



GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3170412

Semester –VII

Subject Name: Bioenergy

Type of course: Professional Elective course

Prerequisite: Basic Statistics, Engineering mathematics, PPS

Rationale: With the rise of issues like climate change and alternative fuels, green fuels, it is important that the student understands the engineering problems and corresponding solutions with respect to viable biofuel production.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
2	0	4	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	Introduction: What are biofuels, what is the need for biofuels, Classification of biofuels into liquid, solid, gaseous and electric. Assessing whether a biofuel is truly carbon negative. The economic problems associated and the Biorefinery concept.	4
2	Biofuel Feedstocks : cereals and starchy feedstock, Concept of food and fuel competition, lignocellulosic feed stock, oligogenous feedstocks including algae, seeds, animal and plant waste, 1 st , 2 nd and 3 rd generation biofuels	4
3	Biomethane production: Process of hydrolysis, acidogenesis, acetogenesis and methanogenesis, Microbial communities involved in methane production, Preferred feedstock for biomethenation, Reactor designs- floating dome, bag type, cstr, fixed dome type, process parameters and design. Biogas composition and use for fuel, electricity generation and cooking. Biohydrogen production: Microorganisms and pathways associated with biohydrogen production, Light	4



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	fermentation and Dark fermentation for Biohydrogen production, hydrogen inhibition, feedstocks and process parameters, Quality and quantity measurements for generated biohydrogen stream.	
4	Bioethanol and Biobutanol: Microorganisms and pathways associated with solventogenesis, Process parameters and technology with simple substrates (sugarcane and corn starch process), Process parameters and technology with lignocellulosic feedstocks (chemical and enzymatic hydrolysis of feedstock along with pretreatment technologies), utilization of pentose streams, Purification of solvents, Economic analysis of process.	8
5	Biodiesel: Feedstock oil sources, Trans esterification using base or alkali catalysts, esterification, lipase catalyzed transesterification, Supercritical esterification and transesterification, Titration, Byproduct utilization, quality analysis of biodiesel,	5
6	Bioelectricity: Microbial fuel cells, Microbes involved, anode and cathode materials, choosing the correct proton exchange membrane, Sediment MFC, single chamber and two chamber MFC, Waste water treatment, MFC performance assessment	7

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	10	10	10	10	-

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:



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1. Drapcho, Caye M., Nhuan Ph Nghim, and Terry Walker. Biofuels engineering process technology. McGraw-Hill Education, 2008. (2nd edition).
2. Pandey, Ashok, Christian Larroche, and Steven C. Ricke, eds. Biofuels: alternative feedstocks and conversion processes. Academic Press, 2011.
3. Pandey, Ashok, et al., eds. *Biohydrogen*. Newnes, 2013.
4. Pandey, Ashok, et al., eds. *Biomass, biofuels, biochemicals: biohydrogen*. Elsevier, 2019.
5. Logan, Bruce E. *Microbial fuel cells*. John Wiley & Sons, 2008.

Course Outcomes:

Students should be able to

Sr. No.	CO statement	Marks % weightage
CO-1	Understand feedstocks required for biofuel production	20
CO-2	Evaluate the requirements and process of biomethanation and biohydrogen	20
CO-3	Evaluate the requirements and process of bioethanol and biobutanol	40
CO-4	Evaluate the requirements and process of biodiesel and bioelectricity generation.	20

List of Experiments:

1. Ethanol fermentation from cane sugar.
2. Titration of oils for biodiesel production.
3. Biodiesel synthesis from waste cooking oil/virgin cooking oil.
4. Labscale set up of biogas production using schott duran bottle.
5. Calculation of labscale biogas production using inverted measuring cylinder method.

Major Equipments:

Glass ware and equipment required in a typical chemistry and microbiology laboratory.

List of Open Source Software/learning website:

1. Students can refer to video lectures available on portal NPTEL/SWAYAM.