CHOICE BASED CREDIT SYSTEM
EVALUATION SCHEME

AND
COURSE OF STUDY

(According to AICTE Model Curriculum2023 as per NEP 2020)

B. TECH. Minor Degree

IN

ROBOTICS

Eligible Branches:

All branches

FACULTY OF ENGINEERING AND TECHNOLOGY

GURUKULA KANGRI (DEEMED TO UNIVERISTY), HARIDWAR

[Effective from 2024-25]

Faculty of Engineering & Technology

Bachelor of Technology

MINOR DEGREE IN ROBOTICS

To enhance employability skills and impart deep knowledge in emerging areas that are usually not covered in the undergraduate degree credit framework, AICTE has come up with the concept of a 'Minor Degree' in emerging areas. The concept of a Minor Degree in discussed in the Approval Process Handbook (APH). A minor degree will carry 18 to 20 credits in addition to the credits essential for obtaining the Undergraduate Degree in Major Discipline (i.e. 160 credits for regular students and 120 credits for lateral entry students).

The **Bachelor of Technology (B.Tech.)** with a Minor program focuses on the fundamental principles of multiple Engineering disciplines, critical and analytical thinking and the ability to develop a distinctive approach to interdisciplinary problems.

OBJECTIVES

The key objectives of offering B.Tech. with Minor programs are:

- To enable students to pursue an allied academic interest in contemporary areas
- To expand the domain knowledge of the students in one of the other branches of engineering.
- To provide an academic mechanism for fulfilling the multidisciplinary demands of industries.
- To provide an opportunity to students to explore and persue different emerging fields of study in addition to their Major program.
- To increase the employability of undergraduate students keeping in view better opportunities in interdisciplinary areas of engineering & technology.
- To enable students, build knowledge in the areas that are identified as emerging technologies/thrust areas of Engineering.
- Provides an opportunity for students to become entrepreneurs and leaders by taking a business/ management minor.
- Provides an opportunity to Applicants to pursue higher studies in an interdisciplinary/ emerging field of study.
- To increase the overall scope to the undergraduate degrees.

Minor Courses Syllabus

The Board of Studies (BoS) of the University shall recommend the ONLINE courses for minor degrees. The list of the courses that are included in each track will form a syllabus for minor degree programs. These courses are to be offered between the fourth to eighth semesters for all branches. The eligible list of programs for various minor baskets shall be published by the University.

Short Title, Applicability, and Commencement:

- These Regulations shall be called “GK(DU) Regulations Governing the Award of B.Tech program with Minor Degree.
- These Regulations shall apply to all B.E/B.Tech. Programs are being conducted by the University.
- These Regulations shall come into force from the date of their notification by the University.

Definitions:

- In these Regulations, unless the context requires otherwise or it is specifically defined:
- **‘AICTE’** means the All-India Council for Technical Education and was established by an Act of Parliament in 1987.
- **‘Coursework”** means the Courses prescribed for the Minor program, which the candidate shall complete in the specified period for the Degree award.
- **‘E-resources’** means learning material saved electronically in online storage platforms/devices for use anywhere/any time accessed online or after being downloaded from the relevant sources.
- ‘**Minor’** means a recognition award to an undergraduate (UG) student on earning the specified extra credits after satisfying the relevant Degree award conditions.

Eligibility Criteria for Registration:

- Registration for a Minor degree shall start from the **fourth** semester of the B.Tech. program.
- A student can opt for only one minor program along with major (degree) program. No student shall be permitted to register for both honors as well as minors.
- A student may choose to pursue a B.Tech. degree with a minor program if, at the time of registration, he has permissible backlogs up to the third semester under the regulations governing the B.Tech. degree and provided that the student’s cumulative grade point average (CGPA) after the third semester does not fall below 5.0
- Before receiving a major degree, students who enroll in a minor degree program must successfully complete (pass) all prerequisite courses. Even if he fails in the courses chosen for minor degree programs, they must be finished (passed) before a major degree is granted.
- The minimum CGPA required to maintain up to 3rd semester of the major (core) degree program is ≥ 5.0.
- Prior approval of the mentor, Head of the Department, and Dean of Faulty, for the enrolment into the Minor program, before commencement is mandatory

Registration Procedure:

- Any student meeting the eligibility criteria specified above and intending to register for the Minor Degree shall apply to the University through the respective Head of the Department in the prescribed form/online form along

with the prescribed application fees within 15 Working days after notification by the University.

- There shall be no limit on the intake of students for registration for the minor qualification. All the applicants fulfilling the eligibility criteria can register.
- The department must give notice of registration for a minor degree program; otherwise, students must register for a minor degree program within the next 15 working days following the announcement of the third-semester results on the university website/ notice boards.
- The students shall pay a one-time non-refundable registration fee as prescribed by the University to confirm the registration.
- Fees for late registration may be imposed as per the university norms.

Instructions:

- The choice to opt/take a minor program is purely the choice of the students.
- For B.Tech. with a Minor, a student needs to earn an additional 18-20 credits (over and above the required 160 credits for the B. Tech program). The list of ONLINE courses of each Minor program, the respective credits weightage, and the semester-wises break-up of the courses are published by the University. All these 18-20 credits need to be completed from the IV semester to the VIII semester only.
- These 18-20 credits are to be earned from the additional recommended courses offered through ONLINE mode.
- After registering for the Minor program, if a student is unable to earn all the required 18-20 credits in a specified duration, he/she shall not be awarded a Minor degree. However, if the student earns all the required 160 credits of B.Tech., he will be awarded only B.Tech degree in the concerned branch.
- Minor must be completed simultaneously with a major degree program. A student cannot earn the Minor after he has already earned a bachelor's degree.
- The student can choose only one Minor program along with his/her basic engineering degree. A student who chooses an Honours program is not eligible to choose a Minor program and vice-versa.
- There is no transfer of credits from Minor program courses to regular B.Tech. Degree course and vice-versa. No student is permitted to switch from Honour's program to Minor's program and vice-versa.
- A student can graduate with a Minor if he fulfills the requirements for his regular B.E./B.Tech program as well as fulfills the requirements for the Minor program.
- The student shall be given a choice of withdrawing all the courses registered and/or the credits earned for the Minor program at any time: in that case, the student will be awarded only B.Tech., degree in the concerned branch on earning the required credits of 160.
- The department shall maintain a record of students registered and pursuing their Minor program, minor program-wise, and parent branch-wise. The same report needs to be sent to the University once the enrolment process is complete.

- All the students who complete the course as prescribed above and submit their certificates in time before the closure of the UG (8^{th} Semester) as per the academic calendar shall be eligible for the “Minors” qualification.
- The CGPA and/or Class awarded to the students shall be only based on students’ performance in the various semester-level examinations conducted proctored manner.
- The University shall have the powers to issue clarifications to remove any doubt difficulty or anomaly which may arise during the implementation of the provisions of these Regulations.

Gurukula Kangri (Deemed to be University), Haridwar
Faculty of Engineering & Technology

Bachelor of Technology

MINOR DEGREE IN ROBOTICS

COURSE STRUCTURE

S.NO.	SEMESTER	COURSE CODE	SUBJECT	Period per week			EVALUATION SCHEME				Credit	Subject TOTAL
							SESSIONAL EXAM.			EXAM. ESE		
				L	T	P	CT	TA	TOTAL			
THEORY SUBJECTS												
1	IV	BME-M401	Introduction to Robotics	3	1	0	20	10	30	70	4	100
2	V	BME-M501	Kinematics & Dynamics of Manipulator	3	1	0	20	10	30	70	4	100
3	VI	BET-M601	Microprocessor & Embedded System	3	1	0	20	10	30	70	4	100
4	VII	BET-M701	Control of Robotics	3	0	0	20	10	30	70	3	100
5	VIII	BME-M860	Project in ROBOTICS	1	0	6	20	10	60	140	4	200
			TOTAL	13	3	6	100	50	180	420	19	600

L-Lecture; **T**-Tutorial; **P**-Practical; **CT**-Cumulative Test; **TA**- Teacher Assessment; **ESE**–End Semester Examination;

Grading & Grade Points: O(Outstanding**)= 10; A^{+}(**Excellent**)= 9; A(**Very Good**)= 8; B^{+}(**Good**)= 7; B(**Above Average**)= 6; C(**Average**)= 5; P(**Pass**)= 4; F(**Fail**)= 0; Ab(**Absent**)= 0**

TEMPLATE FOR DETAILED SYLLABUS

Title of the Course : Introduction to Robotics

Course Code : BME-M401

Nature of the Course :

Total Credits : 4

Distribution of Marks : 100 (70(ESE) + 30(Sessional Exam))

COURSE OUTCOMES: After completion of course, students would be able:

CO1: To express his views as per terminologies related to Robotics technology.

CO2: To apply logic for selection of robotic sub systems and systems

CO3: To analyse basics of principals of robot system integration.

CO4: To understand ways to update knowledge in the required area of robotic technology.

UNITS	CONTENTS	L	T	P	Total Hours
1	**Introduction to robotic:** Brief History, Basic Concepts of Robotics such as Definition, Three laws, Elements of Robotic System i.e. Robot anatomy, DOF , Misunderstood devices etc., Classification of Robotic system on the basic of various parameters such as work volume, type of drive, etc., Associated parameters i.e. resolution , accuracy , repeatability , dexterity, compliance, RCC device etc., Introduction automation, Industrial applications of robot.				8

2	**Grippers and Sensors for robotics:** Grippers for Robotics – Types of Grippers, Guidelines for design for robotic gripper, Force analysis for various basic gripper system. Sensors for Robots_ Types of Sensors used in Robotics, Classification and applications of sensors, Characteristics of sensing devices, Selections of sensors. Need for sensors and vision system in the working and control of a robot.				8
3	**Drives and control for Robotics:** Drive _ Types of Drives, Types of transmission systems, Actuators and its selection while designing a robot system. Control System: Types of Controllers, Introduction to closed loop control				8
4	**Programming and Languages for Robotics:** Drive – Types of Drives, types of transmission system, Actuators and its selection while designing a robot system. Control System: Types of Controllers, Introduction to closed loop control				8
5	**Related Topics 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 application of AI, New trends & recent				8
	Total (in Hrs)				40

L: Lectures T: Tutorials P: Practicals

MODES OF IN-SEMESTER ASSESSMENT:

SUGGESTED READINGS:

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, Contra, Applications, 3rd edition, John Wiley & Sons Ltd., (2020)
6. J. Angeles, Fundamentals of Robotic Mechanical Systems Theory Methods and Algorithms, Springer (1997)
7. Mikell Groover, 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 Mechael Negin, Robotic Engineering - An Integrated Approach, EEE, Prentice Hall India, Pearson Education Inc. (2019)

TEMPLATE FOR DETAILED SYLLABUS

Title of the Course : Kinematics & Dynamics of Manipulators

Course Code : BME-M501

Nature of the Course :

Total Credits : 4

Distribution of Marks : 100 (70(ESE) + 30(Sessional Exam))

COURSE OUTCOMES: After completion of course, students would be able:

CO1: To understand terminologies related to Kinematics and Dynamics of Robotics.

CO2: To apply mathematics for manipulator positioning and motion planning.

CO3: To analyse basics of motion programming as per kinematics.

CO4: To estimate the force/torque required to drive a robot.

UNITS	CONTENTS	L	T	P	Total Hours
1	**Mathematical Preliminaries of Robotics:** Spatial Descriptions: positions, orientations, and frame, mappings: changing description from frame to frame, Operators: translations, rotations and transformations, transformation arithmetic, compound Transformations, inverting a transform, transform equations, Euler Angles, Fixed Angles, Euler Parameters.				8
2	**Robot Kinematics:** Manipulator Kinematics, Link Description, Link to reference frame connections, Denavit-Hartenberg Approach, D-H Parameters, Position Representations.				8

3	**Robot Kinematics:** Homogeneous Transformation Matrix, Forward Kinematics. Inverse Kinematics, Geometric and analytical approach.				6
4	Velocities & Statics: Cross Product Operator for kinematics, Jacobians - Direct Differentiation, Basic Jacobian, , Jacobian Jv / Jw, Jacobian in a Frame, Jacobian in Frame {0}, Kinematic Singularity, Kinematics redundancy, Force balance equation, Forces, Velocity /Force Duality, Virtual Work, Force ellipsoid, Jacobian, Kinematic Singularity, Kinematics redundancy, Mechanical Design of robot linkages,				10
5	Robot Dynamics: Introduction to Dynamics, Velocity Kinematics, Acceleration of rigid body, mass distribution Newton's equation, Euler's equation, Iterative Newton -Euler's dynamic formulation, closed dynamic, Lagrangian formulation of manipulator dynamics, dynamic simulation, computational consideration.				8
	Total (in Hrs)				40

L: Lectures ***T: Tutorials*** ***P: Practicals***

MODES OF IN-SEMESTER ASSESSMENT:

SUGGESTED READINGS:

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014).
2. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, (2019)
3. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press (2006)
4. M. Spong, M. Vidyasagar, S. Hutchinson, Robot Modeling and Control, Wiley & Sons, (2005).
5. J. J. Craig, "Introduction to Robotics: Mechanics and Control", 3rd edition, Addison- Wesley (2003).

TEMPLATE FOR DETAILED SYLLABUS

Title of the Course : Microprocessor & Embedded Systems

Course Code : BET-M601

Nature of the Course :

Total Credits : 4

Distribution of Marks : 100 (70(ESE) + 30(Sessional Exam))

COURSE OUTCOMES: After completion of course, students would be able:

CO1: To prepare block diagrams for any robotic control-hardware design,

CO2: To choose appropriate flow of embedded systems for a specific application.

CO3: To Write code for micro controller devices.

CO4: To use advanced embedded processor and software.

UNITS	CONTENTS	L	T	P	Total Hours
1	Introduction to Embedded Systems and microcomputers: Introduction to Embedded Systems, Embedded System Applications, Block diagram of embedded systems, Trends in Embedded Industry, Basic Embedded System Models, Embedded System development cycle, Challenges for Embedded System Design, Evolution of computing systems and applications. Basic Computer architecture: Von-Neumann and Harvard Architecture. Basics on Computer organizations. Computing performance, Throughput and Latency, Basic high performance CPU architectures, Microcomputer applications to Embedded systems and Mechatronics.				8

2	**Microprocessor:** 8086 Microprocessor and its Internal Architecture, Pin Configuration and their functions, Mode of Operation, Introduction to 1/0 and Memory, Timing Diagrams, Introduction to Interrupts. Introduction to C language, Instruction format, C language programming format, Addressing mode, Instruction Sets, Programming 8086 microprocessor.				8
3	**Microprocessor Interfacing:** Introduction to interfacing, Memory Interfacing, Programmable Peripheral Interfacing, Programmable 1/0, Programmable Interrupt Controller, Programmable Timers, Programmable DMA Controller, Programmable Key Board Controller, Data acquisition Interfacing: ADC, DAC, Serial and parallel data Communication interfacing. Microcontroller: Introduction to Microcontroller and its families, Criteria for Choosing Microcontroller. Microcontroller Architecture, Programming model, addressing modes, Instruction sets, Assembly and C programming for Microcontroller, 1/0 programming using assembly and C language, Interrupt Controller, 1/0 interfacing, Timers, Real Time Clock, Serial and parallel Communication protocols, SPI Controllers. LCD Controller.				10
4	**Microcontroller Interfacing:** Introduction to Microcontroller Interfacing and applications: case studies: Display Devices, controllers and Drivers for DC, Servo and Stepper Motor.				6

5	**Introduction to Advanced Embedded Processor and Software:** ARM Processor, Unified Model Language (UML), Embedded OS, Real Time Operating System (RTOS), Embedded C **Microprocessor and Embedded System Laboratories:** Basic C language programming implementation on Microprocessor and Microcontroller. Interfacing Displays, Key boards and sensors with Microprocessors and Microcontrollers, Data Acquisition using Microprocessor and Microcontroller, Implementation of Controlling schemes for DC, Servo, Stepper motor using C programming in microprocessors and Microcontrollers.				8
	Total (in Hrs)				40

L: Lectures ***T: Tutorials*** ***P: Practicals***

MODES OF IN-SEMESTER ASSESSMENT:

SUGGESTED READINGS:

1. K. V. Shibu, Introduction to Embedded Systems, McGRAW Hill Publications (2009).
2. Raj Kamal, Embedded Systems, TATA McGRAW Hill Publications (2003).
3. M. Morris Mano, Computer System Architecture, 3ed, Pearson Publication, (2007).
4. D. V. Hall, 8086 Microprocessors and Interfacings, TATA McGRAW Hill, (2005).
5. B. B. Brey, The Intel Microprocessors, Prentice Hall Publications, 8th ed, (2018).
6. M. A. Mazidi, R.D. Mckinlay and D. Casey, PIC Microcontrollers and Embedded Systems, Pearson Publications, (2008).
7. M. Predko, Programming and Customizing the PIC Microcontroller, McGRAW Hill Publications. 3ed, (2017).
8. R. Barnett, L. O'Cull and S. Cox, Embedded C Programming and Microchip PIC, Cengage Learning, (2003).

TEMPLATE FOR DETAILED SYLLABUS

Title of the Course : Control of Robotics

Course Code : BET-M701

Nature of the Course :

Total Credits : 3

Distribution of Marks : 100 (70(ESE) + 30(Sessional Exam))

COURSE OUTCOMES: After completion of course, students would have thorough understanding of linear, non-linear control systems and Motion Control.

UNITS	CONTENTS	L	T	P	Total Hours
1	**Basics of Control:** Differential Equation, Transfer function, Frequency response, Routh-Hurwitz test, relative stability, Root locus design, construction of root loci, phase lead and phase-lag design, lag-lead design, Bode, polar, Nyquist plot.				8
2	**Linear Control:** Concept of states, state space model, different form, controllability, observability; pole placement by state feedback, observer design, P, PI & PIO Controller, control law partitioning, modelling and control of a single joint.				8
3	**Non-Linear Control System:** Common physical non-linear system, phase plane method, system analysis by phase plane method, stability of non-linear system, stability analysis by describing function method, Liapunov's stability criterion, the control problems for manipulators.				8

4	**Motion Control:** Point to Point Control, trajectory generation, Continuous Path Control, Joint based control, Cartesian Control, Force Control, hybrid position/force control system.				8
5	**Frequency response Analysis:** RouthHurwitz test, relative stability, Root locus design, construction of root loci, phase lead and phase-lag design, lag-lead design, Bode, polar, Nyquist plot.				8
	Total (in Hrs)				40

L: Lectures ***T: Tutorials*** ***P: Practicals***

MODES OF IN-SEMESTER ASSESSMENT:

SUGGESTED READINGS:

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. Alok Sinha, "Linear Systems: Optimal and Robust Control", Taylor & Francis (2007).

TEMPLATE FOR DETAILED SYLLABUS

Title of the Course : Project in Robotics

Course Code : BME-M860

Nature of the Course :

Total Credits : 4

Distribution of Marks : 200 (140(ESE) + 60(Sessional Exam))

COURSE OUTCOMES: The outcomes are envisaged as follows:

CO1: Each participant will know students from other colleges/states and their work ethics/culture.

CO2: To Practice how to work together in a team. An essential skill in an industry.

CO3: To apply the theoretical knowledge learnt from other courses, which is required by an industry.

CO4: To learn how to make presentation in a team. A soft skill needed in research and industry.

CO5: Peer learning from the evaluation of other teams' work. A skill which is essential when one is in a workforce.

CO5: To examine different hardware components and their working/control using software.

S. No.	CONTENTS	L	T	P	Total Hours
1	Participants will be divided into teams of two/four 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				5
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).				5

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 RoboAnalyzer 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.				5
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
5	Students MUST spend about 6 hours in a week to discuss their progress together, study together or individually, write programmes, fabricate circuits, etc.				5
6	During the one lecture hour 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.				5
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).				5

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 10 marks. b. Expert evaluation (80%): Coordinators will take a presentation of 3 mins. plus, Q&A in a common online to give marks out of 80.				5
	Total (in Hrs)				40

L: Lectures ***T: Tutorials*** ***P: Practicals***

MODES OF IN-SEMESTER ASSESSMENT:

SUGGESTED READINGS: 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 Eduation in Engineering, Pothi.com
2. Baun, M., and Chaffe, J., 2018, Engineering and Building Robots for Competitions, Amazon.com