Detailed Curriculum for Open Elective Courses

Subject: Introduction to Mechatronics (Code: MET901)	**Year and Semester: 3rd Year and 5th Semester (Open Elective Course)**		**Total Course Credit: 3**		
			L	T	P
			2	1	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Understand the basic electrical, semiconductor, and digital logic concepts relevant to mechatronic systems.
CO2	Explain the working of sensors and actuators and their role in measurement and control.
CO3	Develop Microcontroller-based applications involving signal conditioning and hardware interfacing.
CO4	Implement basic feedback control and integrate components into simple mechatronic systems.

Detailed Syllabus:

UNIT I **CH - 11**

Introduction to Mechatronics: definition, interdisciplinary nature, basic elements (sensors, actuators, controllers, mechanical components), common applications; Basic circuit elements: resistors, capacitors, inductors; Semiconductor electronics: diodes (Zener and optoelectronic), transistors (BJT and MOSFET), voltage regulators; Digital logic fundamentals: combinational logic (basic gates, adders, multiplexers), sequential logic (flip-flops, latches, counters, shift registers), brief overview of logic families (TTL, CMOS).

UNIT II **CH - 10**

Sensors: position and speed measurement, vibration and acceleration measurement, stress and strain measurement, force and pressure measurement, semiconductor sensors and microelectromechanical devices; Actuators: overview of actuator types - electrical, hydraulic, pneumatic (their principles and characteristics); Electrical actuators: DC Motors (brushed, brushless, PWM control), stepper motors, servo motors, motor drivers (H-bridge), relays, and solenoids.

UNIT III **CH – 12**

Signal conditioning: analog vs. digital signals, amplification, basic filtering (RC filters), ADC/DAC concepts; Analog signal processing: operational amplifiers (Op-Amps) and their basic configurations for signal conditioning; Arduino architecture and programming: digital and analog I/O, PWM, serial communication; Polling vs. interrupts, use of timers, libraries, and serial monitors; Direct register manipulation and bit masking; Interfacing sensors and actuators with Arduino.

UNIT IV **CH - 09**

Control fundamentals: open-loop vs. closed-loop control, block diagrams, time and frequency response; Basic control actions: proportional, integral, derivative, and their combinations; Arduino-based implementation of feedback control: speed and position control of DC motors, sensor-based control of LEDs; Emphasis on real-world mechatronic system integration through hands-on projects and case studies.

Text Book:

1. David G. Alciatore, Introduction to Mechatronics and Measurement Systems, 5th Edition, McGraw Hill, 2019

Reference Books:

1. W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, 7th Edition, Pearson, 2023
2. G. Onwubolu, Mechatronics - Principles and Applications, 1st Edition, Elsevier (Butterworth-Heinemann), 2005.

Subject: Introduction to Electric Vehicle(Code: MET902)	**Year and Semester: 3rd Year and 5th Semester (Open Elective Course)**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Articulate the configuration of Electrical Vehicles (EV's).
CO2	Recognize the EV control systems and vehicle dynamics.
CO3	Demonstrate of EV battery chargers, electric vehicle supply equipment, and battery thermal management system.
CO4	Evaluate the feasibility and challenges of EV into existing automobile industry.

Detailed Syllabus:

UNIT I **CH - 09**

History and benefits of Electric Vehicles (EVs), fundamentals of EVs, social, environmental, and economic impacts of electric and hybrid vehicles, tractive effort, vehicular dynamics, drive cycle and vehicle control unit, impact of modern drive-trains on energy supplies.

UNIT II **CH - 11**

Power train configurations and components, traction motor characteristics, tractive effort, drive cycles, rear-wheel drive powertrains, front-wheel drive (FWD) powertrains, vehicle control unit, vehicle modelling methodology, range modelling of battery electric vehicle, auxiliary system in electric vehicle, powertrain component sizing, auxiliary control functions (anti-roll, start stop etc.)

UNIT III **CH - 10**

Importance of control system in electrical vehicle, study of control architecture in electric vehicle, systems models and their classifications, principles used in modelling of systems, fundamental studies of modelling of vehicle dynamics and control, integrated vehicle dynamics.

UNIT IV **CH - 12**

Introduction to energy storage requirements in electric vehicles, battery-based energy storage and its analysis, battery charging modes, types of EV supply equipment (EVSE), components of EV battery chargers, charging infrastructure challenges, battery performance characteristics, rechargeable battery vehicles, battery thermal management system (BTMS), types of BTMS, comparison between different BTMS, opportunity and advancement.

Text Books:

1. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001.

2. M. Ehsani, Y. Gao, S. Gay and Ali Emadi Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design CRC Press 2005.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

Reference Books:

1. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals CRC Press 2003.
2. Hybrid Electric Vehicles Principles and Applications with Practical Perspectives Chris Mi, M. Abul Masrur, David Wenzhong Gao Wiley Publication 2011.
3. Iqbal Husain, Electric and Hybrid Vehicles – Design Fundamentals, 2nd edition, CRC Press, 2011.

<table>
<tr><td rowspan="3">Subject: Basic Robot Mechanics (Code: MET903)</td><td colspan="2" rowspan="3">Year and Semester:
3rd Year and 6th Semester
(Open Elective Course)</td><td colspan="3">Total Course Credit: 3</td></tr>
<tr><td>L</td><td>T</td><td>P</td></tr>
<tr><td>2</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">Evaluation Policy</td><td>Mid-Term</td><td>Continuous Assessment</td><td colspan="3">End-Term</td></tr>
<tr><td>26 Marks</td><td>24 Marks</td><td colspan="3">50 Marks</td></tr>
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Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Understand robotic structure and kinematics using coordinate transformations and DH representation.
CO2	Analyze manipulator velocities using Jacobians and identify singularities.
CO3	Model simple robotic systems dynamically using the Lagrangian method.
CO4	Apply basic trajectory planning in joint and Cartesian spaces.

Detailed Syllabus:

UNIT I **CH – 15**

Introduction to robotics: definition, applications, and classification of robots; robot anatomy—links, joints, degrees of freedom, end-effectors; coordinate frames and transformation matrices; rotation matrices, Euler angles, and homogeneous transformations; Denavit–Hartenberg representation; forward and inverse kinematics of typical planar manipulators; workspace analysis and singularities.

UNIT II **CH – 13**

Differential motion of manipulators; velocity relationships and Jacobian matrix—geometric and analytical formulations; Jacobian for standard manipulator structures; interpretation of Jacobian in joint and operational space; kinematic singularities and their implications; Jacobian transpose; basic understanding of dexterity and manipulability.

UNIT III **CH – 14**

Dynamic modeling of manipulators; physical interpretation of mass, inertia, and acceleration in robotic arms; Lagrangian formulation for simple manipulators; notable properties of dynamic models; conceptual overview of forward and inverse dynamics; Basic trajectory planning in joint and Cartesian space.

Text Book:

1. S. B. Niku, Introduction to Robotics: Analysis, Control, Applications, 3rd Edition, John Wiley, 2024.

Reference Books:

1. J. J. Craig, Introduction to Robotics: Mechanics and Control, 3rd Edition, Pearson, 2004
2. K. M. Lynch and Frank C. Park, Modern Robotics: Mechanics, Planning, And Control, Cambridge English, 2017

Subject: Sustainable Engineering (Code: MET904)	**Year and Semester: 3rd Year and 6th Semester (Open Elective Course)**		**Total Course Credit: 3**		
			L	T	P
			3	0	0
Evaluation Policy	Mid-Term	Continuous Assessment	End-Term		
	26 Marks	24 Marks	50 Marks		

Pre-requisites: Nil

Course Outcomes: At the end of the course, the student should be able to:

CO1	Explain sustainable development and different environmental agreements and protocols
CO2	Discuss real time activities causing environmental issues and different methods to use renewable energy resources
CO3	Differentiate between carbon emissions for regular and sustainable cities and explain different practices to move industries towards sustainability
CO4	Discuss different renewable energy resources and explain methods to implement green technology

Detailed Syllabus:

UNIT I **CH – 08**

Foundations of Sustainable Engineering: Sustainable development, conceptual frameworks: triple bottom line model, egg of sustainability model, Atkisson's pyramid model, prism model, tenets of sustainable development and engineering, sustainability risks.

Environmental Ethics and Governance: Environmental ethics and education, international environmental agreements and protocols, implementation of India's environmental statutes – The Water Act, The Air Act, The Environment Act.

UNIT II **CH – 09**

Community-Scale Environmental Problems: Solid waste management, consequences of solid waste for natural assets, zero waste philosophy and reduce-reuse-recycle principle, energy recovery from waste: thermo-chemical conversion, biochemical conversion.

Planetary Environmental Challenges: Resource deterioration: degradation of aquatic resources, soil deterioration, atmospheric pollution, climatic change and global heating, stratospheric ozone depletion, carbon footprint, emissions trading.

UNIT III **CH – 05**

Sustainability Implementation Tools: Environmental Management System (EMS), ISO14000 framework, Life Cycle Assessment (LCA): core elements, benefits, limitations, case example. Environmental Impact Assessment (EIA), environmental auditing, biomimicry, case analyses.

UNIT IV **CH – 10**

Eco-Conscious Habitats: Green building principles, eco-friendly construction materials, building sustainability certification and ratings: Green Rating for Integrated Habitat Assessment (GRIHA), Leadership in Energy and Environmental Design (LEED) rating, energy-conserving structures, sustainable urban areas, eco-friendly transit, sustainable pavement systems, sustainability engineering exemplars: Green building, sustainable metropolis, sustainable transit network.

Sustainable Industrial and Urban Development: Eco-sensitive urbanization, sustainable industrial practices, sustainable material choice, pollution abatement, industrial ecosystems, industrial mutualism, alleviating impoverishment.

UNIT V **CH – 10**

Alternative Energy Sources: Traditional and alternative energy forms, solar power, fuel cells, wind power, micro-hydropower installations, biogas systems, biofuels, marine energy, geothermal power, energy preservation.
Eco-Technology and Sustainable Enterprise: Environmentally responsible business, eco-technology, clean energy, sustainable construction, low-impact transportation, environmentally benign chemistry, energy-efficient computing.

Text Book:

1. R. L. Rag and Lekshmi Dinachandran Remesh. Introduction to Sustainable Engineering. 2nd Edition, PHI Learning Pvt. Ltd., 2016.

Reference Books:

1. D. T. Allen and D. R. Shonnard. Sustainability Engineering: Concepts, Design and Case Studies, 1st Edition, Prentice Hall, 2011.
2. A.S. Bradley, A. O. Adebayo, P.Maria. Engineering applications in sustainable design and development, 1st Edition, Cengage learning, 2016.