Tulsiramji Gaikwad-Patil College of Engineering and Technology

Wardha Road, Nagpur-441108

NAAC Accredited with A+ Grade

(An Autonomous Institute Affiliated to RTM Nagpur University, Nagpur)

Third Year (Semester-VI) B.Tech. Mechanical Engineering

BME33625: Sustainable & Green Manufacturing (Honor Course)

Teaching Scheme		Examination Scheme	
Lectures	3 Hr / Week	**CT**	30
Tutorials	-	**CA**	10
Total Credits	3	**ESE**	60
		Total	100 Marks
		Duration of ESE: 03 Hrs	

Course Objectives:

1	Understand the fundamental concepts, principles and importance of sustainable and green manufacturing.
2	Explain the environmental impacts associated with manufacturing processes, materials and industrial operations.
3	Apply green manufacturing techniques for efficient utilization of energy, materials and resources.
4	Analyze waste minimization, cleaner production, life-cycle assessment and sustainable production systems.
5	Evaluate emerging technologies and strategies for developing sustainable and environmentally responsible manufacturing systems.

Course Contents

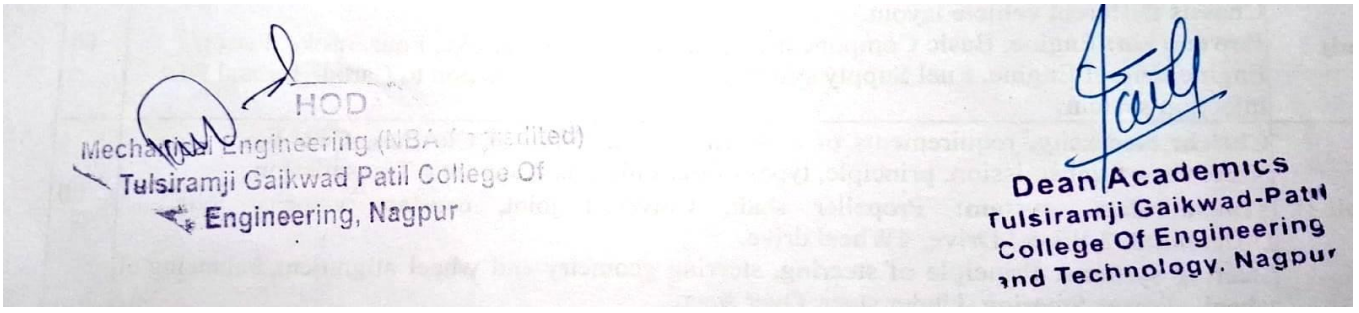
Unit I	**Fundamentals of Sustainable & Green Manufacturing** Introduction to Sustainability: Concept of sustainability, sustainable development, three pillars of sustainability, sustainable manufacturing and its need, drivers and benefits of sustainable manufacturing. Green Manufacturing: Definition, principles, objectives, characteristics and framework of green manufacturing. Difference between conventional, lean and green manufacturing. Sustainable Manufacturing Indicators: Resource productivity, energy intensity, material efficiency, carbon emissions and environmental performance indicators.
Unit II	**Green Materials, Processes and Energy Management** Green Materials: Renewable, recyclable, biodegradable and eco-friendly materials; material selection for sustainable manufacturing; material substitution and dematerialization. Green Manufacturing Processes: Sustainable machining, minimum quantity lubrication, dry machining, near-net-shape manufacturing, additive manufacturing and environmentally conscious casting, forming and joining processes. Energy Management: Energy consumption in manufacturing, energy-efficient machines and processes, energy conservation techniques, renewable energy integration in manufacturing.
Unit III	**Waste Minimization and Cleaner Production** Industrial Waste: Types and sources of manufacturing waste; solid, liquid and gaseous waste. Waste Minimization: 3R principle – Reduce, Reuse and Recycle; source reduction, process optimization, material recovery and waste segregation. Cleaner Production: Concept, principles, methodology and benefits; pollution prevention at source; cleaner production assessment.
Unit IV	**Life Cycle Assessment and Circular Manufacturing** Life Cycle Thinking: Product life cycle, environmental aspects throughout the product life cycle and sustainable product development. Life Cycle Assessment (LCA): Concept, objectives, phases of LCA, goal and scope definition, inventory analysis, impact assessment and interpretation. Circular Economy: Linear economy versus circular economy, circular manufacturing, closed-loop production, remanufacturing, refurbishment and recycling.
Unit V	**Smart, Digital and Emerging Sustainable Manufacturing** Industry 4.0 and Sustainability: Smart manufacturing, IoT, sensors, cloud computing, digital twins and data analytics for sustainable production. Additive and Advanced Manufacturing: Role of additive manufacturing, advanced machining and automation in reducing material and energy consumption. Emerging Trends: Zero-waste manufacturing, net-zero manufacturing, carbon-neutral factories,

	sustainable automation, smart factories and Industry 5.0 for human-centric and sustainable manufacturing.

Text Books	
T.1	*S. L. Hart*, Beyond Greening: Strategies for a Sustainable World, *Harvard Business Review*.
T.2	*J. Sarkis*, Greening the Supply Chain, *Springer*.
T.3	*David A. Dornfeld*, Green Manufacturing: Fundamentals and Applications, *Springer*.
Reference Books	
R.1	David A. Dornfeld, Green Manufacturing: Fundamentals and Applications, Springer.
R.2	J. A. Hauschild, R. K. Rosenbaum and S. I. Olsen, Life Cycle Assessment: Theory and Practice, Springer.
R.3	M. P. Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, Pearson.

	Useful Links
1	https://www.nist.gov/programs-projects/sustainable-manufacturing-program?utm
2	https://www.unido.org/cross-cutting-priorities/cleaner-production-and-circular-economy?utm
3	https://www.ellenmacarthurfoundation.org/circular-economy-principles?utm

Course Code	**Course Outcomes**	**CL**	**Class Sessions**
BME33625.1	**Explain** the principles and importance of sustainable and green manufacturing.	**2**	**9**
BME33625.2	**Apply** green materials, energy-efficient processes and sustainable practices.	**3**	**9**
BME33625.3	**Analyze** waste, energy use, emissions and environmental impacts for cleaner production.	**4**	**9**
BME33625.4	**Evaluate** products and manufacturing systems using LCA, eco-design and circular economy principles.	**5**	**9**
BME33625.5	**Apply** digital, smart and advanced manufacturing technologies for sustainable and resource-efficient production.	**3**	**9**



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Third Year (Semester-VI) B.Tech. Mechanical Engineering

BME33621: Electric & Hybrid Vehicle Technology (Minor Course)

Teaching Scheme		Examination Scheme	
Lectures	3 Hr / Week	**CT**	30
Tutorials	-	**CA**	10
Total Credits	3	**ESE**	60
		Total	100 Marks
		Duration of ESE: 03 Hrs	

Course Objectives:

1	To understand the fundamentals, architecture, components, and operating principles of electric and hybrid electric vehicles.
2	To study various energy sources, battery technologies, battery management systems, and charging methods used in electric vehicles.
3	To understand electric motors, power electronic drives, propulsion systems, and regenerative braking techniques used in electric vehicles.
4	To analyze different hybrid vehicle configurations, energy management strategies, and vehicle performance characteristics.
5	To examine safety requirements, environmental impacts, emerging technologies, and practical applications of electric and hybrid vehicles.

Course Contents

Unit I	Introduction to Electric and Hybrid Vehicles: History and evolution of electric mobility; need for electric and hybrid vehicles; conventional vs electric vehicles; vehicle architectures and classifications; basic EV components; longitudinal vehicle dynamics; tractive force, rolling resistance, aerodynamic drag, grade resistance and performance requirements; energy consumption and driving cycles.
Unit II	Energy Storage and Charging Systems: Batteries for EVs—lead-acid, Ni-MH, lithium-ion and emerging battery technologies; battery parameters and characteristics; cell, module and pack configuration; battery thermal management; Battery Management System (BMS)—functions, SOC and SOH estimation; supercapacitors and fuel cells; charging methods, AC and DC charging, charging levels, connectors, charging infrastructure and vehicle-to-grid (V2G) concept.
Unit III	Electric Propulsion and Power Electronics: Electric machines for EVs—DC, induction, permanent magnet synchronous and BLDC motors; motor characteristics and selection; power electronic converters—inverter, DC-DC converter and rectifier; motor control techniques; torque-speed characteristics; regenerative braking; traction control; efficiency and performance of electric drive systems.
Unit IV	Hybrid Electric Vehicles: HEV concept and classification; series, parallel and series-parallel hybrid configurations; mild, full and plug-in hybrid vehicles; major components and power flow; engine-generator and motor integration; hybrid powertrain operating modes; regenerative braking; energy management strategies; control of hybrid systems; comparison of HEV, PHEV and BEV.
Unit V	Vehicle Performance, Safety and Emerging Technologies: EV/HEV performance assessment—range, acceleration, efficiency and energy consumption; thermal management of battery and powertrain; electric vehicle safety, high-voltage safety and protection systems; environmental impact, life-cycle considerations and battery recycling; charging standards and infrastructure; autonomous and connected electric mobility; wireless charging; hydrogen fuel-cell vehicles; emerging trends and challenges in electric and hybrid mobility.

Text Books	
T.1	Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay and Ali Emadi, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles, CRC Press.
T.2	Chris Mi, M. Abul Masrur and David W. Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, Wiley.
T.3	Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press.
Reference Books	
R.1	James Larminie and John Lowry, Electric Vehicle Technology Explained, Wiley.
R.2	Ali Emadi, Advanced Electric Drive Vehicles, CRC Press.
R.3	John M. Miller, Propulsion Systems for Hybrid Vehicles, IET.

Useful Links	
1	https://www.iea.org/energy-system/transport/electric-vehicles
2	https://www.energy.gov/eere/vehicles/electric-vehicles

Course Code	Course Outcomes	CL	Class Sessions
BME33621.1	**Explain** the fundamentals, architectures and operating principles of electric and hybrid electric vehicles.	**2**	**9**
BME33621.2	**Analyze** battery technologies, Battery Management Systems and charging systems used in electric vehicles.	**4**	**9**
BME33621.3	**Apply** electric motor and power electronic drive principles to analyze propulsion and regenerative braking systems.	**3**	**9**
BME33621.4	**Analyze** hybrid vehicle configurations, power flow and energy management strategies for improved vehicle performance.	**4**	**9**
BME33621.5	**Evaluate** EV/HEV performance, safety, environmental aspects and emerging electric mobility technologies.	**5**	**9**

