RAMDEOBABAUNIVERSITY

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NAGPUR–440013

RAMDEOBABA UNIVERSITY, NAGPUR

Formerly Shri Ramdobaba College of Engineering & Management (RCOEM) Est. 1984

SchoolofEngineering and Science

Department of Mechanical Engineering

B. Tech Mechanical Engineering/Robotics &AI

PROGRAMMESCHEME&SYLLABI

MultidisciplinaryMinor[MDM], Honorand Minor

2025-26

MDM in Defense Technology

Overview:

The Minor in Defense Technology is tailored for undergraduate engineering students aiming to contribute to national security through advanced technological innovation. This program provides foundational and specialized knowledge in defense platforms, weapon systems, warfare technologies, and protective mechanisms essential to modern military and strategic operations.

Through a blend of theoretical coursework, simulation-based training, and domain-specific case studies, students will explore the technologies driving today's defense systems. The program nurtures a systems-thinking approach and interdisciplinary understanding—blending mechanical, electrical, electronics, materials, and computer science perspectives—essential for designing and optimizing future-ready defense solutions.

Program Objectives:

By the end of this minor, students will be able to:

1. **Understand Core Defense Technologies** – Gain foundational knowledge in land, air, sea, and space-based defense platforms and their operational roles.
2. **Explore Warfare and Combat Systems** – Study modern warfare systems, including surveillance, targeting, guidance, and communication networks.
3. **Analyze Weapon Systems Engineering** – Learn the design, control, and integration of weapon systems including ballistics, propulsion, and guidance technologies.
4. **Design Self-Defense and Protection Mechanisms** – Examine advanced armor, electronic countermeasures, active protection systems, and stealth technologies.
5. **Engage with Emerging Defense Trends** – Understand cyber warfare, autonomous weapons, UAVs, AI in defense, and hybrid warfare strategies.
6. **Collaborate with Industry and Strategic Agencies** – Work on defense-focused projects and interact with experts from DRDO, armed forces, and defensestartups.

Who Should Enrol?

This minor is ideal for BTech students who:

- Are passionate about national security, defense innovation, and strategic technology development
- Seek to explore careers in defense R&D, DRDO labs, PSUs, private defense firms, or armed forces technology wings
- Wish to gain interdisciplinary exposure in high-impact domains such as aerospace, robotics, cybersecurity, and materials science
- Aspire to contribute to Atmanirbhar Bharat in defense manufacturing and next-generation military systems

MDM: Track-I: Defense Technology

Sr. No.	Sem	Course Code	CourseTitle	Hours/week L	T	P	Credits	Maximummarks ContinuousE	EndSemExam	Total	ESE Duration (Hrs)
1	III	25ES03TH0307	Defence Platforms	3	0	0	3	50	50	100	3
2	IV	25ES03TH0407	Warfare system	3	0	0	3	50	50	100	3
3	V	25ES03TH0507	Weapon Systems	3	0	0	3	50	50	100	3
4	VI	25ES03TH0607	Self-defence & Protection system	3	0	0	3	50	50	100	3
			TOTAL	12	0	0	12				

MDM scheme for School of Engineering Sciences (B. Tech Programs)

Track-I: Defense Technology

Course Code: 25ES03TH0307			Course: Defence Platforms
L: 3	T: 0	P: 0	Total Credits: 3
Semester: III			Total Marks: 100 (50 CE + 50 ESE)

Course Objectives:

1. To introduce students to the structural, functional, and technological aspects of land, naval, and aerial defense platforms.
2. To develop awareness about emerging technologies, indigenous capabilities, and strategic applications in defense systems.

Course Outcomes:

CO1: Identify and classify various defense platforms used in land, sea, and air operations.

CO2: Explain the basic design principles behind mobility, protection, and firepower in defense vehicles.

CO3: Demonstrate an understanding of the structure and functions of naval and aerial defense systems.

CO4: Analyze the role of emerging technologies such as AI, robotics, and unmanned systems in modern defense applications.

CO5: Evaluate India's indigenous defense capabilities and compare them with global defense technologies.

Syllabus

Unit 1: Introduction to Defense Systems and Platforms
Overview of national defense and security framework, Classification of defense platforms: Land, Air, Naval, Cyber, and Space, Basic technology: weapon systems, support systems, communication and control, Role of mechanical engineers in defense

Unit 2: Land-Based Platforms
Tracked vehicles: Tanks, ARVs, Light Tanks, Infantry Combat Vehicles (ICVs), Armoured Personnel Carriers (APCs), Artillery systems: Towed, SPG, ATAGS, Design principles: mobility, armour, firepower, Logistics and maintenance systems

Unit 3: Naval Platforms
Design, structure and classification of vessels, Warships: Destroyers, Frigates, Corvettes, Submarines, Propulsion systems: Diesel-electric, nuclear, Weaponry and stealth in naval platforms, Vehicle robotics and underwater drones

Unit 4: Aerial Platforms
Fighter aircraft types (Tejas, Sukhoi-30 MKI), UAV/drones: Nishant, Rustom, Heron, Helicopters: LCH, Dhruv, Apache, Aerodynamics, propulsion, stealth and avionics, Future aerial combat systems

Unit 5: Emerging Technologies in Defense
Network centric warfare and systems, Artificial Intelligence and decision making, Directed Energy Weapons, Unmanned systems: hypersonics, swarm drones, directed-energy weapons, indigenous technology development

Books:

Understanding Modern Warfare – David Jordan et al.
Introduction to Defense Acquisition Management – Defense Acquisition University
Weapons: An International Encyclopedia – Diagram Group
Military Vehicle Technology – David McLellan
Jane's Armour and Artillery – Jane's Information Group

Evaluation Scheme

Component	**Marks**	**Description**
Mid Term Test	20+20	Subjective Test
Teacher's Assignment	10	Assignment, MCQ,Viva
End Semester Examination	50	Descriptive 3-hour written exam

Course Code: 25ES03TH0407			**Course: Warfare Systems**
L: 3	**T: 0**	**P: 0**	**Total Credits: 3**
Semester: IV			**Total Marks: 100 (50 CE + 50 ESE)**

Course Objectives:

1. To provide insights into historical and modern warfare systems and their technological evolution.
2. To understand the structure, components, and working principles of various warfare systems.
3. To explore mechanical engineering contributions in designing and maintaining warfare technologies.

Course Outcomes:

CO1: Define and classify different types of warfare and identify their historical evolution.

CO2: Analyze the mechanical engineering aspects of conventional weapon systems including tanks, firearms, and artillery.

CO3: Explain the design and functioning of naval and submarine warfare systems including propulsion and stealth.

CO4: Evaluate air and space warfare capabilities including aircraft design, missile systems, and satellite surveillance.

CO5: Assess modern cyber and electronic warfare technologies and their impact on mechanical system vulnerabilities.

Syllabus

Unit 1: Fundamentals of Warfare Systems
Definition and evolution of warfare, Classifications: Conventional, Asymmetric, Cyber, Electronic, Nuclear, Mechanics and dynamics of military engagements, Mechanical engineering relevance in warfare design

Unit 2: Conventional Weapon Systems
Ballistics and projectile dynamics, Firearms, artillery, and their mechanical subsystems, Tanks and armored systems – mobility and firing mechanisms, Personal protective equipment and soldier systems

Unit 3: Naval and Submarine Warfare
Structure and propulsion of naval ships and submarines, Torpedoes, anti-ship missiles, and sonar systems, Stealth technologies and undersea warfare strategies, Role of materials and mechanics in naval platforms

Unit 4: Air and Space Warfare
Combat aircraft and missile systems – design and aerodynamics, Air defense systems – RADAR, AWACS, SAMs, Space-based warfare capabilities – satellites and surveillance, Anti-satellite weapons and hypersonic threats

Unit 5: Cyber and Electronic Warfare
Electronic warfare systems – jammers, decoys, ECM and ECCM, Cyber-attacks and defenses – mechanical system vulnerabilities, Role of AI, IoT and robotics in future warfare, Hybrid warfare and information warfare trends

Textbook

1. *Introduction to Modern Warfare Systems* – DRDO Publication
2. *Warfare and Military Technology* – Martin van Creveld

Reference Books

- *Art of War* – Sun Tzu
- *Modern Weapons and Warfare* – Chris Bishop
- *Future Warfare* – Col. John Antal
- *Understanding Cyber Warfare* – Christopher Whyte
- DRDO, HAL, and Ministry of Defence technical papers and publications

Online Resources

- https://drdo.gov.in – DRDO Official Site
- https://mod.gov.in – Ministry of Defence, India
- https://nptel.ac.in – NPTEL Modules
- YouTube Channels: Indian Army, Indian Navy, DRDO, HAL
- Coursera/edX: AI in Defense, Cybersecurity Fundamentals, Military Technology Courses

Evaluation Scheme

Component	Marks	Description
Mid Term Test	20+20	Subjective Test
Teacher’s Assignment	10	Assignment, MCQ,Viva
End Semester Examination	50	Descriptive 3-hour written exam

Course Code: 25ES03TH0507			Course: Weapon Systems
L: 3	T: 0	P: 0	Total Credits: 3
Semester: V			Total Marks: 100 (50 CE + 50 ESE)

Course Objectives:

1. To understand the fundamental principles, classifications, and operation of modern weapon systems.
2. To explore the mechanical engineering aspects involved in the design, dynamics, and deployment of various weapon systems.
3. To study the integration of fire control, propulsion, guidance, and stabilization technologies in weapon design.

Course Outcomes:

CO1: Classify and describe the various types of weapon systems used in defense applications.

CO2: Explain the working principles of internal ballistics, external ballistics, and terminal effects.

CO3: Analyze the structural and mechanical components of firearms, cannons, and missile systems.

CO4: Understand the integration of guidance, propulsion, and control in modern smart weapons.

CO5: Evaluate the technological challenges and recent advancements in indigenous weapon development.

Syllabus

Unit 1: Introduction to Weapon Systems
Definition and classification of weapon systems, Evolution of weapon systems from ancient to modern era, Components: launcher, projectile, guidance, fire control, Role of mechanical engineering in weapon design

Unit 2: Ballistics and Firing Mechanisms
Internal ballistics – combustion, chamber pressure, recoil, External ballistics – trajectory, drag, wind effects, Terminal ballistics – impact mechanics, penetration, Firing mechanisms in rifles, machine guns, artillery

Unit 3: Missile and Rocket Systems
Basic structure and classification of missiles and rockets, Propulsion systems – solid, liquid, hybrid, Aerodynamics and heat shielding, Guidance and control mechanisms

Unit 4: Fire Control and Launch Systems
Fire control systems – analog/digital, RADAR integration, Launch platforms – mobile, static, naval and aerial-based, Stabilization and recoil mechanisms in launchers

Unit 5: Advanced and Smart Weapons
Precision-guided munitions (PGMs), loitering munitions, Drone-based delivery systems, Electromagnetic railguns and laser-based weapons, Indigenous technologies – BrahMos, Pinaka, NAG, AKASH, Future trends: hypersonics, AI-guided weapons

Textbook

1. *Principles of Guided Missile Design* – Dr. M. N. Sinha
2. *Weapon Systems and Ballistics* – R.K. Arora

Reference Books

- *Modern Weapons and Warfare* – Chris Bishop
- *Fundamentals of Naval Weapons Systems* – CDR Craig M. Payne (US Navy)
- *Missile Guidance and Control Systems* – George M. Siouris
- *Indian Defence Technology Series* – DRDO Publications
- *Military Ballistics: A Basic Manual* – Malcolm J. D. Powell

Online Resources

- https://drdo.gov.in – DRDO Official Site
- https://nptel.ac.in – NPTEL Defense Modules
- YouTube Channels: DRDO, Bharat Forge, Indian Army Tech, MBDA Missiles
- Coursera/edX: Missiles and Rockets, Fundamentals of Ballistics, Weapon Design

- YouTube Channels: Indian Army, Indian Navy, DRDO, HAL
- Coursera/edX: AI in Defense, Cybersecurity Fundamentals, Military Technology Courses

Evaluation Scheme

Component	Marks	Description
Mid Term Test	20+20	Subjective Test
Teacher's Assignment	10	Assignment, MCQ,Viva
End Semester Examination	50	Descriptive 3-hour written exam

Course Code: 25ES03TH0607			Course: Self-defense& Protection systems
L: 3	T: 0	P: 0	Total Credits: 3
Semester: VI			Total Marks: 100 (50 CE + 50 ESE)

Course Objectives:

1. To introduce students to the fundamentals and technologies behind personal, vehicular, and infrastructure protection systems.
2. To study the application of mechanical and material engineering in designing armor, shelters, and anti-threat mechanisms.
3. To develop an understanding of modern self-defense technologies and threat mitigation strategies in civil and military domains.

Course Outcomes:

CO1: Classify and explain different types of self-defense and protection systems used by individuals and defense forces.

CO2: Understand the design and materials used in bulletproof vests, helmets, and riot gear.

CO3: Analyze vehicle protection technologies including mine-resistant and ambush-protected (MRAP) designs.

CO4: Evaluate technologies used in anti-intrusion, perimeter security, and blast mitigation.

CO5: Assess new-age protection technologies such as exoskeletons, active armor, and AI-based threat response.

Syllabus

Unit 1: Introduction to Self-Defense & Protection Systems
Threat landscape: Civilian and military, Classification: Personal, vehicle, infrastructure protection, Principles of threat assessment and risk analysis, Historical evolution of armor and protective technologies

Unit 2: Personal Protective Equipment (PPE)
Ballistic vests, helmets, shields – materials and manufacturing, Stab and blast resistant clothing, Riot gear and tactical suits, Standards: NIJ, STANAG, IS codes

Unit 3: Vehicle Protection Systems
Armoring of military and VIP vehicles, Design of MRAPs, blast seats, and underbody protection, Transparent armor: bulletproof glass and visors, Add-on and reactive armor systems

Unit 4: Infrastructure and Perimeter Protection
Blast-proof bunkers and shelters – structural design, Perimeter security: fences, intrusion sensors, drones, Access control, surveillance systems, and automated countermeasures

Unit 5: Advanced & Smart Protection Technologies
Exoskeletons and wearable robotics, Active protection systems (APS): Trophy, Iron Fist, Drone detection and counter-UAV systems, AI-based threat detection and emergency response systems

Textbook

1. *Personal Protective Equipment: Design, Material and Technologies* – Joseph R. Davis
2. *Armor and Protection Systems* – R.K. Arora

Reference Books

- *Modern Ballistic Armor* – L. J. Arnold
- *Protective Relaying and Infrastructure Defense* – J. Lewis Blackburn
- *Blast Protection of Civil Infrastructures and Vehicles* – A. G. Malvar
- DRDO Publications and DRTC Lecture Notes on Protective Systems
- IS/NIJ/STANAG specifications and defense procurement guidelines

Online Resources

- https://drdo.gov.in – DRDO Official Site
- https://bis.gov.in – Bureau of Indian Standards
- NPTEL modules on material science, structural protection, smart systems
- YouTube: DRDO labs, Military Tech, PPE testing videos
- Coursera/edX: Courses on smart wearables, armor design, structural protection

Evaluation Scheme

Component	Marks	Description
Mid Term Test	20+20	Subjective Test
Teacher’s Assignment	10	Assignment, MCQ,Viva
End Semester Examination	50	Descriptive 3-hour written exam

Honors scheme Track-I: Robotics & AI (B. Tech Program)

Sr. No.	Sem	Course Code	Course Title	Hours/week			Credits	Maximum marks			ESE Duration (Hrs)
				L	T	P		Contin	End Sem Exam	Total	
1	III	25ES03HT0301	Field & Service Robot	3	0	0	3	50	50	100	3
2	IV	25ES03HT0401	Advanced sensors & Actuators	3	0	0	3	50	50	100	3
3	V	25ES03HT0501	Mobile and Micro Robotics	4	0	0	4	50	50	100	3
4	VI	25ES03HT0601	Multi-Robot Systems and Swarm Intelligence	4	0	0	4	50	50	100	3
5	VII	25ES03HP0701	Project	0	0	8	4	50	50	100	3
			TOTAL	14	0	8	18				

Honors scheme Track-II: Product Design & CAM (Mechanical Engg, B.TechProgram)

Sr. No.	Sem	Course Code	CourseTitle	Hours/week			Credits	Maximummarks			ESE Duration (Hrs)
				L	T	P		ContinuousE	EndSem Exam	Total	
1	III	25ES04HT0301	Geometric Dimensioning and Tolerances	3	0	0	3	50	50	100	3
2	IV	25ES04HT0401	Advanced Solid Modelling & Assembly	3	0	0	3	50	50	100	3
3	V	25ES04HT0501	Additive Manufacturing Techniques	4	0	0	4	50	50	100	3
4	VI	25ES04HT0601	Design for Manufacturing	4	0	0	4	50	50	100	3
5	VII	25ES04HP0701	Project	0	0	8	4	50	50	100	3
			TOTAL	14	0	8	18				

Minors scheme Track- I : Robotics & AI (B.Tech Program)

Sr. No.	Sem	Course Code	CourseTitle	Hours/week L	T	P	Credits	Maximummarks ContinuousE	EndSemExam	Total	ESE Duration (Hrs)
1	III	25ES03MT0301	Introduction toRobotics	3	0	0	3	50	50	100	3
2	IV	25ES03MT0401	Mechatronics and Automation	3	0	0	3	50	50	100	3
3	V	25ES03MT0501	Modelling and Simulation of Robotic Systems	4	0	0	4	50	50	100	3
4	VI	25ES03MT0601	Robot safety and maintenance	4	0	0	4	50	50	100	3
5	VII	25ES03MP0701	Project	0	0	8	4	50	50	100	3
			TOTAL	14	0	8	18				

Minors scheme Track- II: Mechanical Engg. (B.Tech Programs)

Sr. No.	Sem	Course Code	CourseTitle	Hours/week L	T	P	Credits	Maximummarks ContinuousE	EndSemExam	Total	ESE Duration (Hrs)
1	III	25ES04MT0301	Basics of Mechanical Engineering	3	0	0	3	50	50	100	3
2	IV	25ES04MT0401	Energy system and technologies	3	0	0	3	50	50	100	3
3	V	25ES04MT0501	Product Design & Digital Manufacturing	4	0	0	4	50	50	100	3
4	VI	25ES04MT0601	Automotive Technology	4	0	0	4	50	50	100	3
5	VII	25ES04MP0701	Project	0	0	8	4	50	50	100	3
			TOTAL	14	0	8	18				

Honors scheme Track-I: Robotics & AI (B.Tech Program)

Syllabus of Semester III B. Tech. in Robotics and AI

Course Code: **Course: Field & Service Robot**

L: 3 Hrs., T: 0 Hrs., P: 0 Hrs., Per week **Total Credits: 03**

Course Objective: To introduce the world of field and service robots.

Course Outcome:

At the end of this course, the students will able to

CO1: Learn basic terminology and application of industrial robots.

CO2: Understand and applythe application of Underwater, Aerial and Space Robots

CO3: Understand and applythe application of Agriculture, Construction and Mining Robots

CO4: Understand and applythe application of Domestic and Medical Robotics

CO5: Understand and applythe application Humanoids and Intelligent Vehicles

Unit 1: Industrial robotics

History and evolution of robotics, laws of robotics, robots, robot subsystems, robot configurations, classification of robots, Typical applications- welding, assembly, painting, automated material transfer, machining, human-robot cooperation for handling tasks.

Introduction to parallel manipulators, structure classification of parallel manipulators, applications.

Unit 2: Underwater, Aerial and Space Robotics

Introduction to underwater robotics, historical background, sensor systems, actuating systems, applications.

Introduction to aerial robotics, historical background, unmanned aerial vehicles, quadrotors, components of autonomous flight, applications and challenges of aerial robotics.

Introduction to space robotics, historical background, orbital robotics systems, surface robotic systems, applications and examples.

Unit 3: Agriculture, Construction and Mining Robotics

Introduction to agricultural robotics, overview of the agricultural robots, typical applications, challenges of the field.

Introduction to robotics in construction, system overview, basic types of construction robots, economic aspects, applications.

Introduction to robotics in mining, historical background, applications in mining process.

Unit 4: Domestic and Medical Robotics

Introduction to home automation, domestic robotics, cleaning robots, lawn moving robots, challenges and applications.

Introduction to medical robotics, historical background, surgical robots, rehabilitation robots, exoskeletons, issues related to safety and ethics, applications and challenges in medical robotics.

Unit 5: Humanoids and Intelligent Vehicles

Introduction to humanoids, historical background, locomotion and manipulation of humanoids, whole body activities, teaching methodologies, applications.

Concept of intelligence, need and necessity of intelligent vehicles, driver assistance systems, driver monitoring systems, road scene interpretation, automated vehicles, applications and challenges.

Reference Books:

1. Industrial Robotics: Technology, Programming and Applications, by Groover M.P., Tata McGraw Hill Publication Ltd.
2. Parallel Robots: Mechanics and Control, by Taghirad H.D., CRC Press.
3. Underwater Robotics: Science, Design & Fabrication, by Moore S.W.,Bohm H., and ,Jensen V., Marine Advanced Technology Education (MATE) Center, 2010.
4. Aerial Robots: Aerodynamics, Control and Application, by Mejia O.D.M., Gomez J.A.E., (eds.), InTech Open Publications.
5. Robot Oriented Design: Design and Management Tools for the Deployment of Automation and Robotics in Construction, by Bock T., Linner T., Cmbridge University Press,
6. Robotics and Mechatronics for Agriculture, by Zhang D., Wei B., (eds.), CRC Press.
7. Medical Robotics, by Schweikard A., Ernst F., Springer Publications.
8. Household Service Robotics, by Xu Y., Qian H., and Wu X., Zhejiang University Press.
9. Springer Handbook of Robotics, by Khatib O., (ed.), Springer Publications.
10. Humanoid Robotics: A Reference, Vadakkepat P., Goswami A.,Springer Netherlands, 2017.
11. On Road Intelligent Vehicles, by Kala R., Elsevier Publications, 2017.

Syllabus of Semester IV B. Tech. in Robotics and AI

Advanced Sensors and Actuators

Course Code: (To be assigned)
Credits: 3 (L: 3, T: 0, P: 0)
Prerequisites: Basic Electronics, Control Systems, Physics of Sensors
Course Type: Elective / Advanced Application

Course Objectives:

- To understand the principles, design, and application of modern and smart sensors and actuators.
- To analyze sensing mechanisms and interface technologies in automation and robotics.
- To explore MEMS/NEMS-based sensor systems and intelligent actuators.
- To integrate sensors and actuators in cyber-physical systems and smart devices.

Course Outcomes:

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

1. Classify and explain advanced sensor technologies based on transduction principles.
2. Interface and calibrate advanced sensors for dynamic measurements.
3. Select and apply intelligent actuators for robotic, automotive, and biomedical systems.
4. Analyze sensor performance in harsh and embedded environments.
5. Integrate sensor-actuator pairs into real-time intelligent control systems.

Syllabus Content:

Unit 1: Introduction to Advanced Sensors

- Overview: Role of sensors in modern systems
- Classification: Physical, Chemical, Biological Sensors
- Smart Sensor Characteristics: Self-diagnostics, Signal Conditioning, Digital Output
- Performance Metrics: Sensitivity, Resolution, Drift, Range, Accuracy
- Sensor Interface Standards (I2C, SPI, CAN, Modbus)

Unit 2: Physical and Environmental Sensors

- **Position & Displacement:** Capacitive, Inductive, Optical Encoders, LVDTs
- **Force, Pressure, Strain:** Piezoresistive, Piezoelectric, MEMS-based
- **Temperature & Humidity:** RTDs, Thermocouples, Thermistors, Hygrometers
- **Vibration & Acceleration:** Accelerometers, Gyroscopes, IMUs
- Applications in automotive, aerospace, and wearable tech

Unit 3: Chemical, Biosensors and Optical Sensors

- Chemical Sensors: Gas sensors (MQ-series), pH, Ion-selective
- Biosensors: Glucose sensors, Enzyme-based sensors
- Optical Sensors: Photodiodes, Fiber Optic Sensors, Spectroscopic Sensors
- Application Areas: Environmental monitoring, Healthcare, Food safety

Unit 4: Advanced Actuators

- Classification: Electrical, Hydraulic, Pneumatic, Smart Material-based

- **Electrical Actuators:** Stepper Motors, Servo Motors, Voice Coil Actuators
- **Smart Actuators:** Shape Memory Alloys (SMA), Piezoelectric Actuators, Magnetostrictive Actuators
- Control and Drive Circuits for Actuators
- Feedback and Closed-Loop Operation in Precision Systems

Unit 5: Integration and Emerging Technologies

- Sensor Fusion and Embedded Processing (Kalman Filter, AI-based Sensor Fusion)
- Cyber-Physical Systems and IoT Sensor Integration
- Wireless Sensor Networks and Edge Sensing
- Safety, Reliability, and Calibration of Sensors and Actuators
- Trends: Bioinspired Sensors, Energy Harvesting Sensors, AI-Enabled Sensing Systems

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Textbooks:

1. **"Sensors and Actuators: Engineering System Instrumentation"** – Clarence W. de Silva
2. **"Smart Sensors and MEMS"** – S. Middelhoek& S.A. Audet
3. **"Measurement Systems: Application and Design"** – Ernest O. Doebelin

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Reference Resources:

- IEEE Sensors Journal, Elsevier's *Sensors and Actuators A & B*
- NPTEL: "Sensors and Actuators" and "Smart Materials"
- Sensor/Actuator Datasheets (STMicroelectronics, Bosch, Honeywell)

Syllabus of Semester V B. Tech. in Robotics and AI

Mobile and Micro Robotics – Syllabus

Credits: 3 (L: 3, T: 0, P: 0)

Course Objectives:

- To introduce fundamentals of mobile and micro robotic systems.
- To study locomotion, sensing, and control systems in mobile robots.
- To expose learners to MEMS technology for micro-robotics.

- To understand the design, integration, and application of mobile and micro robots in real-world scenarios.

Unit 1: Introduction to Mobile Robotics

- Basics of mobile robotics: Definition, history, and applications.
- Types of mobile robots: Wheeled, legged, aerial, underwater, and hybrid robots.
- Components of mobile robots: Sensors, actuators, controllers, and power systems.
- Kinematic models of mobile robots.

Unit 2: Locomotion and Navigation

- Locomotion mechanisms: Wheels, tracks, legs.
- Locomotion kinematics: Differential drive, synchro drive, omnidirectional.
- Path planning: Grid-based, graph-based, potential field methods.
- Navigation techniques: GPS, SLAM (Simultaneous Localization and Mapping), odometry.

Unit 3: Control of Mobile Robots

- Feedback control basics: PID controllers for robot motion.
- Trajectory tracking and motion control.
- Obstacle avoidance techniques.
- Sensor fusion for localization.

Unit 4: Micro Robotics and MEMS

- Introduction to micro robotics and its applications (medical, military, industrial).
- MEMS: Basics, materials, fabrication techniques.
- Microactuators and microsensors.
- Energy and power systems for micro robots.

Unit 5: Design and Integration

- Hardware-software integration in mobile/micro robots.
- Communication systems (wired/wireless, Bluetooth, Zigbee, Wi-Fi).
- Real-time operating systems (RTOS) and embedded platforms (Arduino, Raspberry Pi, MSP430).
- Case Studies: Swarm robotics, bio-inspired robots, microbot surgery tools.

Textbooks:

1. **Siegwart, R., Nourbakhsh, I., Scaramuzza, D.** – *Introduction to Autonomous Mobile Robots*, MIT Press.
2. **Asada, H., Slotine, J. J. E.** – *Robot Analysis and Control*, Wiley.
3. **Marc Madou** – *Fundamentals of Microfabrication: The Science of Miniaturization*, CRC Press.

Reference Books:

- Dudek, G., & Jenkin, M. – *Computational Principles of Mobile Robotics*.
- Ghosh, P. K. – *Microprocessors and Microcontrollers*.
- Khoshnevisan, B. – *MEMS and Nanotechnology-Based Sensors and Devices for Smart Systems*.

Syllabus of Semester VI B. Tech. in Robotics and AI

Course Title: Multi-Robot Systems and Swarm Intelligence

Course Code: (To be assigned)
Credits: 3 (L: 3, T: 0, P: 0)
Prerequisites: Basics of Robotics, Control Systems, Artificial Intelligence
Course Type: Elective / Advanced

Course Objectives:

- To introduce students to the foundations of multi-robot coordination and swarm intelligence.
- To study decentralized control, communication, and collaboration strategies in robotic teams.
- To explore algorithmic approaches for task allocation, coverage, formation, and flocking.
- To understand biologically inspired behaviors and emergent phenomena in robotic swarms.
- To apply concepts to real-world problems such as search and rescue, surveillance, and mapping.

Course Outcomes:

By the end of the course, students will be able to:

1. Understand and model the behavior of multi-robot and swarm systems.
2. Analyze communication, localization, and control strategies for robotic teams.
3. Implement coordination and cooperation algorithms in multi-agent systems.
4. Apply swarm intelligence techniques like PSO, ACO, and behavior-based control.
5. Design and simulate multi-robot tasks using open-source tools or hardware platforms.

Syllabus Content:

Unit 1: Introduction to Multi-Robot Systems (MRS)

- Motivation and Applications
- Homogeneous vs. Heterogeneous Teams
- Centralized vs. Decentralized Architectures
- Communication Models: Broadcast, Peer-to-Peer, Indirect (Stigmergy)
- Challenges: Scalability, Robustness, Interference

Unit 2: Multi-Robot Coordination and Control

- Task Allocation Strategies (Market-Based, Consensus-Based)
- Motion Coordination: Formation Control, Leader-Follower, Flocking
- Coverage and Exploration Algorithms
- Path Planning and Collision Avoidance in Teams
- Localization and Mapping in Multi-Robot Contexts (Cooperative SLAM)

Unit 3: Swarm Robotics Fundamentals

- Principles of Swarm Intelligence
- Behavior-Based Control and Finite State Machines
- Emergent Behavior and Collective Intelligence
- Bio-Inspired Algorithms: Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), Bee Algorithms
- Real-world Swarm Robotics Applications

Unit 4: Simulation and Implementation Tools

- Software Frameworks: ROS (Robot Operating System), Stage, Webots, V-REP, Gazebo
- Multi-Robot Simulations using ARGoS, CoppeliaSim
- Integration with AI and Machine Learning Models
- Hardware Platforms: Kilobots, e-pucks, TurtleBots
- Case Studies in Search & Rescue, Environmental Monitoring, Surveillance

Unit 5: Advanced Topics and Trends

- Multi-Agent Reinforcement Learning (MARL)
- Human-Swarm Interaction
- Swarm Robotics in Unstructured Environments
- Distributed Task Planning and Fault Tolerance
- Research Challenges and Future Directions in Swarm and MRS

Textbooks:

1. **"Swarm Robotics: From Biology to Robotics"** – Sahin and Spears (Springer)
2. **"Multi-Robot Systems: From Swarms to Intelligent Automata"** – Parker, Schneider, Schultz (Kluwer Academic)
3. **"Distributed Autonomous Robotic Systems"** – Hajime Asama et al.

Reference Books & Resources:

1. **Research Papers from journals:** IEEE Transactions on Robotics, Autonomous Robots, Swarm Intelligence
2. NPTEL/EdX/MOOC: Swarm Robotics, AI for Robotics
3. ROS Tutorials and GitHub Repositories for Multi-Robot Projects

Honors scheme Track-II :Product Design & CAM (Mechanical Engg., B.Tech Program)

Geometric Dimensioning and Tolerancing (GD&T)

Semester: III (3rd Semester, B. Tech. Mechanical Engineering)
Credits: 3 (L:3, T:0, P:0)
Evaluation Scheme: 50 Marks Continuous Evaluation + 50 Marks End Semester Exam = 100 Marks
End Semester Exam Duration: 3 Hours

Course Objectives

- Understand GD&T principles and their application in design and manufacturing.
- Interpret technical drawings and identify tolerancing requirements.
- Apply form, orientation, and position tolerances.
- Use GD&T for improved functionality and manufacturability.

Course Outcomes

Upon completion of the course, students will be able to:

1. Define and apply GD&T as per ASME Y14.5 standard.
2. Interpret and annotate drawings using correct GD&T symbols.
3. Use GD&T for defining form, orientation, location, and runout tolerances.
4. Explain the role of datums and material condition modifiers.
5. Evaluate manufacturability and inspect ability using GD&T.

Detailed Syllabus

1. **Introduction to GD&T**
    - Need, importance and scope of GD&T
    - Coordinate vs. geometric tolerancing
2. **Drawing Standards and Feature Control Frames**
    - ASME Y14.5 symbols
    - Feature control frames, datum reference frame
3. **Form Tolerances**
    - Straightness, flatness, circularity, cylindricity
4. **Orientation Tolerances**
    - Parallelism, perpendicularity, angularity
5. **Location Tolerances**
    - Position tolerance, concentricity, symmetry
6. **Runout Tolerances**
    - Circular and total runout
7. **Modifiers & Material Conditions**
    - MMC, LMC, RFS, bonus tolerance
8. **Measurement and Inspection**
    - CMM, surface plates, functional gauges
    - GD&T in inspection reports and manufacturing drawings

Textbooks

1. Krulikowski, A., *Fundamentals of Geometric Dimensioning and Tolerancing*, Cengage Learning.
2. Parkinson, A. C., *Principles of Engineering Drawing*, Longman.

Reference Books

1. James D. Meadows, *Geometric Dimensioning and Tolerancing: Applications, Analysis & Measurement*, CRC Press.
2. Madsen, D. A., & Madsen, D. P., *Engineering Drawing and Design*, Cengage Learning.

Online Resources

- Engineers Edge GD&T Guide
- NPTEL GD&T Course
- GD&T Basics - YouTube Channel
- ASME Y14.5 Info

Advanced Solid Modelling& Assembly

Semester: 3rd
Program: B.Tech Mechanical Engineering
Credits: 3 (L3-T0-P0)
Evaluation:

Continuous Evaluation (CE): 50 Marks
End Semester Exam (ESE): 50 Marks
Total Marks: 100
Exam Duration: 3 Hours

Course Objectives:

1. To master advanced 3D modeling techniques using CAD software (e.g., SolidWorks, CATIA, Autodesk Inventor).
2. To understand assembly design, constraints, and motion simulation.
3. To apply GD&T (Geometric Dimensioning & Tolerancing) principles in modeling.
4. To develop skills in surface modeling, parametric design, and finite element analysis (FEA) integration.
5. To prepare for real-world mechanical design challenges through project-based learning.

Syllabus

Module 1: Advanced 3D Modeling Techniques

- Parametric vs. Direct Modeling
- Sketching constraints and best practices
- Complex features: Lofts, Sweeps, Ribs, Shells

Module 2: Surface Modeling

- Introduction to surface modeling
- Creating complex surfaces (Blends, Patches)
- Conversion between solid and surface models

Module 3: Assembly Design

- Bottom-up vs. Top-down assembly approaches
- Mating conditions (Coincident, Concentric, Gear, Cam)
- Exploded views and Bill of Materials (BOM)

Module 4: Motion Simulation & Analysis

- Kinematic and dynamic simulations
- Interference detection and collision analysis
- Force, torque, and friction applications

Module 5: GD&T in CAD

- ASME Y14.5 standards
- Applying tolerances to 3D models
- Datum references and feature control frames

Module 6: Integration with FEA & Prototyping

- Exporting models for Finite Element Analysis (FEA)
- 3D printing considerations (Supports, Overhangs)
- Case studies in automotive/aerospace components

Textbooks

1. **SolidWorks 2023: Advanced Techniques** – *Paul Tran* (SDC Publications)
2. **CATIA V5: From Beginner to Advanced** – *Stefan Berisha* (CreateSpace)
3. **Engineering Design with SolidWorks** – *David Planchard* (McGraw-Hill)

Reference Books

1. **Parametric Modeling with Autodesk Inventor** – *Randy Shih* (SDC Publications)
2. **Geometric Dimensioning and Tolerancing** – *James D. Meadows* (CRC Press)
3. **Advanced CAD Modeling: Explicit, Parametric, Free-Form CAD** – *Nikola Vukašinović* (Springer)

Online Resources

1. **LinkedIn Learning:**
   - SolidWorks Advanced Assembly Techniques
   - CATIA Surface Modeling
2. **YouTube:**
   - **SolidWorks Tutorials** (by GoEngineer)
   - **GD&T Explained** (by The Efficient Engineer)
3. **Official Software Tutorials:**
   - SolidWorks Tutorials
   - Autodesk Inventor Learning
4. **Coursera:** CAD and Digital Manufacturing

Additive Manufacturing Techniques

Credits: 3 (L: 3, T: 0, P: 0)

Course Objectives:

- To understand the fundamental principles and classification of additive manufacturing (AM) processes.
- To study materials, design considerations, and applications of AM.
- To explore post-processing, quality control, and recent trends in AM.
- To enable students to apply AM techniques for prototyping and production.

Unit 1: Introduction to Additive Manufacturing (AM)

- Definition, history, and evolution of AM.
- Comparison with subtractive and formative manufacturing.
- Classification of AM processes (ASTM F42): Vat photopolymerization, material extrusion, powder bed fusion, binder jetting, etc.
- Advantages, limitations, and applications of AM.

Unit 2: Additive Manufacturing Processes

- **Vat Photopolymerization (SLA, DLP)** – Process, materials, applications.
- **Material Extrusion (FDM/FFF)** – Process, equipment, filament materials.
- **Powder Bed Fusion (SLS, SLM, EBM)** – Mechanisms, lasers/electron beams, materials.
- **Binder Jetting and Material Jetting** – Working principles and applications.
- **Sheet Lamination & Directed Energy Deposition (DED)**.

Unit 3: Materials for Additive Manufacturing

- Polymers: Thermoplastics (PLA, ABS, Nylon), thermosets.
- Metals: Titanium, Aluminum, Stainless steel, Inconel.
- Ceramics and composites in AM.
- Material behavior, process-material compatibility, mechanical properties.

Unit 4: Design for Additive Manufacturing (DfAM)

- Principles of DfAM.
- Topology optimization and lattice structures.
- Support structures and build orientation.
- CAD tools and file formats (STL, AMF).
- Design rules and constraints in AM.

Unit 5: Post-Processing and Applications

- Post-processing techniques: Heat treatment, surface finishing, machining, infiltration.
- Inspection, testing, and quality assurance.
- Applications: Aerospace, biomedical, automotive, architecture, tooling.
- Sustainability and economic aspects of AM.

Textbooks:

1. **Ian Gibson, David Rosen, Brent Stucker** – *Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing*, Springer.
2. **Andreas Gebhardt** – *Understanding Additive Manufacturing*, Hanser Publishers.

Reference Books:

- Chua C.K., Leong K.F. – *3D Printing and Additive Manufacturing: Principles and Applications*.
- ASTM/ISO Standards for AM (e.g., ISO/ASTM 52900, ISO/ASTM 52901).
- Kalpakjian, S., Schmid, S. – *Manufacturing Engineering and Technology* (relevant chapters).

Design for Manufacturing (DFM)

Credits: 3 (L: 3, T: 0, P: 0)

Course Objectives:

- To understand the integration of product design with manufacturing processes.
- To impart knowledge of DFM principles for different materials and manufacturing methods.
- To enhance decision-making in selection of processes, materials, and tolerances.
- To enable students to design cost-effective, manufacturable, and high-quality products.

Unit 1: Introduction to DFM

- Importance and scope of Design for Manufacturing.
- Product life cycle and concurrent engineering.
- General principles of DFM and DFA (Design for Assembly).
- Cost estimation and value engineering in product design.
- Case studies of successful DFM applications.

Unit 2: Tolerances and Fits

- Dimensional and geometric tolerances.

- Impact of tolerances on manufacturability and cost.
- Selective assembly and statistical tolerancing.
- Design considerations for interchangeable parts.
- Use of GD&T (Geometric Dimensioning and Tolerancing).

Unit 3: DFM for Machining Processes

- Design recommendations for turning, milling, drilling, and grinding.
- Influence of design on tool life, surface finish, and machining time.
- Design features to avoid machining problems (undercuts, sharp corners, etc.).
- Material selection and machinability considerations.

Unit 4: DFM for Casting, Forging, and Welding

- Design guidelines for cast components: wall thickness, draft angles, risers.
- Design considerations for forgings: grain flow, flash, die parting line.
- Welding design: joint types, distortions, residual stresses, accessibility.
- Defect minimization through better design.

Unit 5: DFM for Sheet Metal and Plastic Parts

- Design principles for shearing, bending, deep drawing.
- Design for press working tools.
- Design for injection molding, blow molding, and extrusion.
- Minimizing defects like warping, shrinkage, sink marks.
- Assembly considerations for plastic parts (snap fits, welding, adhesives).

Textbooks:

1. **James G. Bralla** – *Design for Manufacturability Handbook*, McGraw Hill.
2. **Geoffrey Boothroyd, Peter Dewhurst** – *Product Design for Manufacture and Assembly*.

Reference Books:

- Dieter G.E., Schmidt L.C. – *Engineering Design*, McGraw-Hill.
- Karl T. Ulrich, Steven D. Eppinger – *Product Design and Development*.
- Spotts M.F. – *Dimensioning and Tolerancing for Engineering Drawings*.

Design for Manufacturing

⚜ Course Objectives:

1. To familiarize students with the principles of designing for manufacturability.
2. To enable cost-effective, reliable, and high-quality product design considering process limitations.
3. To integrate tolerance, material selection, and manufacturing process capabilities into design decisions.
4. To promote critical thinking for optimizing product function and ease of fabrication/assembly.

⚜ Course Outcomes (COs):

After completing this course, students will be able to:

- CO1: Apply DFM principles to optimize component design for manufacturing processes.
- CO2: Select appropriate materials and processes for manufacturability and cost-efficiency.
- CO3: Integrate geometric tolerances and dimensional controls into engineering design.
- CO4: Evaluate the impact of design features on manufacturability across casting, machining, forming, and joining.
- CO5: Redesign mechanical components for improved manufacturability and assembly.

⚜ Course Content:

Unit 1: Introduction to DFM and Product Design Considerations

- Role of DFM in product development
- Concurrent engineering and early design decisions
- Cost–quality–time trade-offs
- Design simplification and modularity
- Case studies: Good and bad DFM practices

Unit 2: Tolerances, Fits, and Dimensional Control

- Fundamentals of dimensional and geometric tolerancing (GD&T)
- Limits, fits, and tolerance stack-up
- Statistical tolerance analysis
- Effect of tight tolerances on manufacturing cost

- Selective assembly vs interchangeable parts

Unit 3: Design for Machining and Metal Removal

- General guidelines for turning, milling, drilling, grinding
- Design for tool accessibility and chip removal
- Minimizing machining time, tool wear, and set-up
- Surface finish considerations
- Design rules for high-speed CNC machining

Unit 4: Design for Casting, Forging, and Welding

- Design for Casting: Draft, fillets, parting lines, shrinkage
- Design for Forging: Flash formation, grain flow, symmetry
- Design for Welding: Weld symbols, distortion control, access
- Welding joints vs. mechanical fasteners: cost and strength considerations
- Common defects and design remedies

Unit 5: Design for Sheet Metal and Plastics Manufacturing

- Sheet Metal Design: Bending, blanking, forming, relief features
- Minimizing burrs, springback, and distortion
- Design for Injection Molding: Parting lines, ribs, bosses, undercuts
- Material behavior and wall thickness variation
- Assembly techniques: snap fits, ultrasonic welding, adhesives

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⚜ Textbooks:

1. **James G. Bralla** – *Design for Manufacturability Handbook*, McGraw Hill.
2. **Boothroyd, Dewhurst, and Knight** – *Product Design for Manufacture and Assembly*, CRC Press.

⚜ Reference Books:

- G.E. Dieter and L.C. Schmidt – *Engineering Design*.
- Kevin Otto & Kristin Wood – *Product Design*.
- Spotts M.F. – *Dimensioning and Tolerancing for Engineering Drawings*.

Minors scheme Track- I : Robotics & AI (B.Tech Program)

B. Tech Second year (Robotics and AI)

Semester III

Course Code: Course Name: Introduction to Robotics

L: 3Hrs. T: 0 Hrs. P: 0 Hrs. Per week Total Credits:3

Course Objective

To introduce students to the fundamental principles of robotics including robot classification, industrial applications, the role of sensors and actuators, and the mathematical foundations of spatial transformations and robot kinematics, enabling them to analyse and design basic robotic systems.

Course Outcomes (COs)

By the end of this course, students will be able to:

1. **CO1:** Describe the evolution, structure, and classification of robotic systems along with their basic components.
2. **CO2:** Identify and analyze various types of industrial robots and their applications in manufacturing and automation.
3. **CO3:** Explain the working principles and selection criteria of sensors and actuators used in robotic systems.
4. **CO4:** Apply transformation techniques such as rotation matrices and homogeneous transformations to model robot motion.
5. **CO5:** Analyze the kinematic structure of serial manipulators using Denavit–Hartenberg parameters for forward kinematic analysis.

Unit 1: Introduction to Robotics

- Definition and classification of robots
- Historical development and evolution of robots
- Anatomy of a robot: Links, joints, DOF, workspace
- Types of robots (serial, parallel, mobile)

- Robot characteristics and performance parameters
- Basic components: Controller, manipulator, end effector, sensors

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Unit 2: Industrial Robots and Their Applications

- Types of industrial robots: Cartesian, SCARA, Articulated, Delta
- Selection criteria for industrial robots
- Programming methods: Teach pendant, offline programming
- Applications:
    - Material handling and machine loading/unloading
    - Welding, painting, and assembly operations
    - Pick-and-place and palletizing
    - Inspection and quality control
- Case studies from automotive, electronics, and manufacturing industries

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Unit 3: Sensors and Actuators in Robotics

Sensors:

- Internal vs external sensors
- Position sensors: Potentiometers, encoders, resolvers
- Velocity and acceleration sensors
- Proximity and tactile sensors
- Force/torque sensors
- Vision and ultrasonic sensors

Actuators:

- Electric actuators: DC, stepper, and servo motors
- Hydraulic and pneumatic actuators
- Comparisons and selection criteria
- Drive systems: Direct drive, gearboxes, belts

Unit 4: Transformation and Robot Kinematics

- Introduction to coordinate frames
- Homogeneous transformation matrices
- Rotation matrices and Euler angles
- Denavit–Hartenberg (D-H) parameters
- Forward kinematics for serial manipulators
- Basic introduction to inverse kinematics
- Robot configuration and singularity

Textbooks / Reference Books

1. **Introduction to Robotics: Mechanics and Control** – John J. Craig
2. **Robotics: Control, Sensing, Vision, and Intelligence** – K.S. Fu, R.C. Gonzalez, C.S.G. Lee
3. **Robotics: Modelling, Planning and Control** – B. Siciliano, L. Sciavicco, L. Villani, G. Oriolo
4. **Robot Modeling and Control** – Mark W. Spong, Seth Hutchinson, M. Vidyasagar

Mechatronics and Automation

⚜ Course Objectives:

1. To provide an interdisciplinary understanding of mechanical, electrical, and computer systems.
2. To introduce sensors, actuators, controllers, and microprocessors for automated systems.
3. To understand the architecture and applications of mechatronic systems in modern automation.
4. To design and analyze real-time embedded control systems using PLCs and microcontrollers.

✅Course Outcomes (COs):

- **CO1:** Understand the fundamentals of mechatronic systems and components.
- **CO2:** Analyze the operation of sensors, actuators, and interfacing elements.
- **CO3:** Develop logic for automated systems using PLCs and microcontrollers.
- **CO4:** Apply control principles for real-time systems.
- **CO5:** Design simple mechatronic systems for industrial and domestic applications.

⚜ Course Content:

Unit 1: Introduction to Mechatronics

- Definition, scope, and applications
- Elements of mechatronics system: sensors, actuators, control systems
- Mechatronic system design approach
- Case studies: Home appliances, robotics, automotive systems

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Unit 2: Sensors and Transducers

- Types of sensors: Displacement, temperature, pressure, proximity, flow, force, level

- Signal conditioning and data acquisition
- Analog and digital sensors, resolution, accuracy
- Interfacing sensors with controllers

Unit 3: Actuators and Drives

- Electrical actuators: DC/AC motors, stepper motors, servo motors
- Pneumatic and hydraulic actuators: valves, cylinders
- Motor characteristics and control
- Drive circuits and interfacing techniques

Unit 4: Microcontrollers and PLCs in Mechatronics

- Architecture of 8051 / Arduino / PIC microcontrollers
- Basics of programming and interfacing: I/O, timers, ADC, PWM
- Introduction to PLC: Architecture, ladder logic, programming instructions
- PLC interfacing with sensors and actuators
- Simple applications: Traffic light, conveyor, elevator system

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Unit 5: Industrial Automation and Control

- Introduction to automation and its levels
- Feedback and open-loop control systems
- PID control: Theory, tuning, implementation
- SCADA and HMI basics
- Integration of systems: Communication protocols (RS232, CAN, Modbus)

⚜ Suggested Laboratory Experiments / Mini Projects:

- Interfacing IR sensor and DC motor with Arduino
- Speed control of stepper motor using microcontroller
- Ladder logic program for elevator / bottle filling system using PLC
- Real-time temperature monitoring and control
- Industrial automation project using Arduino + relay + sensors

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⚜ Textbooks:

1. **W. Bolton** – *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering*, Pearson.
2. **Devdas Shetty & Richard Kolk** – *Mechatronics System Design*, Cengage Learning.

⚜ Reference Books:

- R.K. Rajput – *Mechatronics*
- Sabri Cetinkunt – *Mechatronics with Experiments*
- J. Stenerson& J. Currie – *Industrial Automation and Process Control*

Modeling and Simulation of Robotic Systems

⚜ Course Objectives:

1. To introduce the mathematical foundations for modeling robotic systems.
2. To develop dynamic models and simulate robotic motion and control.
3. To understand kinematics, dynamics, and trajectory planning for manipulators and mobile robots.
4. To apply simulation tools (like MATLAB/Simulink, ROS) for robotic system analysis.

✅Course Outcomes (COs):

- **CO1:** Understand and model the kinematics of robotic systems.
- **CO2:** Analyze and simulate the dynamics of robotic manipulators.
- **CO3:** Design and simulate trajectory planning algorithms.
- **CO4:** Implement control strategies for robotic systems using simulation tools.
- **CO5:** Apply modeling and simulation for mobile and industrial robotic applications.

⚜ Course Content:

Unit 1: Introduction to Robotics and Modeling

- Overview of robotic systems and components
- Types of robots: Serial, parallel, mobile
- Coordinate frames, DH parameters
- Homogeneous transformation matrices
- Robot modeling concepts: analytical, numerical, graphical

Unit 2: Kinematic Modeling

- Forward and inverse kinematics of robotic manipulators

- Geometric and analytical approaches
- Velocity kinematics: Jacobian matrix, singularities
- Workspace analysis
- Case studies using 2R and 3R manipulators

Unit 3: Dynamic Modeling of Robots

- Newton-Euler and Lagrangian methods
- Equations of motion for manipulators
- Dynamic model of 2-DOF and 3-DOF robots
- Inertia matrix, Coriolis and centrifugal terms, gravity terms
- Simulating dynamic equations using MATLAB/Simulink

Unit 4: Trajectory Planning and Control

- Joint space and Cartesian space trajectory generation
- Linear, cubic, quintic polynomial trajectories
- Velocity and acceleration profiles
- PID and feedforward control for manipulators
- Motion control simulation using MATLAB/Simulink or ROS-Gazebo

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Unit 5: Modeling and Simulation of Mobile Robots

- Kinematics of wheeled mobile robots: differential drive, omnidirectional
- Dynamic modeling of mobile robots
- Path planning and obstacle avoidance
- SLAM basics and simulation
- Simulation platforms: ROS, Gazebo, V-REP/CoppeliaSim

⚜ Laboratory / Practical (Optional, 1 credit recommended):

- Modeling of 2R/3R manipulators in MATLAB/Simulink
- Simulation of forward and inverse kinematics
- Trajectory tracking using PID controller
- Mobile robot path simulation in Gazebo/ROS
- Modeling using Simscape Multibody or V-REP

⚜ Textbooks:

1. **Craig, J. J.** – *Introduction to Robotics: Mechanics and Control*, Pearson.

2. **Spong, M. W., Hutchinson, S., Vidyasagar, M.** – *Robot Modeling and Control*, Wiley.

⚜ Reference Books:

- Siciliano, B., Khatib, O. – *Springer Handbook of Robotics*
- Kelly, R. et al. – *Control of Robot Manipulators in Joint Space*
- Corke, P. – *Robotics, Vision and Control* (Toolbox-based)

Here is a comprehensive and academic syllabus for the course titled **"Robot Safety and Maintenance"**, ideal for **undergraduate/postgraduate engineering programs** in **Robotics, Mechatronics, Mechanical, or Automation Engineering**.

Robot Safety and Maintenance

⚜ Course Objectives:

1. To impart knowledge of safety practices in robotic systems and work environments.
2. To understand the causes of robotic failures and design preventive maintenance strategies.
3. To familiarize students with safety standards and risk assessment protocols.
4. To develop troubleshooting skills and maintenance planning for robotic systems.

✅Course Outcomes (COs):

- **CO1:** Identify potential safety hazards associated with industrial and mobile robots.
- **CO2:** Interpret and apply international robot safety standards (e.g., ISO, ANSI, OSHA).
- **CO3:** Analyze failure modes and implement condition-based or preventive maintenance.
- **CO4:** Plan and schedule systematic maintenance procedures.
- **CO5:** Recommend and apply safety and emergency protocols in robotic environments.

⚜ Course Content:

Unit 1: Introduction to Robot Safety

- Definition and importance of robot safety
- Types of hazards: mechanical, electrical, environmental, software
- Accident case studies in industrial robotics
- Safety system components: sensors, interlocks, emergency stops
- Safety in collaborative robot environments (cobots)

Unit 2: Safety Standards and Regulations

- Overview of international safety standards:
  - ISO 10218-1 & 2: Safety for industrial robots
  - ANSI/RIA R15.06, OSHA 1910
  - ISO/TS 15066: Collaborative robots
- Risk assessment and mitigation: hazard identification, severity, probability
- Safe design practices and safeguarding methods
- Human-robot interaction (HRI) safety aspects

Unit 3: Robot Maintenance Principles

- Types of maintenance: preventive, predictive, reactive, condition-based
- Maintenance objectives: uptime, reliability, MTBF, MTTR
- Maintenance tools and diagnostic software
- Lubrication, calibration, alignment, cleaning practices

Unit 4: Troubleshooting and Fault Diagnosis

- Root cause analysis techniques (Fishbone diagram, FMEA)
- Electrical, mechanical, hydraulic, pneumatic fault diagnostics
- Sensor and actuator failure analysis
- Use of diagnostic interfaces in robots (HMI, SCADA)

Unit 5: Maintenance Planning and Management

- Maintenance scheduling and documentation
- Computerized Maintenance Management Systems (CMMS)
- Spare parts inventory management
- Maintenance safety procedures and PPE
- Case studies on robot maintenance in manufacturing industries

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⚜ Suggested Laboratory / Project Work (Optional 1 Credit):

- Prepare a risk assessment sheet for a robotic cell
- Develop a preventive maintenance checklist for a 6-axis industrial robot
- Fault simulation and troubleshooting using a virtual robot system
- Design a safety layout with interlock and emergency stops
- Use of digital twins for predictive maintenance (simulation-based)

⚜ Textbooks:

1. **Mikell P. Groover** – *Industrial Robotics: Technology, Programming, and Applications*, McGraw-Hill.
2. **Deborah S. Ray, Michael A. Ray** – *Industrial Robotics: Fundamentals of Robot Applications*, Cengage Learning.

⚜ Reference Books & Standards:

- **RIA/ANSI/ISO Safety Standards** (ISO 10218-1/2, ISO 15066, OSHA 1910)
- F. Mondada et al. – *Autonomous Mobile Robotics: Safety and Applications*
- Maintenance manuals from manufacturers like ABB, KUKA, FANUC

Minors scheme Track- II: Mechanical Engg. (B.Tech Programs)

Basics of Mechanical Engineering

Course Code: (To be assigned)
Credits: 3 (L: 3, T: 0, P: 0)
Prerequisites: None
Course Type: Foundation / Core (First Year)

Course Objectives:

- To introduce students to fundamental concepts of mechanical engineering.
- To provide basic knowledge of thermodynamics, IC engines, power plants, and refrigeration.
- To explain manufacturing processes and engineering materials.
- To provide exposure to basic mechanical systems like power transmission and mechanisms.
- To develop an understanding of applications in multidisciplinary engineering.

Course Outcomes:

By the end of this course, students will be able to:

1. Understand and apply basic laws of thermodynamics and heat engines.
2. Explain working principles of IC engines and power generation systems.
3. Identify and understand commonly used engineering materials and their properties.
4. Comprehend basic manufacturing processes.
5. Understand mechanical elements used in machines and power transmission.

Syllabus Content:

Unit 1: Thermodynamics and Heat Engines

- Basic Concepts: System, Boundary, Properties, State, Process, Cycle
- Zeroth, First and Second Laws of Thermodynamics
- Types of Heat Engines and Efficiencies
- Concept of Entropy (Introductory)
- Working of Carnot and Rankine Cycles

Unit 2: Internal Combustion (IC) Engines and Power Plants

- IC Engines: Classification, Components, Working of 2-Stroke and 4-Stroke Petrol and Diesel Engines
- Performance Parameters
- Overview of Power Plants: Thermal, Hydro, Nuclear, and Solar
- Introduction to Renewable Energy Sources

Unit 3: Refrigeration and Air Conditioning

- Basic Concepts of Refrigeration
- Working Principle of Vapour Compression and Vapour Absorption Systems
- Air Conditioning: Summer and Winter AC Systems

- Applications in Domestic and Industrial Sectors

Unit 4: Engineering Materials and Manufacturing Processes

- Classification of Materials: Metals, Polymers, Ceramics, Composites
- Properties: Mechanical, Thermal, Electrical
- Manufacturing Processes: Casting, Forging, Welding, Machining, 3D Printing
- Introduction to CNC and Automation in Manufacturing

Unit 5: Mechanical Systems and Power Transmission

- Mechanisms: Slider Crank, Four-Bar, Cam-Follower (Basic Types)
- Power Transmission: Belts, Chains, Gears, Couplings
- Basic Concepts of Bearings and Clutches
- Introduction to Pumps and Compressors

Textbooks:

1. **"Basic Mechanical Engineering"** – Pravin Kumar, Pearson
2. **"Elements of Mechanical Engineering"** – R.K. Rajput, Laxmi Publications
3. **"Basic Mechanical Engineering"** – D.S. Kumar, S.K. Kataria& Sons

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Reference Books:

1. **"Fundamentals of Mechanical Engineering"** – Saeed Moaveni
2. **"Basic Mechanical Engineering"** – P. K. Nag (McGraw Hill)
3. **Online Resources:** NPTEL Lectures, MOOC platforms (SWAYAM, Coursera)

Energy Systems and Technologies

Course Code: (To be assigned)
Credits: 3 (L: 3, T: 0, P: 0)
Prerequisites: Thermodynamics, Fluid Mechanics, Basics of Electrical Engineering
Course Type: Core / Elective

Course Objectives:

- To introduce students to various conventional and non-conventional energy systems.
- To study energy conversion technologies and their environmental impacts.
- To develop an understanding of design, performance, and integration of modern energy systems.
- To evaluate energy policies, efficiency strategies, and system economics.

Course Outcomes:

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

1. Understand and classify different energy systems and technologies.
2. Analyze the working and efficiency of thermal, electrical, and renewable energy systems.
3. Design and assess hybrid and integrated energy systems.
4. Evaluate the economic and environmental aspects of energy technologies.
5. Apply principles of energy system integration for sustainable development.

Syllabus Content:

Unit 1: Introduction to Energy Systems

- Global and Indian Energy Scenario
- Classification of Energy Sources
- Characteristics of Conventional and Non-Conventional Energy
- Energy Chain: Source → Conversion → Transmission → Utilization
- Energy Conversion Principles and Efficiencies

Unit 2: Conventional Energy Systems

- **Fossil Fuel-Based Systems:** Thermal Power Plants, Combustion Systems, Efficiency Improvement
- **Nuclear Energy Systems:** Reactor Types, Fuel Cycles, Safety Aspects
- **Hydropower Systems:** Types, Site Selection, Components, Environmental Impact
- Emissions and Carbon Footprint of Conventional Systems

Unit 3: Renewable Energy Technologies

- **Solar Energy Systems:** Thermal Collectors, PV Systems, Storage
- **Wind Energy Systems:** Aerodynamics, Turbines, Siting, Hybrid Integration
- **Biomass and Bioenergy:** Biogas, Gasifiers, Biofuels
- **Geothermal and Ocean Energy Systems:** Tidal, Wave, OTEC
- Comparison and Suitability of Renewable Systems

Unit 4: Integrated and Emerging Energy Systems

- **Hybrid Energy Systems:** Solar-Wind-Diesel, Smart Grids, Microgrids
- **Energy Storage Technologies:** Thermal, Electrochemical, Mechanical
- **Cogeneration and Trigeneration Systems**
- Fuel Cells and Hydrogen-Based Systems
- Smart Energy Networks and Demand Response

Unit 5: Energy System Management and Policy

- Energy Efficiency in Systems and Devices
- Economic Evaluation: Costing, LCOE, Payback, NPV
- Life Cycle Analysis and Environmental Impact Assessment
- Government Policies and Incentives (MNRE, BEE, International Energy Agencies)
- Case Studies: Integrated Energy Planning for Urban and Rural Areas

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Textbooks:

1. **"Energy Systems Engineering: Evaluation and Implementation"** – Francis Vanek & Louis Albright
2. **"Non-Conventional Energy Resources"** – B.H. Khan
3. **"Renewable Energy: Power for a Sustainable Future"** – Godfrey Boyle

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Reference Books & Resources:

- NPTEL: "Energy Resources and Technology", "Energy Systems"
- Reports from MNRE, BEE, IEA, TERI, IRENA
- RETScreen, HOMER Pro, PVsyst (Simulation Tools)

Product Design and Digital Manufacturing

⚜ Course Objectives:

1. To introduce the fundamentals of product design, innovation, and development.
2. To expose students to tools and technologies in digital design and manufacturing.
3. To integrate CAD, CAM, CAE, and Industry 4.0 tools for product lifecycle.
4. To understand the role of digital twins, additive manufacturing, and automation in modern manufacturing.

✅Course Outcomes (COs):

- **CO1:** Apply structured methods for concept generation, design thinking, and product development.
- **CO2:** Utilize CAD/CAE tools for product modeling and validation.
- **CO3:** Understand and apply principles of digital manufacturing and Industry 4.0.
- **CO4:** Implement additive and subtractive manufacturing strategies for rapid prototyping.
- **CO5:** Integrate digital technologies for smart and sustainable product development.

⚜ Course Content:

Unit 1: Fundamentals of Product Design

- Product development process and lifecycle
- Design thinking and innovation frameworks
- User-centered design, ergonomics, aesthetics
- Concurrent engineering and DFX principles
- Case studies of successful product designs

Unit 2: CAD and CAE in Product Design

- Solid and surface modeling (parametric and direct modeling)
- Assembly modeling and tolerance analysis
- Finite Element Analysis (FEA) for design validation
- Topology optimization and generative design
- Digital mock-ups and design iterations

Unit 3: Digital Manufacturing Fundamentals

- Definition and components of digital manufacturing
- Cyber-Physical Systems and Smart Factories
- Role of CAD/CAM/CAE/PDM/PLM
- Digital threads and digital twins
- Real-time data monitoring and decision-making

Unit 4: Additive and Subtractive Manufacturing

- Additive Manufacturing (AM) processes and integration
- Design for Additive Manufacturing (DfAM)
- CNC-based subtractive manufacturing techniques
- Toolpath generation and simulation
- Hybrid manufacturing approaches

Unit 5: Industry 4.0 and Intelligent Manufacturing

- IoT in manufacturing: sensors, data acquisition
- Cloud manufacturing and digital supply chains
- Automation, robotics, and smart assembly systems
- Sustainability and green manufacturing
- Case studies: Digital manufacturing in automotive, aerospace, healthcare

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⚜ Suggested Laboratory / Project Work (Optional 1 Credit Recommended):

- Design a product in CAD and validate it using CAE tools
- 3D print a prototype and evaluate its fit/form/function
- Develop a digital twin model of a manufacturing process
- Simulate a manufacturing line with digital manufacturing software (e.g., Siemens Tecnomatix, FlexSim, Arena)
- Create a bill of materials and process plan using PLM tools

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⚜ Textbooks:

1. **Ulrich, K.T. & Eppinger, S.D.** – *Product Design and Development*, McGraw-Hill
2. **Gibson, I., Rosen, D.W., Stucker, B.** – *Additive Manufacturing Technologies*, Springer
3. **Michael McClellan** – *Collaborative Manufacturing: Using Real-Time Information to Support the Supply Chain*, CRC Press

⚜ Reference Books:

- **Chitale& Gupta** – *Product Design and Manufacturing*
- **Madhusudan Reddy** – *Digital Manufacturing and Automation*
- **Kalpakjian& Schmid** – *Manufacturing Engineering and Technology*

Automotive Technology

⚜ Course Objectives:

1. To introduce the layout, structure, and key components of modern automobiles.
2. To study internal combustion engine systems, transmission, suspension, and vehicle control systems.
3. To explore modern technologies like electric vehicles, hybrid systems, and ADAS.
4. To understand safety, emission, and diagnostic technologies in vehicles.

✅Course Outcomes (COs):

- **CO1:** Describe the construction and working of automotive powertrains and sub-systems.
- **CO2:** Analyze the performance of engines, transmission, suspension, and braking systems.
- **CO3:** Understand vehicle electronics and control systems including sensors, ECUs, and CAN.
- **CO4:** Evaluate emerging automotive technologies including EVs and hybrid vehicles.
- **CO5:** Apply diagnostic tools and standards for vehicle safety and emission control.

⚜ Course Content:

Unit 1: Vehicle Layout and Powertrain Systems

- Classification and layout of vehicles (FWD, RWD, AWD)
- Chassis and body types
- IC engine types, construction and working (SI and CI engines)
- Engine components, valve timing, engine balancing
- Power transmission system: clutch, gearbox (manual and automatic), differential, propeller shaft

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Unit 2: Suspension, Steering, and Braking Systems

- Suspension types: rigid axle, independent suspension
- Springs: leaf spring, coil spring, torsion bar
- Hydraulic shock absorbers, active suspension
- Steering systems: rack and pinion, power steering, steering geometry
- Braking systems: disc, drum, ABS, EBD, regenerative braking

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Unit 3: Automotive Electronics and Control

- Sensors: throttle position, MAP, oxygen, speed, temperature
- ECUs and their functions (engine, transmission, ABS, airbag)
- Communication protocols: CAN, LIN, FlexRay
- Vehicle diagnostics: OBD-I and OBD-II standards
- Instrument clusters and electronic dashboard systems

Unit 4: Advanced Vehicle Technologies

- Introduction to Hybrid Electric Vehicles (HEV) and Electric Vehicles (EV)
- Types of hybrid configurations: series, parallel, power-split
- Battery technologies (Li-ion, NiMH), BMS and thermal management
- Power electronics in EVs: inverters, converters, controllers
- Introduction to Fuel Cell Vehicles (FCV)

Unit 5: Safety, Emissions and Diagnostics

- Passive and active safety systems: airbags, crumple zones, ESC
- ADAS: cruise control, lane assist, parking assist
- Emission norms: BS-VI, Euro VI
- Catalytic converters, DPF, SCR technologies
- Diagnostic Trouble Codes (DTCs) and scan tools

⚜ Suggested Practical / Laboratory Work (Optional - 1 credit):

- Dismantling and assembly of a 4-stroke IC engine
- Simulation of vehicle dynamics using software (e.g., ADAMS, AVL Cruise)
- CAN bus communication experiment
- Diagnostic scanning using OBD-II scanner
- Visit to EV/Automotive manufacturing unit and report submission

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⚜ Textbooks:

1. **Kirpal Singh** – *Automobile Engineering Vol I & II*, Standard Publishers
2. **William H. Crouse, Donald L. Anglin** – *Automotive Mechanics*, McGraw-Hill
3. **Bosch Automotive Handbook**, Bosch GmbH

⚜ Reference Books:

- R. B. Gupta – *Automobile Engineering*
- Jack Erjavec – *Automotive Technology: A Systems Approach*
- Iqbal Husain – *Electric and Hybrid Vehicles: Design Fundamentals*