MINOR DEGREES OFFERED UNDER SVEC-19 REGULATIONS

Offering Dept.	Title of the Minor	Students of Eligible Branches
CSE	Artificial Intelligence and Machine Learning	All branches except CSE, IT and CSSE
IT	Internet of Things	All branches except IT
CSSE	Cyber Security	All branches except CSE, IT and CSSE
ECE	VLSI and Embedded Systems	All branches except ECE
EEE	Power Systems and Drives	All branches except EEE
EIE	Instrumentation and Control Engineering	All branches except EIE
ME	Robotics	All branches except ME
CE	Sustainable Engineering	All branches except CE

Academic Regulations for Minor Degree:

The concept of Minor degree is introduced in the curriculum of all B.Tech. programs offering a Major degree. The main objective of Minor degree in a discipline is to provide additional learning opportunities for academically motivated students and it is an optional feature of the B.Tech. Program. To earn a Minor degree in a discipline, a student has to earn 18 extra credits (By studying FIVE theory & THREE laboratory courses or SIX Theory Courses) from the core courses of the minor discipline.

a. Students having a CGPA of 8.0 or above up to II B.Tech I-Semester without any backlogs shall be permitted to register for a Minor degree by paying the requisite fee.

b. In the subsequent semesters, the student has to pass all the courses registered for Major and Minor Degrees in the first attempt i.e., regular examinations without any backlog to keep the Minor Degree registration active or else it shall be cancelled.

c. If a student becomes ineligible for continuing the Minor Degree, the earned credits under Minor Degree cannot be transferred to Major

Degree; they will remain extra. These additional courses will be mentioned in the transcript. However, they are eligible to receive B.Tech. Degree after satisfying its requirements.

d. The evaluation pattern of the courses shall be similar to the evaluation of regular program courses.

e. Minimum strength required for offering Minor Degree in a discipline is 40 students.

f. A student registered for Minor degree shall pass in all subjects that constitute the requirement for the Minor degree program. No class/division (i.e., second class, first class and distinction, etc.) shall be awarded for Minor degree program.

g. The Minor degree shall be mentioned in the degree certificate as Bachelor of Technology in XXX with Minor in YYY. For example, Bachelor of Technology in Computer Science & Engineering with Minor in Title of the Minor Pursued. This shall also be mentioned in the transcripts, along with the list of courses taken for Minor degree program. However, the performance of the student in the Minor courses will not be considered for the calculation of SGPA and CGPA for the award of Major Degree.

h. Separate course/class work and time table shall be arranged for the various Minor degree programs. Attendance regulations for these Minor discipline programs shall be as per regular courses.

i. Students aspiring for Minor degree must register from III B.Tech I-Semester onwards and must opt for a Minor in a discipline other than the discipline he is registered in.

j. A Student shall register for Minor with the following combinations:

Offering Theory and Laboratory Courses: SEVEN credits in a semester starting from III B.Tech I-Semester to III B.Tech II-Semester (TWO theory & ONE laboratory courses) and FOUR credits in IV B.Tech I-Semester (ONE theory & ONE laboratory courses).

Offering Theory Courses only: SIX credits in a semester starting from III B.Tech I-Semester to IV B.Tech I-Semester (TWO theory courses).

NOTE: Interested meritorious students shall be permitted to register either for a Minor degree in a discipline (or) Honors Degree in a discipline only, but not both.

MINOR DEGREE IN

ROBOTICS

Offering Department: MECHANICAL ENGINEERING

Students of Eligible Branches: CSE, CSSE, IT, ECE, EEE, EIE and CE

COURSE STRUCTURE

Semester	Course Code	Course Title	Contact Periods per week				Credits	Scheme of Examination Max. Marks		
			L	T	P	Total		Int. Marks	Ext. Marks	Total Marks
III B.Tech. I-Sem (2 Theory)	19BM50301	Computer Integrated Manufacturing	3	-	-	3	3	40	60	100
	19BM50302	CNC Programming	3	-	-	3	3	40	60	100
	19BM50303	Introduction to Mechanical systems *	3	-	-	3	3	40	60	100
III B.Tech. II-Sem (2 Theory)	19BM60301	Principles of Industrial Automation	3	-	-	3	3	40	60	100
	19BM60302	Principles of Robotics*	3	-	-	3	3	40	60	100
	19BM60303	Robot Kinematics and Dynamics	3	-	-	3	3	40	60	100
IV B.Tech. I-Sem (2 Theory)	19BM70301	Applied and Industrial Robotics	3	-	-	3	3	40	60	100
	19BM70302	Robotic Programming	3	-	-	3	3	40	60	100
	19BM70303	Sensors and Machine Vision Systems	3	-	-	3	3	40	60	100

* Compulsory Course, if not studied in Major Degree.

Note: If any student has chosen a course from the above list in their regular curriculum then, he/she is not eligible to opt the same course/s for the Minor degree. It is the responsibility of the student to acquire/complete the prerequisite before taking the respective course.

III B. Tech. – I Semester

(19BM50301) **COMPUTER INTEGRATED MANUFACTURING**

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: -

COURSE DESCRIPTION:

Introduction to CIM, CAD/CAM, product life cycle, Fundamentals of NC and CNC, Group Technology AND FMS, Computer Aided Planning Systems, Adaptive control systems.

COURSE OUTCOMES: After successful completion of this course, the students will be able to:

CO1. Apply the principles of Computer integrated manufacturing to control and foster the production process.

CO2. Analyze the architecture of numerical control and apply the Numerical control programming techniques for the machining process.

CO3. Analyze different part families through grouping and construe different machine cell designs and flexible manufacturing systems.

CO4. Demonstrate different approaches and techniques for computer-aided process planning in automation.

CO5. Demonstrate knowledge of Adaptive control systems for different applications.

DETAILED SYLLABUS:

UNIT I: FUNDAMENTALS OF CIM (9 Periods)

Introduction to Manufacturing; CIM - Types, Manufacturing Systems, CIM Definition, CIM wheel, CIM components, Evolution of CIM - Development of computers, needs of CIM, Benefits of CIM, CIM Hardware & Software, Fundamentals of CAD / CAM, Product cycle.

UNIT II: FUNDAMENTALS OF NC AND CNC (9 Periods)

Numerical control machines: Introduction, basic components of an NC system, the NC procedure, NC coordinate system, NC motion control system, application of numerical control and Economics of Numerical control.

Computer controls in NC: Principle of CNC, types of CNC machine tools, programming and applications of CNC machine tools, Direct Numerical control (DNC), Database and DBMS-requirement, features and architecture of DBMS.

UNIT III: GROUP TECHNOLOGY AND FMS (9 Periods)

Group Technology: Group Technology - Part families, Parts classification and coding, Production flow analysis, Composite part concept, Machine cell design and Benefits of GT.

Flexible Manufacturing Systems: FMS - Components of FMS, FMS Work stations, Material Handling Systems, Computer Control system, FMS layout configurations and Benefits of FMS.

UNIT IV: COMPUTER AIDED PLANNING SYSTEMS (9 Periods)

Computer aided planning systems - Approaches to Computer aided Process Planning (CAPP), Generative and Retrieval CAPP systems, Benefits of CAPP, Material Requirement Planning (MRP), Mechanism of MRP, Benefits of Capacity Planning.

UNIT V: ADAPTIVE CONTROL SYSTEMS: (9 Periods)

Adaptive control machining system - Adaptive control optimization system, Adaptive control constraint system, Applications to machining processes, Computer process monitoring, Hierarchical structure of computers in manufacturing, and computer process control.

Total Periods: 45

Topics for self-study are provided in the lesson plan

TEXTBOOKS:

1. Mikel.P.Groover, *Automation, Production systems and Computer Integrated Manufacturing Systems*, Pearson Education; 4th Edition,2016.
2. P.N.Rao, *CAD/CAM: Principles and Applications,* McGraw Hill Education*, 3rd edition, 2017.*

REFERENCE BOOKS:

1. Radhakrishnan and Subramanian, *CAD/CAM/CIM*, New Age International Pvt Ltd, 4th Edition, 2018.
2. M. Groover, *CAD/CAM*, Pearson Education; 1st Edition, 2003.

CO-PO-PSO Mapping Table :

Course Outcome	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1		-	1	1		-	-	-	-	-			
CO2	3	3	1	-	1	1	-	-	-	-	-	-			
CO3	3	3	1	-	1	1	-	-	-	-	-	-			
CO4	3	1		-	1	1	-	-	-	-	-	-			
CO5	3	1		-	1	1		-	-	-	-	-			
Average	3	1.8	1		1	1		-	-	-	-	-			
Correlation level	**3**	**2**	**1**		**1**	**1**									

Correlation Levels: 3– High 2 - Medium 1– Low

III B. Tech. – I Semester

(19BM50302) **CNC PROGRAMMING**

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: -

COURSE DESCRIPTION:

Fundamentals of NC And CNC Machines, CNC Machine Elements, CNC Machine Structure and Machining Centers, Machining Centers, Adaptive Control Systems and Drives, DNC Systems and Adaptive Control, Feedback Devices, Fundamentals of CNC Programming, CNC Part Programming, CNC Turning and Milling Programming, CNC Turning, CNC Milling.

COURSE OUTCOMES:

After successful completion of this course, the students will be able to:

CO1. Demonstrate the knowledge of numerical controls & computerized numerical control of a manufacturing system.

CO2. Demonstrate the knowledge of constructional and functional features of machines and its support systems.

CO3. Analyze CNC machines with the knowledge of Adaptive control systems and drive systems considering societal needs.

CO4. Apply CNC coding used in CNC programming for a given operation.

CO5. Apply CNC programming for basic Turning and Milling Operations.

DETAILED SYLLABUS:

UNIT I: FUNDAMENTALS OF NC and CNC MACHINES (9 Periods)

NC machines: Fundamentals of numerical control, advantage of NC systems, classification of NC systems, point to point, NC and CNC, incremental and absolute, open and closed-loop systems, features of NC Machine tools, interpolations.

CNC Machines: CNC machine elements, principle of operation of CNC, features of CNC, classification of CNC systems, Advantages of CNC system, Application of CNC systems.

UNIT II: CNC MACHINE STRUCTURE AND MACHINING CENTERS (9 Periods)

CNC Machine Structure: Guideways, feed drives, spindles, spindle bearings, slide ways - Friction, Antifriction and types of guideways; Recirculating ball screw; Torque transmission elements - gears, timing belts, flexible couplings and bearings.

Machining centers: Features, Auto Tool Changer (ATC) & Automatic Pallet Changer (APC).

UNIT III: ADAPTIVE CONTROL SYSTEMS AND DRIVES (9 Periods)

DNC Systems and Adaptive Control: Introduction, type of DNC systems, advantages and disadvantages of DNC, adaptive control with optimization, adaptive control with constraints. **Feedback devices** – Open loop and closed loop control systems, positional feedback, velocity feedback devices.

Drives: spindle drives-DC shunt motor, 3 phase induction motor, Feed drives-stepper motors, servo principle, DC and AC servo motors.

UNIT IV: CNC PROGRAMMING (9 Periods)

CNC PART PROGRAMMING: Coordinate systems- structure of part program, Types of interpolation, Methods of CNC part programming, Part Program Terminology-G and M Codes, Machine and workpiece datum, absolute and incremental programming, tool offset and tool nose radius compensation, fixed cycles, subroutines in part programming, computer-aided part programming, CNC controllers (FANUC and SINUMERIC),

UNIT V: CNC TURNING AND MILLING PROGRAMMING (9 Periods)

CNC Turning: Basic programs on Turning, Facing, Drilling, Threading, Taper Turning, Boring, reaming, and tapping

CNC Milling: Basic programs on Face Milling, End Milling, Drilling, Chamfering, Boring, Reaming, Tapping, Sinking.

Features of typical CAM packages: Master CAM, Edge CAM, Siemens NX CAM.

Total Periods: 45

Topics for self-study are provided in the lesson plan

TEXTBOOKS:

1. Mike Mattson, *CNC Programming: Principles & Applications: Principles and Applications*, Delmar; 1st edition, 2013.
2. Yorem Koren, *Computer Control of Manufacturing Systems*, Mc Graw Hill Book Co, 2017.
3. P. Radhakrishnan, *Computer Numerical Control (CNC) Machines*, New Central Book Agency; 1st edition,2013

REFERENCE BOOKS:

1. M. Adithan and B.S. Pable, *CNC Machines*, New Age, Third edition, 2018.
2. Mikell P. Groover, *Automation, Production Systems and Computer-Integrated Manufacturing*, Pearson Education; Fourth edition, 2016.
3. J.S. Narang, *CNC Machines And Automation*, Dhanpat Rai & Co. (P) Limited, 2016.

CO-PO-PSO Mapping Table :

Course Outcome	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1		-	1	1		-	-	-	-	-			
CO2	3	1		-	1	1	-	-	-	-	-	-			
CO3	3	3		-	1	1	-	-	-	-	-	-			
CO4	3	3		-	1	1	-	-	-	-	-	-			
CO5	3	1		-	1	1		-	-	-	-	-			
Average	3	1.8			1	1		-	-	-	-	-			
Correlation level	**3**	**2**			**1**	**1**									

Correlation Levels: 3– High 2 - Medium 1– Low

III B.Tech. – I Semester

(19BM50303) **INTRODUCTION TO MECHANICAL SYSTEMS**

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: -

COURSE DESCRIPTION:

Statics of rigid bodies; Laws of mechanics; Force couple system; Equilibrium of rigid bodies; Supports and reactions forces; Moment and couple and their representation; Dynamics of rigid bodies; Motion of a rigid bodies; Energy equations; Frictional forces; Robotics and automation; Configuration and anatomy of robots; End effectors; Robotic drive and control systems; Actuators.

COURSE OUTCOMES:

After successful completion of this course, the students will be able to:

CO1. Analyze the mechanical behavior of a rigid body and components of forces involved in it.

CO2. Analyze conditions of equilibrium applied over a rigid body in different dimensions and compute its moments and couples.

CO3. Analyze the dynamic behavior of a rigid body and its condition of motion.

CO4. Demonstrate knowledge of robots and their components.

CO5. Analyze the functional characteristics of robot drives, actuators and controls for configurations.

DETAILED SYLLABUS:

UNIT I: STATICS (9 Periods)

Introduction, Units and Dimensions, Laws of Mechanics, Force Characteristics, System of forces, Lami's theorem, Parallelogram and triangular Law of forces, Statics of rigid bodies in two dimensions, force couple system.

UNIT II: EQUILIBRIUM OF RIGID BODIES (9 Periods)

Free body diagram, Types of supports, Action and reaction forces, Moments and Couples, Moment of a force about a point and about an axis, Vectorial representation of moments and couples, Varignon's theorem, Equilibrium of Rigid bodies in two dimensions.

UNIT III: RIGID BODY DYNAMICS (9 Periods)

Displacements, Velocity and acceleration, their relationship, Relative motion, Curvilinear motion, Newton's laws of motion, Work Energy Equation; Friction force – Laws of sliding friction, Equilibrium analysis of simple systems with sliding friction.

UNIT IV: ROBOTICS (9 Periods)

Robotics and programmable automation, Law of robotics, Anatomy, Configuration of robots, Robot end effectors-classification, force analysis, active and passive grippers.

UNIT V: ROBOTIC DRIVES, ACTUATORS & CONTROLS (9 Periods)

Functions of Drive Systems, General Types of Fluids, Classification of fluid power systems, Components of hydraulic fluid power systems, components of pneumatic systems, Pump Classification, Introduction to Pneumatic Systems, Electrical Drives, D.C. Motors and Transfer Functions, A.C. Motors, Piezoelectric Actuators, Stepper Motor, Drive Mechanisms.

Total Periods: 45

Topics for self-study are provided in the lesson plan

TEXTBOOKS:

1. Beer F.P, Johnston Jr.E.R, *Vector Mechanics for Engineers Statics and Dynamics,* McGraw Hill Education, 11th Edition, 2017.
2. Mikell P Groover, Mitchell Weiss, Roger N Nagel, Nicholas Odrey, Ashish Dutta *"Industrial Robotics (SIE): Technology, Programming and Applications*, McGraw Hill Education India, 2012
3. S.R. Deb and S.Deb *"Robotic Technology and Flexible Automation"* McGraw Hill Education India. Second Edition, 2012.
4. Khushdeep goyal, Deepak Bhandari*, Industrial automation and robotics*, Katson books, 2013.

REFERENCES:

1. Hibbeller R.C, Ashok Gupta "*Engineering Mechanics Statics and Dynamics*", Pearson Education, 11th Edition, 2009.
2. Bhavikatti S.S "*Engineering Mechanics*", 7th Edition, New Age International (P) Limited Publishers, 2019.
3. Young D H, Timashenko S "*Engineering Mechanics*", Tata McGraw-Hill., 2006
4. S K Saha *"Introduction to Robotics",* 2nd Edition, McGraw Hill Education India, 2014.

CO-PO-PSO Mapping Table :

Course Outcome	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	1	-	-	-	-	-	-	-	-	-			
CO2	3	3	1		-		-	-	-	-	-	-			
CO3	3	3	1		-		-	-	-	-	-	-			
CO4	3	2	1		-		-	-	-	-	-	-			
CO5	3	3	1		-		-	-	-	-	-	-			
Average	**3**	**2.6**	**1**												
Correlation level	**3**	**3**	**1**												

Correlation Levels: 3– High 2 - Medium 1– Low

III B. Tech. – II Semester

(19BM60301) **PRINCIPLES OF INDUSTRIAL AUTOMATION**

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: -

COURSE DESCRIPTION:

Introduction to automation, Types of automation systems, Fluid power and fluid power systems, Assembly automation equipment, Material handling, transfer and assembly equipment, Types of automated assembly machines, Programmable Logic Controllers, PLC hardware components, Microprocessors and Microcontrollers, Feedback devices.

COURSE OUTCOMES:

After successful completion of this course, the students will be able to:

CO1. Demonstrate knowledge of automation and its different applications.

CO2. Analyze functional characteristics of power systems for industrial applications.

CO3. Demonstrate knowledge of assembly automation equipment and its related components.

CO4. Demonstrate the knowledge of programming logic controller units for industrial applications.

CO5. Demonstrate the knowledge of microprocessors and microcontrollers in integrating mechanical systems with computer and electronic systems.

DETAILED SYLLABUS:

UNIT I: INTRODUCTION TO AUTOMATION (9 Periods)

History, Elements of Automation, Types of Automation systems, Applications of Automation, Goals of Automation, low cost automation, Hierarchical levels in industrial automation systems.

UNIT II: FLUID POWER AND FLUID POWER SYSTEMS (9 Periods)

Introduction to fluid power- Classification of fluid power systems, comparison of electrical, hydraulic and Pneumatic systems; Basic circuit diagram of Hydraulic fluid power and pneumatic power systems, Components of Hydraulic fluid power systems, Components of Pneumatic power system, Logic Gates, Truth tables and Boolean algebra.

UNIT III: ASSEMBLY AUTOMATION EQUIPMENT (9 Periods)

Material Handling: Principles of Material Handling, Material handling equipment- Wheel conveyor, Gravity Roller conveyor, Chain conveyor, Flat belt conveyor, Magnetic belt conveyor, bucket conveyor, Vibrating conveyor, screw conveyor, vertical lift conveyor, trolley conveyor, sortation conveyor, cranes and Hoists, storage equipment, AS/RS, AGV.

Transfer and assembly equipment: Introduction to feeder units, Cycled transfer equipment and non-cycled transfer equipment.

Automated assembly machines: Dial indexing machine, In-line machine, and floating work platform machines.

UNIT IV: PROGRAMMABLE LOGIC CONTROLLERS (9 Periods)

Programmable Logic Controllers (PLC): Parts of a PLC, Principles of Operation, Modifying the Operation, PLCs versus Computers, PLC Size and Applications.

PLC hardware Components: The I/O Section, Discrete I/O Modules, Analog I/O Modules, Special I/O Modules, I/O Specifications, Typical Discrete I/O Module Specifications, Typical Analog I/O Module Specifications, The Central Processing Unit (CPU),Memory Types, Programming Terminal Devices, Recording and Retrieving Data, Human Machine Interfaces (HMIs).

UNIT V: MICROPROCESSORS AND MICROCONTROLLERS (9 Periods)

Evolution of microprocessors and microcontrollers; Architectures of microprocessors and microcontrollers; Integration of mechanical systems with computer and electronic systems (Mechatronic systems).

Feedback devices: LVDT, Linear/Rotary encoders, absolute encoders, resolvers and potentiometers, Fundamentals of SCADA and Data Acquisition Systems.

Total Periods: 45

Topics for self-study are provided in the lesson plan

TEXTBOOKS:

1. Khushdeep Goyal, *Industrial Automation and Robotics*, S.K.Kataria & Sons, 4th Edition, 2013.
2. Frank. D.Petruzella*, Programmable Logic Controllers,* Tata McGraw-Hill Education, 4th Edition, 2011.

REFERENCE BOOKS:

1. M.P. Groover, Automation, *Production systems and Computer Integrated Manufacturing*, Fourth edition, PHI Learning, 2016.
2. Geoffrey Boothroyd, Assembly Automation and Product design, Taylor and Francis Publishers, Second edition 2005.

CO-PO-PSO Mapping Table :

Course Outcome	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3			-	-	1		-	-	-	-	-			
CO2	3	3	1	-	1	1	-	-	-	-	-	-			
CO3	3	2		-	1	1	-	-	-	-	-	-			
CO4	3	2	1	-	-	1	-	-	-	-	-	-			
CO5	3	2	1	-		1		-	-	-	-	-			
Average	3	2.2	1		1	1		-	-	-	-	-			
Correlation level	**3**	**2**	**1**		**1**	**1**									

Correlation Levels: 3– High 2 - Medium 1– Low

III B.Tech. II-Semester

(19BM60302) **PRINCIPLES OF ROBOTICS**

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: -

COURSE DESCRIPTION:

Brief history - Robot – Definition, Various robot manipulators – Linear and angular velocities, tactile, proximity and range sensors, End Effectors and robot economics

COURSE OUTCOMES:

After successful completion of this course, the students will be able to:

CO1. Demonstrate knowledge of robotics, its specifications, functions and different applications.

CO2. Demonstrate knowledge of various robot manipulators

CO3. Demonstrate knowledge of sensors, work cells and programming languages.

CO4. Analyze functional characteristics of robot end effectors through design considerations.

CO5 Analyze the economic aspects of robots by considering different safety parameters.

DETAILED SYLLABUS:

UNIT I: BASIC CONCEPTS (9 Periods)

Brief history, Robot - Definition, Anatomy; Co-ordinate Systems, Work Envelope types and Classification, Robotic Specifications, Pitch, Yaw, Roll, Joint Notations, Speed of Motion, Pay Load, Robot Parts and their Function; Need for Robots, Applications.

UNIT II: ROBOT MANIPULATORS (9 Periods)

Various robot manipulators, Linear and angular velocities, Manipulator Jacobian, Prismatic and rotary joints, Robotic Inverse, Wrist and arm singularity.

UNIT III: ROBOT SENSORS (9 periods)

Desirable features of Sensors; Tactile, proximity and range sensors; Uses of sensors in robotics; work cell; Introduction to Programming languages.

UNIT IV: ROBOT END EFFECTORS (9 periods)

End Effectors-Grippers-Mechanical Grippers, Pneumatic and Hydraulic Grippers, Magnetic Grippers, Vacuum Grippers; Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers; Selection and Design Considerations.

UNIT V: IMPLEMENTATION AND ROBOT ECONOMICS (9 *periods*)

RGV, AGV; Implementation of Robots in Industries-Various Steps; Safety Considerations for Robot Operations - Economic Analysis of Robots.

Total Periods: 45

Topics for self-study are provided in the lesson plan.

TEXTBOOKS:

1. R.K.Mittal and I.J.Nagrath, *Robotics and Control*, Tata McGraw Hill, New Delhi,4th Reprint, 2005.
2. M.P.Groover, M.Weiss, R.N. Nageland N. G.Odrej, *Industrial Robotics*, McGraw-Hill Singapore, 1996.

REFERENCE BOOKS:

1. JohnJ.Craig ,*Introduction to Robotics Mechanics and Control*, Pearson Education, Third edition, 2009.
2. Ashitava Ghoshal, *Robotics-Fundamental Concepts and Analysis*, Oxford University Press, Sixth impression, 2010.

CO-PO-PSO Mapping Table :

Course Outcome	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1		-	-	1		-	-	-	-				
CO2	3	1		-	1	1	-	-	-	-	-				
CO3	3	1	1	-	1	1	-	-	-	-	-				
CO4	3	3	2	-	-	1	-	-	-	-	-				
CO5	3	3	1	-		1		-	-	-	1				
Average	3	1.8	1.3		1	1		-	-	-	1				
Correlation level	**3**	**2**	**1**		**1**	**1**					**1**				

Correlation Levels: 3– High 2 - Medium 1– Low

III B. Tech. – II Semester

(19BM60303) **ROBOT KINEMATICS AND DYNAMICS**

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: -

COURSE DESCRIPTION:

Robot Manipulation, Robot Classification, Robot Specifications, Direct Kinematics, Inverse Kinematics, Manipulator Differential Motion and Statics, Manipulator Jacobian, Dynamic Modeling,

COURSE OUTCOMES:

After successful completion of this course, the students will be able to:

CO1. Demonstrate the knowledge on robot manipulation and control for industrial applications

CO2. Analyze forward and Inverse kinematics for different robot schemes.

CO3. Analyze manipulator differential motion and statics for different robot schemes

CO4. Develop dynamic models for robots using Langrangian mechanics, Lagrange–Euler formulation, Newton–Euler formulation and other techniques.

DETAILED SYLLABUS:

UNIT I: ROBOT MANIPULATION (9 Periods)

Automation and robots; Robot anatomy; Robot Classification; Manipulation and control; Applications; Robot Specifications**-**Number of axes, Capacity and speed, Reach and stroke, Tool orientation, Repeatability, precision and accuracy, Operating environment.

UNIT II: DIRECT KINEMATICS (9 Periods)

Dot and cross products; coordinate frames; Rotations; Homogeneous coordinates; link coordinates; D-H Representation; The ARM equation; Schematic diagram of four, five and six axis articulated robot.

UNIT III: INVERSE KINEMATICS (9 Periods)

Manipulator workspace; Solvability of inverse kinematic model; Existence of solutions; Multiple solutions, Solution techniques; Closed form solution; The inverse kinematics problem; General properties of solutions; Tool configuration; Inverse kinematics of four axis SCARA robot and six axis articulated robot.

UNIT IV: MANIPULATOR DIFFERENTIAL MOTION AND STATICS (9 Periods)

Linear and angular velocity of a rigid body; Relationships between transformation; Mapping, Velocity vector; Velocity propagation along links; Manipulator Jacobian; Jacobian inverse; Jacobian singularities; Static analysis.

UNIT V: DYNAMIC MODELING: **(9 Periods)**

Langrangian mechanics; Two degrees of freedom manipulator–Dynamic model, Lagrange – Euler formulation, Newton–Euler formulation; Comparison of Lagrange–Euler formulation and Newton–Euler formulation; Inverse dynamics.

Total Periods: 45

Topics for self-study are provided in the lesson plan

TEXTBOOKS:

1. Robert J. Schilling, *Fundamentals of Robotics Analysis and Control,* PHI Learning, 2011.
2. R.K.Mittal and Nagrath*, Robotics and Control, TMH, 2017.*

REFERENCE BOOKS:

1. Niku S B*, Introduction to Robotics, Analysis, Systems, Applications,* Prentice Hall, Second edition 2006.
2. Geoffrey Boothroyd, *Assembly Automation and Product design*, Taylor and Francis Publishers, Second edition 2005.

CO-PO-PSO Mapping Table :

Course Outcome	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3					1									
CO2	3	2	1	1		1									
CO3	3	2	1	1		1									
CO4	3	3	1	1		1									
CO5	3	2.3	1	1		1									
Average	3	3	1	1		1									
Correlation level															

Correlation Levels: 3– High 2 - Medium 1– Low

IV B.Tech I Semester

(19BM70301) **APPLIED AND INDUSTRIAL ROBOTICS**

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: -

COURSE DESCRIPTION:

General considerations in Robot material handling, material transfer application, machine loading and unloading, CNC machine tool loading; repeatability, maximum working envelop, kinematic and state values. Robot safety Considerations, Factors affecting robot safety measures; Cooperative manipulation; field robots and robots in health care

COURSE OUTCOMES:

After successful completion of this course, the students will be able to:

CO1. Demonstrate knowledge of robotic material handling and assembly systems.

CO2. Demonstrate the knowledge of expert systems in robotic performance testing and safety

CO3. Demonstrate knowledge of various cooperative and SWARM robots and its applications.

CO4. Analyze robotic configurations and specifications for field and service applications.

CO5. Demonstrate the core concepts of robots in medical applications.

DETAILED SYLLABUS:

UNIT I: **ROBOT MATERIAL HANDLING** **(10 periods)**

General considerations in Robot material handling, material transfer application, machine loading and unloading, CNC machine tool loading, Robot centered cell Assembly and parts presentation methods, Assembly operation, Compliance and the Remote center compliance (RCC) Device, Assembly system configurations, Adaptable programmable assembly system, Designing for robotic assembly, Inspection automation - vision inspection system, robot - manipulated inspection.

UNIT II: EXPERT SYSTEMS **(9 periods)**

Factors influencing the choice of a robot, Robot performance testing - Path/point accuracy and repeatability, Maximum working envelop, Kinematic and State values. Robot safety Considerations, Factors affecting robot safety measures, Safety features built into industrial robot, Safety barriers and other devices.

UNIT III: COOPERATIVE AND SWARM ROBOTS **(7 periods)**

Cooperative manipulation, Challenges in cooperative manipulation- Case studies for Cooperative manipulation for Industrial and Service applications; Introduction to swarm Robots, Comparison with other multi-agent systems, challenges and benefits of swarm systems- Algorithms for swarm Robots, application, case study of swarm Robots.

UNIT IV: FIELD ROBOTS **(10 periods)**

Forestry, Robot locomotion, Forestry automation, Broadacre Applications- Automatic guidance, sowing, weeding, spraying and broad-acre harvesting; Horticulture, Picking of fruits, Robot milking, Sheep shearing, Slaughtering, livestock inspection, Robots in construction, Future directions; Robots for hazardous applications, Enabling technologies- Search and Rescue robotics: Disaster characteristics-Impact on Robots, Robots actually used at disaster, Promising robots, open issues – Case studies; Cleaning Robots, lawn moving Robots- Smart appliances and smart homes.

UNIT V: ROBOTS IN HEALTH CARE **(9 periods)**

Medical robotics, Core concepts, Technology- Medical robotic systems, Research areas and applications; Rehabilitation and Health care robotics- Overview, physical therapy

and training Robots; Robotic aid for people with disabilities- Smart prostheses and orthoses, diagnosis and monitoring.

Total Periods: 45

Topics for self-study are provided in the lesson plan

TEXTBOOKS

1. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel and Nicholas G. Odrey, *Industrial Robotics Technology, Programming and Applications*, Mc Graw Hill Book company, 4th edition, 2016.
2. Bernard Hodges, *Industrial Robotics*, Second Edition, Jaico Publishing House, 1993.

REFERENCE BOOKS

1. Yangsheng Xu Huihuan Qian Xinyu Wu, *Household and Service Robots*, ElsevierLtd, 2015.
2. Aleksandar Lazinica, -*Mobile Robots Towards New Applications*, Advanced Robotic Systems International, 2006.
3. L Marques,A de Almeida,Mo Tokhi,GSVirk, -*Advances in Mobile Robotics*, World Scientific Publishing Co. Pte. Ltd. 2008.
4. Bruno Siciliano, OussamaKhatib, -*Springer Handbook of Robotics*, Springer-Verlag Berlin Heidelberg, 2008.

CO-PO-PSO Mapping Table :

Course Outcome	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1			1									
CO2	3	1	1			2									
CO3	3	1				1									
CO4	3	3	2	1	1	1									
CO5	3			1	1	1									
Average	3	1.5	1.3	1	1	1.2									
Correlation level	3	2	1	1	1	1									

Correlation Levels: 3– High 2 - Medium 1– Low

IV B.Tech. – I Semester

(19BM70302) **ROBOTIC PROGRAMMING**

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES:-

COURSE DESCRIPTION:

Robotic programming; Robotic software functions; Program planning; Modes of programming; Commands for motion control; Lead through robotic programming; Textual robotic programming; End effectors and sensors commands; Program control and subroutines; VAL II Programming; AML Programming;

COURSE OUTCOMES:

After successful completion of this course, the students will be able to:

CO1. Demonstrate the knowledge of basic planning schemes involved in the development of robotic programming.

CO2. Develop Programmes for robots based on the techniques of pendent and command control.

CO3. Demonstrate the knowledge of robotic languages for operations and control.

CO4. Develop Programs for robots on VAL II platform with complete command-based control.

CO5: Develop Programs for robots on AML platform with complete command-based control.

DETAILED SYLLABUS:

UNIT I: FUNDAMENTALS OF ROBOT PROGRAMMING (9 Periods)

Robot software functions - coordinate systems, Position control, Oher control functions, sub-routines, Planning of robotic programming using flowcharting - examples.

UNIT II: METHODS OF ROBOT PROGRAMMING (9 Periods)

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 lead through methods.

UNIT III: ROBOT LANGUAGES (9 Periods)

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 effectors and sensor commands, Computations and operations, Program control and subroutines, Communications and Data processing.

UNIT IV: VARIABLE ASSEMBLY LANGUAGE (9 Periods)

Variable Assembly Language II - Introduction, Monitor commands, motion command, Hand Control, Configuration control, interlock commands, INPUT/OUTPUT Controls, Program Control, Examples

UNIT V: A MANUFACTURING LANGUAGE (9 Periods)

A Manufacturing Language (AML) - Introduction, AML statements, Constant and variables, Program control statements, motion commands, Sensor commands; Grip sensing capabilities, Data processing, Examples.

Total Periods: 45

Topics for self-study are provided in the lesson plan

TEXTBOOKS:

1. Mikell P. Groover, Mitchell Weiss, Roger N. Nagel and Nicholas G. Odrey, *Industrial Robotics Technology, Programming and Applications*, McGraw Hill Book company, 1986
2. Bernard Hodges, *Industrial Robotic*, Jaico Publishing House, 2nd Edition, 1993.
3. S.R. Deb and S.Deb *Robotic Technology and Flexible Automation,* Second Edition McGraw Hill Education India., 2012

REFERENCES:

1. JJ Craig, *Introduction to Robotic Mechanics and Control*, Pearson, 3rd edition, 2004.
2. Fu, Lee and Gonzalez, *Robotics, control vision and intelligence*, McGraw Hill International, 2nd edition, 1987.

CO-PO-PSO Mapping Table :

Course Outcome	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1		1	1									
CO2	3	2	3		1	1									
CO3	3	1	1		1	1									
CO4	3	2	3		1	1									
CO5	3	2	3		1	1									
Average	3	1.6	2.2		1	1									
Correlation level	3	2	2		1	1									

Correlation Levels: 3– High 2 - Medium 1– Low

IV B.Tech. – I Semester

(19BM70303) **SENSORS AND MACHINE VISION SYSTEMS**

Int. Marks	Ext. Marks	Total Marks	L	T	P	C
40	60	100	3	-	-	3

PRE-REQUISITES: --

COURSE DESCRIPTION:

Vison systems; Components of vision systems; Elements of visual perception; Low level vison; Filters; Higher level visions; Boundary and regional description; Sensors in robots; Different sensing variables; Robotic control; Robotic operating System; Open CV.

COURSE OUTCOMES:

After successful completion of this course, the students will be able to:

CO1. Demonstrate the knowledge of vision system components and image interfaces.

CO2. Demonstrate the knowledge of image representations and filters for low level vision system.

CO3. Demonstrate the knowledge of higher level vision for industrial applications.

CO4. Analyze functional characteristics of sensors incorporated in a robot system.

CO5. Demonstrate knowledge of robotic operating system and vision system for robotic simulation.

DETAILED SYLLABUS:

UNIT I: VISION SYSTEM (9 Periods)

Basic Components, Elements of visual perception: structure of the human eye, Image formation in the eye – pinhole cameras - colour cameras – Image formation model – Imaging components and illumination techniques-Picture coding–Basic relationship between pixels -Camera-Computer interfaces.

UNIT II: LOW-LEVEL VISION (9 Periods)

Image representation–Gray level transformations, Histogram, Image subtraction, Image averaging – Filters: Smoothing spatial filters, sharpening spatial filters, smoothing frequency domain filters, sharpening frequency domain filters-Edge detection.

UNIT III: HIGHER LEVELVISION: (9 Periods)

Segmentation-Edge linking and Boundary Detection, Thresholding, Region-oriented segmentation, the use of motion Description: Boundary Descriptors, Regional Descriptors, Recognition: Decision-Theoretic methods, structural methods.

UNIT IV: SENSORS IN ROBOTICS (9 Periods)

Position sensors - optical, non-optical, Velocity sensors, Accelerometers, Proximity Sensors - Contact, non-contact, Range Sensing, touch and Slip Sensors, Force and Torque Sensors. Different sensing variables - smell, Heat or Temperature, Humidity, Light, Speech or Voice recognition Systems, Telepresence and related technologies, robot control through vision

UNIT V: ROBOT VISION **(9 Periods)**

Robotic operating System (ROS) -Introduction, Real and Simulated Robots; Introduction to OpenCV, Open NI and PCL, installing and testing ROS camera Drivers, ROS to OpenCV – The CV_bridge Package.

Total Periods: 45

Topics for self-study are provided in the lesson plan

TEXTBOOKS:

1. K.S.Fu, R.C.Gonzalez, CSG.Lee, *-Robotics control, sensing, vision and Intelligence‖,* McGraw Hill EducationPvt.Ltd.,2017.
2. Richard D. Klafter, Thomas A. Chmielewski, Michael Negin, *Robotics Engineering: An Integrated Approach*, PHI Learning, New Delhi, 2009.

REFERENCEBOOKS:

1. Damian M.Lyons, *Cluster Computing for Robotics and Computer Vision*, World Scientific, Singapore, 2011.
2. Rafael C.Gonzalez, Richard E.Woods, StevenL. Eddins, *Digital Image Processing using MATLAB* ,2nd edition, Tata McGrawHill, 2010.
3. Carsten Steger, MarkusUlrich, Christian Wiedemann, *Machine Vision algorithms and Applications*, WILEY-VCH, Weinheim, 2008.
4. Kenneth Dawson-Howe, *A Practical Introduction to Computer Vision with OpenCV*, Wiley, Singapore, 2nd edition, 2013.

CO-PO-PSO Mapping Table :

Course Outcome	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1				1									
CO2	3	1				1									
CO3	3	1				1									
CO4	3	3	2	1	1	1									
CO5	3	1		1	1	1									
Average	3	2	2	1	1	1									
Correlation level	3	2	2	1	1	1									

Correlation Levels: 3– High 2 - Medium 1– Low