GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Branch: Chemical Engineering

Subject Code: ME03030011

Subject Name: Energy Conversion and BioRefinery

w. e. f. Academic Year:	2024-25
Semester:	3
Category of the Course:	MOPEC-01

Prerequisite:	Basic knowledge of chemical engineering principles, reaction engineering and thermodynamics.
Rationale:	This course will enable students to become skilled professionals in sustainable technology. It gives them the knowledge to create new solutions in renewable energy and green chemistry. The students will be ready to tackle environmental problems and support the growth of the bioeconomy.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes
01	Understand the environmental, economic, and social impacts of biomass utilization and compare it with fossil fuel-based systems.
02	Explore various technologies for biomass conversion to fuels, chemicals, and materials.
03	Evaluate the principles and process flows of biorefineries for the production of biofuels, bioenergy, and value-added chemicals.
04	Develop practical skills to analyze biomass composition, conversion efficiencies, and product characterization.

Teaching and Examination Scheme:

Teaching Scheme(in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	0	3	70	30	0	0	100

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Introduction:** World energy and environmental scenario, Fossil fuel depletion and associated environmental challenges, Global policies promoting bioenergy and bioproducts, Historical development of biorefineries, Overview of successful biorefinery projects.	8	18
2.	**Biomass:** Definition and scope of biomass. Biomass significance as an energy resource. Types and availability of waste biomass (municipal, industrial, agricultural, and forestry). Biomass production, selection, and abundance. Oil crops and their potential for biorefineries. Enhancing biomass properties for biofuel applications. Conversion pathways for biomass utilization. Challenges in biomass utilization and scaling up technologies. Emerging trends and innovations in biomass usage.	10	22
3.	**Thermal and Chemical Conversion:** **Thermal Conversion:** Choice of thermal process based on biomass type and product requirement (combustion, gasification, torrefaction, pyrolysis), Pyrolysis: Types, products (oil, gas, charcoal), and applications, Hydrothermal liquefaction and hydro-pyrolysis, Fischer-Tropsch synthesis and transesterification, Equilibrium and kinetic considerations for thermal processes. **Chemical Conversion:** Hydrolysis & hydrogenation, Solvent extraction of hydrocarbons, Solvolysis of wood, Production of Biocrude and biodiesel and other chemicals from biomass.	10	22
4.	**Biological Conversion:** Biodegradability of substrates and microbial processes, Microalgae as feedstock for biofuels and biochemicals, Biochemistry and process parameters of biomethanation, Biogas digester types, Digester design and biogas utilization, Biogas plant design, utilization, and economic aspects, Bioconversion processes for alcohols, organic acids, solvents, amino acids, and antibiotics.	9	20
5.	**Sustainability and Environmental Aspects of Biorefinery**: Techno-economic analysis (TEA) and life cycle assessment (LCA) of biorefineries, Greenhouse gas mitigation and carbon footprint reduction, Waste valorization and its role in the circular economy, Environmental and social impacts of biorefinery operations, Role of government incentives and subsidies in promoting biorefineries.	8	18
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
5	25	15	10	10	5

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

- Biomass as a Sustainable Energy Source for the Future: Fundamentals of Conversion Processes Wiebren de Jong, J. Ruud van Ommen, AIChE/Wiley, ISBN: 978-1-118-30491-4. (2015)
- Biorefineries: Design and Analysis" by Paul R. Stuart and Mahmoud M. El-Halwagi, CRC Press, 2012.
- Biorenewable Resources: Engineering New Products from Agriculture, Robert C. Brown, Wiley-Blackwell Publishing (2014)
- Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983 3.
- Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991 4.
- Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996
- Biogas Systems: Principles and Applications, Mital K.M
- Handbook of Bioenergy Crops: A Complete Reference to Species, Development, and Applications. London: Earthscan, El Bassam, Nasir, 2010.

Suggested Activities for Students:

- Analyze biomass properties (e.g., calorific value, moisture content, and lignocellulosic composition).
- Visit power plants, renewable energy facilities, and research labs to observe energy conversion technologies in action.
- Study and compare advancements in biomass conversion technologies, including catalytic, thermal, and biological processes.
- Analyze case studies of successful biorefineries and their economic viability.
- Examine trends in biomass availability, cost, and biofuel production in different regions.
- Create a conceptual design for a biorefinery processing municipal waste or agricultural residues into biofuels and chemicals.

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