of pneumatic drives and their applications

Unit 4:
Demonstration using hydraulic and pneumatic kits
Simulation of Drives and controls using software

Unit 5: End-effectors:
Types of end effectors, grippers, applications; drives and actuator system for end effectors and grippers; design considerations and guidelines for end effectors

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Course Resources

a. Essential Reading

1. Class Notes
2. A. Parr (2011) Hydraulics and Pneumatics, 3rd edition, Elsevier Ltd.
3. Mikell P. Groover (2012) Specifications of Industrial Robotics: Technology, Programming, and Applications, 2nd Ed., Mcgraw Hill Education.

b. Recommended Reading

1. Shimon Y. Nof (1999) Handbook of Industrial Robots, 2nd Edition, John Wiley and Sons.
2. Johnson James L. (2002) Introduction to Fluid Power, Thomson Delmar Learning.
3. G. E. Totten (1999) Handbook of Hydraulic Fluid Technology, CRC Press.
4. N. Sclater and N. P. Chironis (2007) Mechanisms and Mechanical Devices: Sourcebook, McGraw-Hill Professional.

c. Other Electronic Resources

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Bangalore

Course Title	Research methodology and IPR
Course Code	19FET508A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with the principles of research, research methodology, significant phases of research, Intellectual property and its rights. Students are taught the realistic guidelines to be followed in the choice of field of research, topic of research and formulation of research problem. Key and careful considerations in the choice of tools for the solution of research problem are covered in this course. The course emphasizes the desirable close knit relation between innovation and concept of out of the box thinking. The principles of effective research and the need for a Proactive approach in a successful research programme are also explained. The course discusses the significant role of Literature Review in a research cycle and the expectations from good literature review as well as procedure for systematic literature review. Students will get an insight into the privilege, honour and the associated responsibilities of a researcher. This course gives insight of the intellectual property rights and over view of the benefits.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Explicate the value, scope, relevance and mandatory steps of research as well as principles of effective research, Nature of Intellectual Property
- **CO 2.** Discuss the guidelines to progress from the choice of broad field of research to specific topic of research, patent rights, process of patenting at National and International level, New Developments in IPR
- **CO 3.** Demonstrate the application and utility of the Systematic approach and out of box thinking concepts for research to be effective
- **CO 4.** Adapt ,Analyze and prepare well-structured research proposal and research paper invoking clearly outlined principles

Course Contents

Unit 1 :
Foundations of Research – Definitions of Research, Mandatory Steps in Research, Types of Research, Relevance of Research for Innovation and Technology Development, Effective Research and Self Discipline.

Unit 2 :
Formulation of Research Problem: Identification of problems, Narrowing down the problem, Factors to be considered for problem selection. History and Evolution of Science & Technology

Unit 3 :
Out Of the Box Thinking and Systematic approach in Research – Transformation to Impossible Thinking, Convergent and Divergent Thinking, Generation, Evaluation and Selection of Ideas, Critical Thinking
Literature Review – Importance of Literature Review, Constituents of Good Literature Review, Strategies for Literature Search, Referencing, Paraphrasing, and Summarizing Academic Standards and Ethics
Research Proposal – Structure of a Good Research Proposal, Getting Started, Tips for Compilation of Good Research Proposal.

Unit 4 :

Nature of Intellectual Property: Patents, Designs, Trade and Copyright.
Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit 5 :

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology.
Patent information and databases, Geographical Indicators

Unit 6 :

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Copy rights for Software's Traditional knowledge Case Studies.

Course Resources

a. Essential Reading

1. Class Notes
2. Dr. Chakroborty, S.K. ValuStuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students"
3. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
4. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
5. Halbert, (2007) "Resisting Intellectual Property", Taylor & Francis Ltd.

b. Recommended Reading

1. Mayall, (1192),"Industrial Design", McGraw Hill.
2. Niebel, (1972), "Product Design", McGraw Hill.
3. Asimov, (1962), "Introduction to Design", Prentice Hall.
4. Robert P. Merges, Peter S. Menell, Mark A. Lemley, (2016)," Intellectual Property in New Technological Age".
5. T. Ramappa, (2008)"Intellectual Property Rights Under WTO", S. Chand.

c. Other Electronic Resources

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M.S. Ramaiah University of Applied Sciences

Course Title	Professional Communication
Course Code	19FET509A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course aims at sensitising students to the essentials of professional communication. Professional Communication is essential to achieve the objectives of an organisation.

Course Outcomes

After undergoing this course students will be able to:

CO 1. Compose effective written business communication
CO 2. Practice the techniques of presentation

Course Contents

Unit 1 :
Introduction to Professional Communication, Conversation and Listening

Unit 2 :
Reading Skills for Effective Professional Communication: Introduction, SQ3R (Survey, Question, Read, Retrieve, and Review) Technique of Reading

Unit 3 :
Written Business Communication: Writing Memos, Letters, Circulars and Notices, Communicating through Email

Unit 4 :
Presentation Skills: Message development, content, projection, inflection, and delivery

Course Resources

a. Essential Reading

1. Class Notes
2. Dr. C.S.G. Krishnamacharyulu (2016) Business Communication, Himalaya Publishing House

b. Recommended Reading

1. V. Lesikar, John D. Pettit, Jr., Marie E. Flatley. (1999), Basic Business Communication, 8th Edition, Tata McGraw Hill

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Course Title	Control Systems for Robots
Course Code	19RBC505A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with mathematical modelling & analysis of robotic systems. Students are taught to determine system response for transient and frequency based inputs. Students are also taught to perform the steady state error, dynamic error and stability analysis on linear, nonlinear and adaptive control system models.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Develop mathematical models of various subsystems of a control system
- **CO 2.** Perform time response and frequency response analysis of robotic control system models
- **CO 3.** Design a controller to meet error, stability and relative stability specifications
- **CO 4.** Suggest suitable drives and control circuits for developing a physical control system
- **CO 5.** Model and simulate linear, nonlinear and adaptive controller for a robotic system using software tools and analyze time response, steady state error and stability of the system

Course Contents

Unit 1: Control for Robotic Systems:
Feedback control, second order systems, control of second order systems, trajectory following control, disturbance rejection, feedback linearization, conventional controller, sliding mode control, variable structure control, adaptive control, fuzzy control

Unit 2: Stability:
Control problem, state equations, state space model of a robot, constant solutions, equilibrium point, liapunov's first method, liapunov's second method, domain of attraction, linear system stability, steady state tracking, transient performance, single axis PID control of robot

Unit 3: Drive control for robotic applications:
Mathematical modelling and simulation - DC servo control system, Stepper motor control system; Applications of stepper motor and dc servo motor in robotics.

Unit 4: Case Studies:
Modelling and Control of Manipulators, Feedback Control of a Robot, Trajectory and Position Control of a Robot, applications of fuzzy logic in robotics, behavior based systems, force feedback control in robots, motion control of a wheel based robots

Course Resources

a. Essential Reading

1. Class Notes
2. Robert J. Schilling (1990) Fundamentals of Robotics: Analysis & Control, 2nd edition, Pearson.
3. J. J. Craig (1989) Introduction to Robotics, Mechanics, and Control. 2nd Edition. Addison Wesley, MA.
4. M. W. Spong and M. Vidyasagar (1989) Robot Dynamics and Control, Wiley, New York.
5. Riazollah Firoozian (2008) Servo Motors and Industrial Control Theory, Springer Science & Business Media.

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b. Recommended Reading

1. K. S. Fu, R. C. Gonzalez and C. S. Lee (1987) Robotics: Control, Sensing, Vision, and Intelligence, McGraw-Hill.
2. R. D. Klafter, T. A. Chmielewski and Michael Negin (2003) Robotic Engineering, An Integrated approach, Prentice Hall of India.

c. Other Electronic Resources

1. http://nptel.ac.in/

Course Title	Image Processing for Robotics
Course Code	19RBE511A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with the development of image processing algorithms for robotic applications. The students are introduced to the field of robotic vision and taught the mathematics and algorithms that underpin it. Students also learn how to interpret images to determine various features like color, size, shape and position of the objects in the scene. Performance metrics of various algorithms and their significance on the functionality of robotic applications are emphasized. Students are taught to model, simulate and analyse image processing algorithms for robotic applications using software tools.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Explicate the utility of vision as a sensor for robots and evaluate the challenges inherent in visual information
- **CO 2.** Discuss the underlying principles of common image processing techniques and their applications
- **CO 3.** Analyze the mathematical and geometric principles underlying the formation of images
- **CO 4.** Evaluate and analyze appropriate image processing algorithms for a specific application
- **CO 5.** Model, simulate and analyze image processing and feature extraction algorithms for robotic applications using software

Course Contents

Unit 1:
Introduction - Characteristics of image, Types, Image formation, image sensors, acquisition and storage of images – Optical, Sonar, and Ultrasonic imaging principles

Unit 2:
Image Enhancement - Gray level transforms, Histogram processing, Enhancement operations, Spatial filtering, Convolution and correlation, Filtering in frequency domain

Unit 3:
Image Restoration - Image degradation and restoration process, Noise models, Restoration in presence of noise, Linear position invariant degradations and estimation, Geometric transformations-spatial transformation, gray level interpolation

Unit 4:
Morphological Image Processing - Basic morphological operations; algorithms for boundary extraction, region filling, extraction of connected components, thinning, thickening, skeletons

Unit 5:
Image Segmentation - discontinuities: point, line and edges; Edge linking and boundary detection - local processing, global processing using Hough transform; Thresholding - local, global and adaptive; Regionbased segmentation - region growing, region splitting and merging

Unit 6:
Image Representation & Description - Representations - chain codes, polygonal approximations, signatures, boundary segments, skeletons; Boundary descriptors - shape numbers, color, statistical moments; Regional descriptors - topological, texture and moments of 2-D Functions

Unit 7:
Case Study: Apply the mathematical and algorithmic and control principles of robotic vision (optical, sonar, and ultrasound modalities) to implement a working robotic vision system.

Course Resources

a. Essential Reading

1. Class Notes
2. Corke P. (2013) Robotics, Vision and Control: Fundamental Algorithms in MATLAB. Springer.
3. Gonzalez R. C. & Woods R. E. (2009) Digital Image Processing. 3rd Edition, Prentice Hall.
4. Chanda B. & Majumder D. D., (2009) Digital Image Processing and Analysis, Prentice Hall of India

b. Recommended Reading

1. Marques O. (2011) Practical Image and Video Processing Using MATLAB. Wiley-IEEE Press.
2. Bovik A. (2009) The Essential Guide to Image Processing, Academic Press.
3. Jahne B. (2005) Digital Image Processing, 6th Edition. Springer.

c. Other Electronic Resources

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Course Title	Industrial Robotics and Automation
Course Code	19RBE521A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with industrial robotics and automation technologies adopted in industries. The need for robotic process automation systems and its role in operation excellence will be explained. Selection of appropriate automation technologies like relay, PLC, HMI and SCADA based for a given application will be discussed. Compilation of technical and managerial requirements in a typical robotic process automation will be explained. Development of robotic work cell is carried out during this module. Project feasibility study including technical, operational, financial, economic, social and environmental for robot implementation and use of appropriate planning software will be taught.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Explicate the role of robotics and automation in industrial applications
- **CO 2.** Compile the technical and economical requirements of robotic automation
- **CO 3.** Develop robotic cell for give industrial applications
- **CO 4.** Conduct feasibility study for robotic projects
- **CO 5.** Compare the competing robotic solutions

Course Contents

Unit 1: Industrial automation

Scope of industrial automation, strategies of automation, systems and sub systems of automation solution. Industrial automation hierarchy, relay based, PLC and SCADA based automation. Role of manufacturing in businesses. Types of manufacturing systems, expectations from different departmental functions in a manufacturing industries and their integration.

Unit 2: Robotic Process Automation

Basic element of robotic process automation, Advantages and limitations of Robotic Process Automation. Key aspects of Productivity: Quality, Cost, Delivery, Safety and Morale and interrelationship with operational performance.

Importance of manufacturing lead time, production rate, cycle time, availability, utilization, cost analysis in manufacturing process. Production layouts and sequence of operation for given product, time and motion study

Unit 3: Robotic Industrial operations

Need for Lean Manufacturing, Value Stream Mapping, Quick Response Manufacturing, Theory of Constraints, FMECA, Smart Maintenance in manufacturing industries.

Accidents and Employee Health and Safety in robotic cells: Introduction to Safety, Definition of industrial Risk, Industrial Hazard – Definition and Classification, Definition of Accidents, Causes and sources of accidents, Safety Programs – Objectives, Four E's in a safety program, OSHAS principle and its significance

Unit 4: Prerequisites for robotic automation

Process information, Process standardization, productivity requirements. Cellular Manufacturing, Preconditions, implementation of cellular manufacturing, advantages and limitations of CM , importance of single piece flow and Case studies

Unit 5: Robotic work cell
Phases in robotic cell design, design and economic considerations. Development of manual task map and robot task map, comparison of manual and robot task map and selection from alternate robotic cell solutions.

Unit 6: Project management
Project management aspects in robotic project: Understanding Project Management, PM Triangle and Relevance, Members of PM team Different views of Project Management, Development of Business system, modeling a business system, Product vs. Project Management, Project life cycles

Unit 7: Feasibility Studies
Feasibility Study, Planning and Scheduling for robotic project: Identification of Strategic Project Variables: Statement of Work, Project Specifications and Milestone Schedules; Project Feasibility Studies: Technical, Operational, Financial, Economic, Social and Environmental; Work Breakdown Structure and Planning Cycle, Master Project Scheduling, PERT/ CPM; Crashing of Projects; Resource Levelling; Project cost estimation.

Unit 8:
Laboratory Practice: MS project software

Course Resources

a. Essential Reading

1. Class Notes
2. Chris McMahon and Jimmie Browne, (2005), CAD-CAM Principles, Practice and Manufacturing Management, 2nd Edition, Pearson Education
3. Ibrahim Zeid, (2008), Mastering CAD/CAM, Tata McGraw-Hill
4. O.C. Zienkiewicz, (2005), The Finite Element Method, Tata McGraw-Hill

b. Recommended Reading

1. K.J. Bathe, (1997), Finite Element Procedures, 1st Edition, PHI, New Delhi
2. Robert D. Cook, David S. Malkus, Michael E. Plesha and Robert J. Witt, (1998), Concepts and Applications of Finite Element Analysis, 4th Edition, Wiley Publications
3. Ibrahim Zeid and R. Sivasubramanian, (2008), CAD/CAM Theory and Practice, Tata McGraw-Hill
4. Cornelius Leondes, (2000), Computer-Aided Design, Engineering, and Manufacturing: Systems Techniques and Applications, (Volume 1-7), CRC Press
5. Kunwoo Lee, (1999), Principles of CAD/CAM/CAE Systems, Addison Wesley

c. Other Electronic Resources

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Course Title	Embedded Systems and Programming for Robots
Course Code	19RBE512A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with the concepts of embedded systems and programming robots for any application. Students are taught the principles of embedded system, programming embedded systems, sensor and peripheral interfacing, peripheral programming, and robot high level language, which are essentials in developing a robot for different applications. Also various communication protocols and their interfaces are discussed. Students are trained to program a robot using a high level robot programming language.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the theory of embedded system organization, peripheral and peripheral interfacing and RTOS
- **CO 2.** Develop algorithms for robot control applications
- **CO 3.** Apply developed algorithms on a microcontroller interfaced with sensor and peripherals
- **CO 4.** Build programs using robotic programming high level languages to control robotic operations
- **CO 5.** Demonstrate various kinematic actions of a robot using programs

Course Contents

Unit 1: Embedded System Organization:
Embedded computing, characteristics of embedded computing applications, embedded system design challenges, build process of real-time embedded system, processors in embedded systems, ASIC and FPGA solutions, peripherals, compilers, assemblers, and debuggers, embedded software architectures, embedded operating system

Unit 2: Interrupts and Exceptions:
Interrupt, software interrupts, hardware interrupts, interrupt vector table, interrupt priority, interrupt flags, Interrupt Service Routines (ISR), Exception Handling, Interrupt handling schemes, Interrupt Programming

Unit 3: Embedded Communication Protocols:
Embedded networking: introduction, serial/parallel communication, serial communication protocols, RS232 standard, RS485, synchronous serial protocols, Serial Peripheral Interface (SPI), Inter Integrated Circuits (I2C), parallel protocols, ISA/PCI bus protocols, USB, firewire, ethernet and CAN, wireless protocols (IrDA, Bluetooth, IEEE 802.11)

Unit 4: Timers and Pulse width modulation
Timers and counter, Timer and counter programming, hardware delay generation, Pulse width modulation, Phased locked loop (PLL), Real time clock (RTC)

Unit 5: Sensor and Peripheral Interfacing
ADC Registers and programming, DAC registers and programming, LCD and keypad interface and programming, DC motor, stepper and servo motor interface and programming, force and tactile sensors and programming, inertial GPS and Odometry and programming, sonar and range sensor and programming, vision sensor modules and programming, PID programming and implementation.

Unit 6: Introduction To Robot Programming
Robot software functions - coordinate systems, position control, other control functions, subroutines, Program planning for Robot flow charting for robot programs with few examples.

Unit 7: Methods of Robot Programming
Online programming, off-line programming, advantages of off-line programming, lead through methods - powered lead through, manual lead through, Teach pendant, Robot program as a path in space, defining position in space, motion interpolation, WAIT, SIGNAL and DELAY commands, Branching capabilities and Limitations of head through methods.

Unit 8: Robot Languages
Textual ROBOT Languages, first generation and second generation languages, structure of a robot language - operating systems, Elements and Functions, constants, variables and other data objects, Motion commands, points in workspace, End effector and sensor commands, computations and operations, program control and subroutines, communications and Data processing, Introduction to high level robot programming languages.
- Programming the robot to study various kinematic motions

Course Resources

a. Essential Reading

1. Class Notes
2. Michael Barr, (1999) Programming Embedded Systems in C and C++, First Edition, O'Reilly & Associates, Inc.
3. Raj Kamal, (2009) Embedded systems: architecture, programming and design, Second Edition, Tata McGraw-Hill Education
4. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel and Nicholas G. Odrey (1986)
5. Industrial Robotics Technology, Programming and Applications, Mc Graw Hill Book company

b. Recommended Reading

1. Thomas Bräunl, (2008) Embedded Robotics: Mobile Robot Design and Applications with Embedded Systems, Third Edition, Springer
2. Joseph L. Jones, (2004) Robot Programming: A Practical Guide to Behavior-Based Robotics, McGraw-Hill
3. Bernard Hodges (1993) Industrial Robotics, Second Edition, Jaico Publishing House, 1993.

c. Other Electronic Resources

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Course Title	Computer Vision
Course Code	19RBE522A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

Computer vision course focuses on development of algorithms and techniques to analyze and interpret the visible world around us. This module is aimed at introducing computer vision which includes fundamentals of image formation, camera imaging geometry, feature detection and matching, stereo, motion estimation and tracking, image classification and scene understanding. The module involves the intuitive and mathematical development of the methods for applications that include finding known models in images, depth recovery from stereo, camera calibration, image stabilization, automated alignment, tracking, boundary detection, and recognition. The module emphasizes on a through hands-on exposure in the form of the implementation of the computer vision algorithms covered in theory.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Explicate basic concepts, terminology, theories, models and methods in computer vision
- **CO 2.** Discuss basic methods of computer vision related to multi-scale representation, edge detection and detection of other primitives, stereo, motion and object recognition and analysis
- **CO 3.** Apply mathematical modelling methods for low-, intermediate- and high-level image processing tasks
- **CO 4.** Recommend a design of a computer vision system for a specific problem
- **CO 5.** Design new algorithms to solve computer vision problems and compare their performance with the state-of-the-art
- **CO 6.** Develop computer vision applications

Course Contents

Unit 1:
Introduction:
Computer vision, Image formation: Geometric primitives and transformations, Photometric image formation, The digital camera Image processing: Point operators, Linear filtering, More neighborhood operators, Fourier transforms, Pyramids and wavelets, Geometric transformations, Global optimization

Unit 2:
Feature detection and matching: Points and patches, Edges, Lines. Segmentation: Active contours, Split and merge, Mean shift and mode ending, Normalized cuts, Graph cuts and energy-based methods

Unit 3:
Feature-based alignment: 2D and 3D feature-based alignment, Pose estimation, Geometric intrinsic calibration, Structure from motion: Triangulation, Two-frame structure from motion, Factorization Bundle adjustment, constrained structure and motion

Unit 4:
Dense motion estimation: Translational alignment, Parametric motion, Spline-based motion, Optical flow, Layered motion, Image stitching: Motion models, Global alignment, Compositing, Computational photography

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Unit 5:

Advanced Topics: Stereo correspondence, 3-D reconstruction, Image-based rendering and Recognition

Unit 6:

Laboratory Contents:

1. Image Segmentation, Filtering and Hybrid Images
2. Local Feature Matching
3. Scene Recognition
4. Camera Calibration
5. Fundamental Matrix Estimation

Course Resources

a. Essential Reading

1. Class Notes
2. Richard Szeliski, 2011, Computer Vision: Algorithms and Applications, London, Springer-Verlag London Limited

b. Recommended Reading

1. David A. Forsyth and Jean Ponce, 2015, Computer Vision: A Modern Approach, Harlow, Pearson Education Limited
2. Emanuele Trucco and Alessandro Verri, 1998, Introductory Techniques for 3-D Computer Vision, Upper Saddle River, Prentice Hall PTR
3. Bogusław Cyganek and J Paul Siebert, 2009, An Introduction to 3D Computer Vision Techniques and Algorithms, Chichester, A John Wiley and Sons Limied Publication
4. R. Hartley and A. Zisserman, 2003, Multiple View Geometry in Computer Vision, New York, Cambridge University Press

c. Other Electronic Resources

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Course Title	Machine Learning and Applications
Course Code	19RBE513A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course is aimed at providing theoretical and hands-on exposure to artificial intelligence, intelligent agents and their applications. The principles of knowledge representation, search strategies, learning, reasoning and planning will be covered in detail. Application of the principles of artificial intelligence in machine learning, robotics and perception will be discussed. There will be a special emphasis on the analysis and synthesis of intelligent agent-based applications of artificial intelligence.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Explicate the concepts of artificial intelligence and intelligent agents
- **CO 2.** Discuss the principles of knowledge representation, search strategies, learning, reasoning and planning
- **CO 3.** Apply the principles of knowledge representation, search strategies, learning, reasoning and planning to design intelligent agents
- **CO 4.** Analyze a scenario and identify strategies for knowledge representation, search, learning, reasoning and planning
- **CO 5.** Synthesize an intelligent agent for a given scenario
- **CO 6.** Evaluate the performance of an intelligent agent based on appropriate measures of performance

Course Contents

Unit 1: Introduction
Overview of AI problems and examples, Intelligent behaviour, The Turing test, Rational versus non-rational reasoning, AI problem characteristics, Nature of agents: Autonomous versus semi-autonomous, Reflexive, goal-based, and utility-based. Perception and environmental interactions.
system

Unit 2: Search Strategies
Problem spaces-states, goals and operators, problem solving by search, Factored representation, Uninformed search, Heuristics and informed search. Game playing and minimax search, Constraint satisfaction-backtracking and local search methods. Advanced search: Search trees, stochastic search techniques.

Unit 3: Machine Learning
Introduction, Supervised and Unsupervised learning: Classification, and Clustering. Theory of learning: PAC learning framework. Artificial Neural Networks, Statistical learning, Decision Trees, Over-fitting problem and generalization.

Unit 4: Agents
Agent architectures. Agent theory-Rationality and Game Theory. Decision-theoretic agents. Software agents: Information gathering and access, Believable and Learning agents. Multi-agent systems: Collaborating agents, Agent teams, Competitive agents, Swarm systems and biologically inspired models.

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Unit 5: Planning
Partial and totally ordered planning, Plan graphs, Hierarchical planning, Planning and execution-conditional planning and continuous planning, Mobile agent/Multi-agent planning.

Unit 6: Reasoning Under Uncertainty
Conditional Independence, Knowledge representations-Bayesian Networks, Exact inference, Randomised sampling methods, Markov Networks, Hidden Markov Models. Causality

Unit 7: Decision Theory
Preferences and utility functions, Maximising expected utility.
Branching capabilities and Limitations of head through methods.

Unit 8: Applications
Natural Language Processing, Robotics, Perception and Computer Vision

Course Resources

a. Essential Reading

1. Class Notes
2. Russel, S. J., and Norvig, P., 2010, Artificial Intelligence: A Modern Approach, 3rd Edn, Prentice-Hall
3. Amit Konar, 2000, Artificial Intelligence and Soft Computing: Behavioral and Cognitive Modeling of the Human Brain, Taylor & Francis Inc

b. Recommended Reading

1. Rich, E., and Knight, K., 2009, Artificial Intelligence, 3rd Edn, Tata McGraw Hill
2. Nilsson, N. J., 1998, Artificial Intelligence: A New Synthesis, , Morgan Kaufmann
3. Neapolitan, R. E., and Jiang, X., 2012, Contemporary Artificial Intelligence, CRC Press
4. Luger, G., and Stubblefield, W., 2004, Artificial Intelligence: Structures and Strategies for Complex Problem Solving, Benjamin/Cummings
5. Sowa, J. F., 2000, Knowledge Representation: Logical, Philosophical, and Computational Foundations, Brooks/Cole
6. Shai, S-S., and Shai, B-D., 2014, Understanding Machine Learning, Cambridge University Press
7. Alpaydın, E., 2014, Introduction to Machine Learning, 3rd Edn, The MIT Press
8. Pearl, J., 1986, Probabilistic Reasoning in Intelligent Systems: Networks of Plausible Inference, Morgan Kaufmann

c. Other Electronic Resources

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M.S. Ramaiah University of Ap
Bangalore-5600

University of Applied Sciences
Bangalore

Course Title	Design of End Effectors
Course Code	19RBE523A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with design of robot end effectors starting from the analysis of task requirement. Concepts of grasp analysis, stiffness, strength and stability of a grasp and procedure for establishing grip properties are introduced. Case study approach would be followed to demonstrate complete end effector development process.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss classification, requirements, characteristics and selection of grippers
- **CO 2.** Analyse kinematic characteristics of grasping
- **CO 3.** Develop model of grasp to analyse stiffness, strength and stability of grasp
- **CO 4.** Assess given grasping arrangement through qualitative and quantitative evaluation
- **CO 5.** Propose hand and wrist design for a given manufacturing application

Course Contents

Unit 1: Introduction to prehension technology:
Grippers for mechanization and automation, Definitions and conceptual basics, Grasping in natural systems, Automatic prehension, Active pair mating, Prehension strategy, Gripping procedure, conditions and force, Gripper flexibility, Gripper classification, Requirements and gripper characteristics, Planning and selection of grippers

Unit 2: Natural Examples of Grasping:
The Human Hand, Conformability, Muscles, Hand/Wrist Interaction, Finger Coupling and Specialization, Grasps, Sensation and Control

Unit 3: Robotic Grasp and Workpiece-Fixture Systems:
Introduction, Robotic Manipulation and Multi fingered Robotic Hands, AMT and Fixtures, Comparison between Grasping and Fixturing

Unit 4:
Designing Hands and Wrists for Manufacturing: Wrist Design, Hand Design, Grasping vs Manipulation, Control aspects

Unit 5: Robot Tasks in a Metal-Working Cell:
Task Descriptions, Materials Handling, Assembly, Grasping, Surface Finishing and Shaping, Grinding, Contour following, Contour modification, Coupled Fine and Gross Motions, Wrist for Fine-Motion Tasks, Wrist Description, Control Architecture, Experiments, Contour Following, State estimation, Control law, , Discussion of Results

Unit 6: Analysis for an Active Robot Hand:
Introduction to Grasp Analysis, Grasping Model and Assumptions, Stiffness, Strength and Stability of a Grasp, Procedure for Establishing Grip Properties, Two-Dimensional Examples, Choosing among five grips: an example, An unstable example, Extension to Three-Dimensional Problems, Forward Force and Displacement Relations, Summary of Forward Transformations

Course Resources

a. Essential Reading

1. Class Notes
2. Monkman G. J., Hesse S., Steinmann R., Schunk H. (2007), Robot Grippers, Wiley VCH

b. Recommended Reading

1. Rich, E., and Knight, K. S. Fu, R. C. Gonzalez and C. S. Lee (1987) Robotics: Control, Sensing, Vision and Intelligence, McGraw-Hill.
2. Caihua Xiong, Han Ding, Youlun Xiong (2007) Fundamentals of Robotic Grasping and Fixturing, World Scientific Publishing Co. Pvt. Ltd.
3. Mark R. Cutkosky, Robotic Grasping and Fine Manipulation, Kluwer Academic Publishers
4. Bruno Siciliano, Oussama Khatib (ed), Springer Handbook of Robotics, Springer-Verlag

c. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Robot System Design and Development
Course Code	19RBE514A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course is intended to provide an understanding on the functional aspects robots, robotic subsystems and components. Students are exposed to design philosophy, selection of sensors, feedback system, actuators, drives and control system for a robotic system based on application. Students are able to integrate all components of a robot and validate its functionality through simulation software.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the functionality of various systems/subsystems/elements of a robot
- **CO 2.** Appraise design philosophies adopted for the development of a robot for a given application
- **CO 3.** Develop specifications for a particular robot application
- **CO 4.** Select all required subsystem and components for a robotic application
- **CO 5.** Create robot integration and validate using simulation software

Course Contents

Unit 1:
Introduction
Review of robots for various applications, their subsystems, concepts and design philosophies

Unit 2:
Need for the development of a robot

Unit 3:
Arriving at specifications of robot:
Concept generation, selection and synthesize (design, kinematics, dynamics, end effector selection, sizing- create geometric models)

Unit 4:
Manipulator mechanism design:
Basing the design on task requirements; kinematic configuration; quantitative measures of workspace attributes; redundant and closed-chain structures; actuation schemes; position sensing; force sensing.

Unit 5:
Selection of actuators and drives

Selection of sensors, feedback system and control system

Unit 6:
Integration of image processing algorithms in robots

Unit 7:
Designing embedded system and programming

Unit 8:
Robot integration, validation through simulation software

Course Resources

a. Essential Reading

1. Class Notes
2. Mikell P. Groover (2012) Specifications of Industrial Robotics: Technology, Programming, and Applications, 2nd Ed., Mcgraw Hill Education
3. Godfrey Onwubolu (2002) Mechatro nics - Principles and Applications, Second edition, Elsevier
4. Franklin G., Powell J. and Emami-Naeini A. (1994) Feedback control of dynamic systems. Reading, Mass.: Addison-Wesley
5. Gonzalez and Woods (2009) Digital Image Processing, 3rd Edition, Prentice Hall
6. Raj Kamal (2009) Embedded systems: architecture, programming and design, Second Edition, Tata McGraw-Hill Education

b. Recommended Reading

1. J. J. Craig (2005) Introduction to Robotics: Mechanics and Controls, 3rd edition, Pearson Education Inc., Harlow
2. K. S. Fu, R. C. Gonzalez and C. S. Lee (1987) Robotics: Control, Sensing, Vision and Intelligence, McGraw-Hill.
3. Mark W. Spong, Seth Hutchinson and M. Vidyasagar (2005) Robotic modeling and control, First edition, John Wiley and Sons, New York
4. Sendra Smith (2004) Microelectronic Circuits, Oxford University Press
5. Richard C. Dorf and Robert H. Bishop (2010) Modern Control Systems, 12th Edition, Prentice Hall
6. Joseph L. Jones, (2004) Robot Programming: A Practical Guide to Behavior-Based Robotics, McGraw-Hill

c. Other Electronic Resources

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Course Title	Value Education
Course Code	19FET510A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course aims at sensitising students to learn the importance of value education. It gives an insight about the Universal Brotherhood.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the role of Values and Ethics in Self-Development
- **CO 2.** Appreciate the importance of Universal Brotherhood

Course Contents

Unit 1 :
Values, Ethics and Self-Development; Awareness of self-destructive habits, Power of faith, Positive Thinking

Unit 2 :
Value judgements – Stereotypes, prejudices and biases

Unit 3 :
Sense of duty, Self-reliance, Confidence, Concentration, Discipline, Honesty, Truthfulness

Unit 4 :
National Unity, Patriotism, Love for nature

Unit 5 :
Universal brotherhood and religious tolerance

Unit 6 :
Character and Competence –Rational Thinking vs Blind faith

Course Resources

a. Essential Reading

1. Class Notes

b. Recommended Reading

1.

c. Other Electronic Resources

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Course Title	Internship
Course Code	19RBP521A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The aim of this course is to make a student experience an industrial or business environment. The student will visit various departments of an industry/business and observe the activities in each department for a certain duration of time and try to relate his/her experience with the theory practiced back at the faculty. The student should develop a report and make a presentation on his/her experience at the industry/business.

Course Outcomes

After undergoing this course students will be able to:

CO 1.
CO 2.

Course Contents

Industry Internship in the relevant organization

Course Resources

a. Essential Reading

1. Organization Website
2. Discussions with Managers/Mentor/Supervisor of different departments of the organization

b. Recommended Reading

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c. Other Electronic Resources

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Course Title	Group Project
Course Code	19RBP522A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course is intended to provide student an opportunity to synergise their learning from the earlier courses through working in a team, sharing responsibilities, to conceiving, designing and fabricating a working prototype of a system related to an automotive application. The students will learn skills related to project identification, planning, management and execution, working in teams and verbal and written communication. During design, analysis and synthesis stage, they will get an opportunity to apply theoretical knowledge to develop real life product and prototyping stage will provide them experience of converting a design into a working system through use of various fabrication techniques available.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Work in a team and undertake a project in their area of specialization
- **CO 2.** Apply their knowledge of general and automotive engineering and application, develop a system for automotive application
- **CO 3.** Apply appropriate research methodology while formulating a project
- **CO 4.** Prepare specifications, design, analyse, synthesize, prototype and assess the system
- **CO 5.** Prepare and present appropriate forms of audio-visual and verbal presentations, and written document, to describe the project, its execution and outcome

Course Contents

Unit 1 :
Team building, Team work and Leadership skills

Unit 2 :
Preparing design specifications, design, analysis and synthesis, design evaluation

Unit 3 :
Costing, Finance Management, Project management

Unit 4 :
Procurement, prototype building and related manufacturing methods

Unit 5 :
Preparing and presenting audio-visual and verbal presentations and preparing written documents

Course Resources

a. Essential Reading

1. Assigned reading relevant to the group project

b. Recommended Reading

1.

c. Other Electronic Resources

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Course Title	Dissertation and Publication
Course Code	19RBP523A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course is intended to give an insight to the students on application of principles of research methodology, preparation of research project proposal, research project management, execution of research project and effective technical communication and presentation. It also emphasizes the need and the relevance of a structured approach to identify a research topic and undertake research. This course provides an opportunity for students to apply theories and techniques learnt during programme work. It involves in-depth work in the chosen area of study.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Critically review scholarly literature collected from various sources for the project purpose and formulate a research
- **CO 2.** Prepare and present a research proposal
- **CO 3.** Conduct research to achieve research objectives
- **CO 4.** Propose new ideas/methodologies or procedures for further improvement of the research undertaken
- **CO 5.** Create research document and write research papers for publications
- **CO 6.** Defend the research findings in front of scholarly audience

Course Contents

Unit 1 :
Research Methodology

Information search, retrieval and review

Unit 2 :
Project definition and project planning

Use of conceptual models and frameworks

Unit 3 :
Problem solving and Evaluation

Interpretations and drawing conclusions

Unit 4 :
Proposing ideas or methods for further work

Thesis writing

Unit 5 :
Oral presentation

Authoring Research paper

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Course Resources

a. Essential Reading

1. Lecture Sessions on individual project, Thesis Preparation delivered by the concerned Head of Dept.

b. Recommended Reading

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c. Other Electronic Resources

1. http://nptel.ac.in/

Course Title	Dissertation and Publication
Course Code	19RBP523A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course is intended to give an insight to the students on application of principles of research methodology, preparation of research project proposal, research project management, execution of research project and effective technical communication and presentation. It also emphasizes the need and the relevance of a structured approach to identify a research topic and undertake research. This course provides an opportunity for students to apply theories and techniques learnt during programme work. It involves in-depth work in the chosen area of study.

Course Outcomes

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Course Contents

Unit 1 :
Research Methodology

Information search, retrieval and review

Unit 2 :
Project definition and project planning

Use of conceptual models and frameworks

Unit 3 :
Problem solving and Evaluation

Interpretations and drawing conclusions

Unit 4 :
Proposing ideas or methods for further work

Thesis writing

Unit 5 :
Oral presentation

Authoring Research paper

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Course Resources

a. Essential Reading

1. Lecture Sessions on individual project, Thesis Preparation delivered by the concerned Head of Dept.

b. Recommended Reading

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c. Other Electronic Resources

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