FACULTY OF ENGINEERING & TECHNOLOGY

BACHELOR OF ENGINEERING

MINOR DEGREE IN ROBOTICS
(DRAFT SYLLABUS)

Course Structure

Sr. No.	Semester	Course Code	Course Title	L	T	P	Credits
1.	3	202180301	Elements of Robotics and kinematics of Robot	3	0	2	4
2.	4	202180401	Robot Mechanics, dynamics and motion planning	3	0	2	4
3.	5	202180501	Microprocessor and Embedded System	3	0	2	4
4.	6	202180601	Control of Robotic System	3	0	2	4
5.	6	202990601	Mini-project	0	0	4	2
			TOTAL	12	0	12	18

Detailed Syllabus

Course code:	**202180301**
Name of the course:	**Elements of Robotics and Kinematics of Robot**
Semester:	**3**
Category of Course:	**ROB**

Course objectives:

This course aims to familiarize students with basic terminologies of the robotics and essential knowledge to be acquainted in the field of Robotics. It also aims to inculcate thorough understanding about basic terminologies, grippers, sensors, actuators and robot kinematics.

Teaching & Examination Scheme:

Contact hours per week			Course Credits	Examination Marks (Maximum / Passing)				
				Internal		External		Total
Lecture	Tutorial	Practical		Theory	J/V/P*	Theory	J/V/P*	
3	0	2	4	50/18	25/9	50/17	25/9	150/53

* **J**: Jury; **V**: Viva; **P**: Practical

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Course Contents:

Unit	Contents	Hours
1	**Module 1: Introduction to robotics** Brief History, Definition, Robot Anatomy, Three laws, Classification of robots, Robot terminologies: work volume, Degree of Freedom, resolution, accuracy, repeatability, dexterity, compliance, payload capacity, speed of response etc., Wrist assembly, Joint notations, Selection criteria of any robot, Industrial applications of robot, Futuristic robotics.	5
2	**Module 2: Robot drive systems, End effectors and Automation** Types of drives – Hydraulic, Pneumatic and Electric, Comparison of all such drives, DC servo motors, Stepper motors, AC servo motor – salient features and applications, pulse count calculations End effectors - Types of Grippers – Mechanical, Magnetic, vacuum, pneumatic and hydraulic, selection and design considerations,	7
3	**Module 3: Robot sensors and Machine Vision** Need for sensors, types of sensors used in Robotics, classification and applications of sensors, Characteristics of sensing devices, Selections of sensors. Robot Vision setup (RVS), block diagram, components, working of RVS, Human vision Vs Robot Vision, Gradient calculations, Applications of RVS	3
4	**Module 4: Mathematical Preliminaries of Robotics** Spatial Descriptions: positions, orientations, and frame, mappings: changing description from frame to frame, Operators: translations, rotations and transformations, Homogeneous transformations, transformation arithmetic, compound Transformations, inverting a transform, transform equations, Euler Angles, Fixed Angles, Euler Parameters.	8
5	**Module 5: Robot Kinematics** Manipulator Kinematics, Link Description, Link to reference frame connections, Denavit-Hartenberg Approach, D-H Parameters, Position Representations, Forward Kinematics, Inverse Kinematics,	7

Suggested Specification table with Marks (Theory)(Revised Bloom's Taxonomy):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10%	20%	20%	20%	20%	10%

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

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Reference Books:

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014)
2. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press (2006)
3. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, (2019)
4. R. K. Mittal, I. J. Nagrath, Robotics and Control, TATA McGraw Hill Publishing Co Ltd, New Delhi (2003)
5. S. B. Niku, Introduction to Robotics – Analysis, Contro, Applications, 3rd edition, John Wiley & Sons Ltd., (2020)
6. J. Angeles, Fundamentals of Robotic Mechanical Systems Theory Methods and Algorithms, Springer (1997)
7. MikellGroover, Mitchell Weiss, Roger N. Nagel, Nicholas Odrey, Ashish Dutta, Industrial Robotics 2nd edition, SIE, McGraw Hill Education (India) Pvt Ltd (2012)
8. R. D. Klafter, Thomas A. Chmielewski, and MechaelNegin, Robotic Engineering – An Integrated Approach, EEE, Prentice Hall India, Pearson Education Inc. (2009)
9. J. J. Craig, "Introduction to Robotics: Mechanics and Control", 3rd edition, AddisonWesley (2003)

Course Outcomes (CO):

Sr. No.	Course Outcome Statements	% weightage
1	Understand terminologies related to robotics	15
2	Identify gripper, sensor and actuator of a robot	25
3	Apply mathematics for manipulator positioning and motion planning	25
4	Analyse robot mechanism using kinematics	25
5	Acquainted with various applications and futuristic robotic technology	10

List of Practicals/Tutorials:

1. Study of components of real robot and its performance
2. Basics of 3D modeling software
3. Modeling of Robot Joints
4. Assembly of 2DOF/3DOF Robot Manipulator
5. Use of drives for robotic joints and its simulation
6. Roboanalyzer: A learning software of robotics study
7. Understanding coordinate frames and transformation
8. Formulation of DH parameters of robot configuration
9. Simulation using open source software of robot kinematics using DH Parameters
10. Forward kinematic analysis of a robot
11. Inverse kinematic analysis of a robot
12. Introduction of MATLAB and Robotic Toolkit introduction.

Supplementary Learning Material:

NPTEL Course Name	Instructor	Host Institute
Robotics	Prof. Dilip Kumar Pratihar	IIT Kharagpur
Robotics	Prof. P. Seshu, Prof. P.S. Gandhi, Prof. K. KurienIssac, Prof. B. Seth, Prof. C. Amarnath	IIT Bombay

Course Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 13	PSO 14	PSO 15
CO1	3	3	3	3	2	3	2	2	3	2	3	3	3	3	2
CO2	3	3	3	3	3	3	2	2	3	2	3	3	3	3	3
CO3	3	3	3	3	3	3	2	2	3	2	3	3	3	3	2
CO4	3	3	3	3	3	3	2	2	3	2	3	3	3	3	2
CO5	3	3	3	3	2	3	2	2	3	2	3	3	3	3	1

1. Slight (Low) 2. Moderate (Medium) 3. Substantial (High) ‘ –‘ No correlation

_AugustDetailed Syllabus

Course code:	**202180401**
Name of the course:	**Robot Mechanics, dynamics and motion planning**
Semester:	**4**
Category of Course:	**ROB**

Course objectives:

This course aims to familiarize students with basic terminologies of the robotics and essential knowledge to be acquainted in the field of Robotics. It also aims to inculcate thorough understanding about basic terminologies, grippers, sensors, actuators and robot kinematics.

Teaching & Examination Scheme:

Contact hours per week			Course Credits	Examination Marks (Maximum / Passing)				
				Internal		External		Total
Lecture	Tutorial	Practical		Theory	J/V/P*	Theory	J/V/P*	
3	0	2	4	50/18	25/9	50/17	25/9	150/53

* **J**: Jury; **V**: Viva; **P**: Practical

Course Contents:

Unit	Contents	Hours
1	**Module 1: Velocities & Statics** Cross Product Operator for kinematics, Jacobians - Direct Differentiation, Basic Jacobian, JacobianJv / Jw, Jacobian in a Frame, Jacobian in Frame {0}, Kinematic Singularity.	6
2	**Module 2: Robot Dynamics** Introduction to Dynamics, Lagrangian formulation of manipulator dynamics, dynamic simulation, computational consideration.	4
3	**Module 3: Motion Control** Path versus Trajectory, Joint space versus Cartesian space descriptions, Point to Point Control, trajectory generation, Continuous Path Control, Force Control, hybrid position/force control system.	6
4	**Module 4: Programming and Languages for Robotics** Robot Programming: Methods of robot programming, WAIT, SIGNAL and DELAY commands, subroutines Programming Languages: Generations of Robotic Languages, Introduction to various types such as VAL, RAIL, AML, Python, ROS etc., Development of languages since WAVE till ROS.	9
5	**Module 5: AI and Machine Learning in Robotics** Socio-Economic aspect of robotisation. Economical aspects for robot design, Safety for robot and standards, Introduction to Artificial Intelligence, AI techniques, Need and applications of AI, Use of Machine learning in Robotics.	5

Suggested Specification table with Marks (Theory)(Revised Bloom's Taxonomy):

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Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10%	20%	20%	20%	20%	10%

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014)
2. AsitavaGhoshal, Robotics: Fundamental concepts and analysis, Oxford University Press (2006)
3. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, (2019)
4. R. K. Mittal, I. J. Nagrath, Robotics and Control, TATA McGraw Hill Publishing Co Ltd, New Delhi (2003)
5. S. B. Niku, Introduction to Robotics – Analysis, Contro, Applications, 3rd edition, John Wiley & Sons Ltd., (2020)
6. J. Angeles, Fundamentals of Robotic Mechanical Systems Theory Methods and Algorithms, Springer (1997)
7. MikellGroover, Mitchell Weiss, Roger N. Nagel, Nicholas Odrey, AshishDutta, Industrial Robotics 2nd edition, SIE, McGraw Hill Education (India) Pvt Ltd (2012)
8. R. D. Klafter, Thomas A. Chmielewski, and MechaelNegin, Robotic Engineering – An Integrated Approach, EEE, Prentice Hall India, Pearson Education Inc. (2009)
9. J. J. Craig, “Introduction to Robotics: Mechanics and Control”, 3rd edition, AddisonWesley (2003)

Course Outcomes (CO):

Sr. No.	Course Outcome Statements	% weightage
1	Understand relationship between joint space and Cartesian space	15
2	Able to calculate force and torque requirements for robotic joints	20
3	Plan trajectory of robot to reach the destination with controlled environment	25
4	Acquainted with methods of programing and various languages used in robotics	20
5	Awareness of AI and Machine learning in robotics	20

List of Practicals/Tutorials:

1. Compute and evaluate Jacobian matrix using MATLAB.
2. Case study: Workspace analysis of 2 DOF Robot
3. Modeling of 2 DOF Robot in MATLAB
4. Path Planning of 2 DOF Robot
5. Forward dynamics of a robot
6. Inverse dynamics of a robot

7. Trajectory planning of a robot
8. Use of ROS toolbox in MATLAB
9. Programming of Robot using ROS
10. Introduction to Prolog
11. To solve Tower of Hanoi in Prolog
12. To write Production rules for Water Jug problem and execute in Prolog

Supplementary Learning Material:

NPTEL Course Name	Instructor	Host Institute
Robotics	Prof. Dilip Kumar Pratihar	IIT Kharagpur
Robotics	Prof. P. Seshu, Prof. P.S. Gandhi, Prof. K. KurienIssac, Prof. B. Seth, Prof. C. Amarnath	IIT Bombay

Course Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 13	PSO 14	PSO 15
CO1	3	3	3	3	3	3	2	2	3	2	3	3	3	3	1
CO2	3	3	3	3	3	3	2	2	3	2	3	3	3	3	2
CO3	3	3	3	3	3	3	2	2	3	2	3	3	3	3	2
CO4	3	3	3	3	3	3	2	2	3	3	3	3	3	3	2
CO5	3	3	3	3	3	3	2	2	3	3	3	3	3	3	3

1. Slight (Low) 2. Moderate (Medium) 3. Substantial (High) ‘ –‘ No correlation

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Detailed Syllabus

Course code:	**202180501**
Name of the course:	**Microprocessor and Embedded Systems**
Semester:	**5**
Category of Course:	**ROB**

Course objectives: This course aims to teach the detailed functioning of AVR Microcontroller andthe role of embedded systems in a robotic system.

Teaching & Examination Scheme:

Contact hours per week			Course Credits	Examination Marks (Maximum / Passing)				
Lecture	Tutorial	Practical		Internal		External		Total
				Theory	J/V/P*	Theory	J/V/P*	
3	0	2	4	50/18	25/9	50/17	25/9	150/53

* **J**: Jury; **V**: Viva; **P**: Practical

Course Contents:

Unit	Contents	Hours
1	**Module 1: Fundamentals of Microprocessors:** History of microprocessor and microcontrollers, Difference between microprocessors and microcontrollers and Applications of microcontrollers, Role of microcontrollers in embedded Systems.	**2**
2	**Module 2: Architecture and instruction set of 8-bit AVR Microcontroller:** AVR Microcontroller architecture: Registers, AVR status register, Memory Space, ATmega32 (**Arduino**) pin-configuration & function of each pin, Addressing mode and instruction set of AVR microcontroller, Data transfer, Arithmetic, Logic and Compare, Rotate and Shift, Branch and Call instructions, Bit manipulation instructions	**6**
3	**Module 3: AVR Assembly and C Programming:** AVR data types and assembler directives, AVR assembly language programs,AVR I/O Port Programming, Time delay loop, Bit addressability, MACROs, Pros and cons of C and assembly language programming, Data types, Simple C programs for general purpose I/O and bit accessibility.	**6**
4	**Module 4: AVR on-chip peripherals and its programming:** General purpose I/O Ports, Timers, Interrupts, serial port, Serial port Interfacing protocols, SPI, I2C, UART. Assembly and C Language programming for peripherals	**8**
5	**Module 5: Device interfacing and its programming:** Sensor interfacing, Relay, Opto-isolator and Stepper Motor Interfacing, Industrial servo interfacing, Raspberry Pi based programming for robots. Inverse Kinematics and Path Planning Programming using ROS.	**8**

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Suggested Specification table with Marks (Theory)(Revised Bloom's Taxonomy):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10%	20%	20%	20%	20%	10%

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Muhammad Ali Mazidi, SarmadNaimi and SepehrNaimi, "The AVR Microcontroller and Embedded Systems", Using Assembly and C, Pearson Education, 1st Edition, 2012.
2. S. K. Saha, "Introduction to Robotics", Tata McGraw Hill Education Pvt. Ltd., New Delhi.
3. DhananjayGadre, "Programming and Customizing the AVR Microcontroller", TMH, 1st Edition, 2001.
4. R. K. Mittal, I. J. Nagrath, "Robotics and Control", Tata McGraw-Hill Publishing Company Ltd.
5. R. S. Gaonkar, ", Microprocessor Architecture: Programming and Applications with the 8085", Penram International Publishing, 1996Raj Kamal, Embedded Systems, TATA McGRAW Hill Publications (2003).

Course Outcomes (CO):

Sr. No.	Course Outcome Statements	% weightage
1	To prepare block diagrams for any robotic control-hardware design	25
2	Learn and analyze assembly language programs for AVR Microcontroller for various peripheral interfacings	25
3	Write programs for interfacing various sensors for robotics applications	25
4	To use advanced embedded processor and software	25

List of Practicals/Tutorials:

1. Introduction to Robotic controller card like Arduino UNO board and write program to blink LED using Arduino instructions, C language & Assembly language.
2. Interfacing drivers for Arduino Controller for Robotic application. Various sensor interfacing with Robotic Controller like Arduino UNO board
3. Interface Digital/Analog input output interfacing module with Arduino board and write programs related to I/O module
4. Write and execute Arduino program for serial communication. Transmit temperature value through serial communication and store it in spreadsheet or text file
5. Write assembly language programs for ATMega32 Microcontroller and simulate using ATMEL Studio

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6. Interface Stepper motor with AVR Microcontroller and Write program to rotate stepper motor in clockwise and anticlockwise direction.
7. Interface DC Motor with AVR Microcontroller and write program to rotate DC motor in clockwise and anticlockwise direction.
8. Write Arduino program to receive IR Signal from IR remote and operate Electrical device based on switch pressed.
9. To simulate joint torque control of manipulator
10. To study feedback control of robot manipulator
11. To study adaptive control of robot manipulator
12. Design a robotic car using Arduino and other accessories

Supplementary Learning Material:

NPTEL Course Name	**Instructor**	**Host Institute**
Embedded Systems	Prof. SantanuChaudhary	IIT Delhi

Course Articulation Matrix:

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO 13**	**PSO 14**	**PSO 15**
CO1	3	3	3	3	3	2	1	2	3	3	1	3	3	3	1
CO2	3	3	3	3	3	2	1	2	3	3	2	3	3	3	2
CO3	3	3	3	3	3	2	1	2	3	3	2	3	3	3	2
CO4	3	3	3	3	3	2	1	2	3	3	2	3	3	3	2

1. Slight (Low) 2. Moderate (Medium) 3. Substantial (High) ‘ –‘ No correlation

Detailed Syllabus

Course code:	202180601
Name of the course:	Control of Robotic Systems
Semester:	6
Category of Course:	ROB

Course objective:

This course aims to develop the understanding of control systems, its designing and application.

Teaching & Examination Scheme:

Contact hours per week			Course Credits	Examination Marks (Maximum / Passing)				
Lecture	Tutorial	Practical		Internal		External		Total
				Theory	J/V/P*	Theory	J/V/P*	
3	0	2	4	50/18	25/9	50/17	25/9	150/53

* **J**: Jury; **V**: Viva; **P**: Practical

Course Contents:

Unit	Contents	Hours
1	**Module 1: MATLAB for Control system** Basics, Language Fundamentals, Mathematical Operations, Graphics, Programming	03
2	**Module 2: Basics of Control** Control Systems: Types of Controllers, Introduction to closed loop control, Differential Equation, Transfer function, Block diagram, Signal Flow Graph,	04
3	**Module 3: Time Response and Frequency Response** Time Response, Routh-Hurwitz test, relative stability, Root locus design, construction of root loci, phase lead and phase-lag design, lag-lead design, Frequency response, Bode, polar, Nyquist plot.	08
4	**Module 4: Linear Control** Concept of states, state space model, different form, controllability, observability; pole placement by state feedback, observer design, P, PI & PID Controller, control law partitioning, modelling and control of a single joint.	08
5	**Module 5: Non-Linear Control System** Common physical non-linear system, phase plane method, system analysis by phase plane method, stability of non-linear system, Liapunov's stability criterion, the control problems for manipulators.	07

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Suggested Specification table with Marks (Theory)(Revised Bloom's Taxonomy):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10%	30%	20%	20%	10%	10%

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: EvaluateC: Create

Reference Books:

1. M. Gopal, Control Systems, McGraw-Hill (2012)
2. K. Ogata, "Modern Control Engineering", Prentice Hall India (2009).
3. M. Spong, M. Vidyasagar, S. Hutchinson, Robot Modeling and Control, Wiley & Sons, (2005).
4. J. J. Craig, "Introduction to Robotics: Mechanics and Control", 3rd edition, Addison-Wesley (2003).
5. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014).
6. Thomas Kailath, "Linear Systems", Prentice Hall (1980). 7. AlokSinha, "Linear Systems: Optimal and Robust Control", Taylor & Francis (2007).

Course Outcomes (CO):

Sr. No.	Course Outcome Statements	% weightage
1	To learn the fundamentals of MATLAB software	10
2	Know the transfer function, signal flow graph representation of linear systems & their controlling actions	30
3	Understand concept of time, frequency response as well as concept of state-space models and their relation to frequency domain models	35
4	Understand the methodology for modelling dynamic systems with concept of stability	25

List of Practicals/Tutorials:

Reviewing the fundamentals of MATLAB software

1. Determination of transfer function parameters of field controlled DC Servo motor
2. Stability analysis of linear system
3. Plot the Root Locus
4. Basics of Simulink
5. Use of Simulink for ROS
6. AC/DC Position control system
7. Design and perform Nyquistand Bode Plot
8. Stepper Motor control system
9. Implementation of P, PI and PID controller
10. Interfacing of Hardware and software with MATLAB
11. Programming and simulation of a robot in MATLAB

Supplementary Learning Materials:

NPTEL Course Name	**Instructor**	**Host Institute**
Robotics and Control: Theory and Practice	Prof. N. Sukavanam, Prof. M. Felix Orlando	IIT Roorkee
Control Systems	Prof. C.S.Shankar Ram	IIT Madras

Course Articulation Matrix:

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**	**PO 11**	**PO 12**	**PSO 13**	**PSO 14**	**PSO 15**
CO1	3	3	3	3	3	1	1	2	3	2	2	3	2	3	2
CO2	3	3	3	3	3	1	1	2	3	2	2	3	3	3	2
CO3	3	3	3	3	3	1	1	2	3	2	2	3	3	3	2
CO4	3	3	3	3	3	1	1	2	3	2	2	3	3	3	2

1. Slight (Low) 2. Moderate (Medium) 3. Substantial (High) ‘ –‘ No correlation

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Detailed Syllabus

Course code:	**202990601**
Name of the course:	**Mini-project**
Semester:	**6**
Category of Course:	**ROB**

Course objectives:

The main objective of Mini Project is to let the students apply the knowledge of theoretical concepts which they have learnt as a part of the curriculum of the minor degree using real time problems or situations.

Teaching and Examination Scheme:

Contact hours per week			Course Credits	Examination Marks (Maximum / Passing)		
Lecture	Tutorial	Practical		Internal	External	Total
				J/V/P*	J/V/P*	
0	0	4	2	50/18	50/17	100/35

* **J**: Jury; **V**: Viva; **P**: Practical

Course Contents:

This course is a project type. The plan of conducting this course is given below:

1. Participants will be divided into teams of two members within first week of the starting of the course by the course coordinators/managers depending on the number of participants registered in the course. The benefits of such team-based projects are listed in the Course Outcomes below.
2. The teams will have a team coordinator or leader, which will be identified by the coordinators/managers of the course (may be the first name in the list of a student team).
3. The projects could be of the following types:
    a) Literature search (LS) type: Studying about an aspect of robotics, say, vision, robot kinematics, dynamic, controls, etc.
    b) Algorithm development (AD) type: Analyse, say, a robot kinematics using Robo Analyzer or Matlab/Octave/Freemat/Scilab or similar software or write an algorithm using any programming language (Python, etc.). For example, writing forward kinematics of a robot or image processing in Vision.
    c) Design/synthesis (DS) type: Proposing a new type of system/device for performing certain task. For example, a mobile robot for Covid-19 isolation wards.
4. The teams will be asked to contact their team members within a week and decide their topic with two weeks, i.e., within first 3 weeks of the starting of the course.
5. Students MUST spend about 4 hours in a week to discuss their progress together,study together or individually, write programs, fabricate circuits, etc.
6. During the project session the coordinators will explain how to do literature survey, how to find the sources of hardware, which software to use for a particular purpose, how to select an electric motor, etc., present case studies, etc.
7. At the end of the course duration, each team will submit no more than 10 slides in .pdf file and/or not more than a video of one min to showcase their project hardware/software/plots,

etc. generated during the project to a cloud (say, Google Drive).

8. Evaluation: It will be done in two parts
   a. Peer Evaluations (20%): Presentations in .pdf will be evaluated (online) by two other teams and grade them out of 20 marks.
   b. Expert evaluation (80%): Coordinators will take a presentation of 3 mins. plus,Q&A in a common online session to give marks out of 80.

Suggested Specification table with Marks (Theory) (Revised Bloom's Taxonomy):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
0	20%	20%	20%	20%	20%

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

Since it is a project type, some experience sharing books and links to similar activities are listed.

1. Chuhan, M., and Saha, S.K., 2010, Robotics Competition Knowledge Based Education in Engineering, Pothi.com
2. Baun, M., and Chaffe, J., 2018, Engineering and Building Robots for Competitions, Amazon.com

Course Outcomes:

Sr. No.	Course Outcome Statements	% weightage
1	Understand, plan and execute a Mini Project with team.	25
2	Students will be able to practice acquired knowledge within the chosenarea of technology for project development.	25
3	Identify, discuss and justify the technical aspects of the chosen projectwith a comprehensive and systematic approach.	25
4	Communicate and report effectively project related activities andfindings.	25

List of Experiments/Tutorials:

Since it is a project type course, students will perform their lab work as mentioned in content section.

Supplementary Learning Material:

1. http://www.ddrobocon.in/
2. http://courses.csail.mit.edu/iap
3. https://fabacademy.org/students

Opp. Shastri Maidan, Beside BVM College, Vallabh Vidyanagar, Dist: Anand, Gujarat - 388120
(O): 02692-238001 | Email: adminoffice@cvmu.edu.in | www.cvmu.edu.in

PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for thepublic health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
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 clearinstructions.
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 leaderin a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

1. Ability to conceptualize interdisciplinary domain knowledge to specific branch of engineering.
2. Ability to acquire employability skills and deep knowledge in emerging and multidisciplinary areas.
3. Carryout engineering projects in broad areas of engineering.

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