GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Renewable Energy

Course / Subject Code : 4356404

Course / Subject Name : Marine and Geothermal Energy

w. e. f. Academic Year:	2024
Semester:	5th
Category of the Course:	Elective II

Prerequisite:	**Basic knowledge related to non-conventional sources of Energy, Renewable Energy, Physics and Chemistry. Knowledge of Electrical Energy Generation engineering.**
Rationale:	The course on Marine and Geothermal Energy is designed to provide students with a comprehensive understanding of the fundamental principles governing the Marine and Geothermal Energy systems and to emphasize the role of Marine and Geothermal Energy technology and its potential. The course aims to introduce the basic concepts of Marine and Geothermal Energy and the preliminary analysis to estimate the energy generation from the Marine and Geothermal Energy systems. Various components involved in the Marine and Geothermal Energy system are covered. In addition to the various applications of Marine and Geothermal Energy generation systems, the course also covers the issues related to the integration of this system in the existing network. Thus, the course is intended to provide the foundation for the Marine and Geothermal Energy generation system. By studying these topics, students will develop a solid foundation in Marine and Geothermal Energy systems and gain practical knowledge necessary for their future careers in renewable and electrical engineering.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Gain knowledge about various technologies related to Marine Energy	R
02	Understand Challenges in Marine Energy	U
03	Gain knowledge about various technologies related to Geothermal Energy	R
04	Understand Challenges in Geothermal Energy	U

**Revised Bloom's Taxonomy (RBT)*

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	2	4	30	70	25	25	150

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Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Introduction to Marine Energy	10	24
2.	Challenges in Marine Energy	12	28
3.	Introduction to Geothermal Energy	12	28
4.	Challenges in Geothermal Energy	08	20
	Total	**42**	**100**

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit I Introduction to Marine Energy	**1a.** Understand the fundamentals of Marine Energy **1b.** Explain different types of Marine Energy Technologies	**1.1** Introduction to Marine Energy **1.2** Fundamentals of Marine Energy • Tidal Energy • Wave Energy • Ocean Thermal Energy Conversion (OTEC) **1.3** Marine Energy Technologies • Tidal Barrages • Tidal Stream Generators • Oscillating Water Columns • Wave Energy Converters
Unit II Challenges in Marine Energy	**2a.** Explain the Technical Challenges in Marine Energy Generation **2b.** Comprehend Economic Challenges in Marine Energy Generation **2c.** Understand Environmental Challenges in Marine Energy Generation	**2.1** Technical Challenges • Intermittency • Harsh Marine Environment **2.2** Economic Challenges • High Capital Costs • Uncertain Return on Investment **2.3** Environmental Challenges • Impact on Marine Ecosystems • Carbon Footprint

Unit III Introduction to Geothermal Energy	**3a.** Understand fundamentals of Geothermal Energy **3b.** Explain different types of Geothermal Energy Generators **3c.** Explain different technologies of Harnessing Geothermal Energy	**3.1** Introduction to Geothermal Energy **3.2** Fundamentals of Geothermal Energy: Sources and Extraction Methods • Dry Steam Power Plants • Flash Steam Power Plants • Binary Cycle Power Plants **3.3** Technologies for Harnessing Geothermal Energy • Enhanced Geothermal Systems (EGS) • Hydrothermal Processes • Direct Use Technologies
Unit IV Challenges in Geothermal Energy	**4a.** Describe challenges and opportunities in Geothermal Energy **4b.** Explain Environmental Impacts of Geothermal Energy **4c.** Comprehend Economic Implications of Geothermal Energy	**4.1** Challenges in Geothermal Energy • Geological Risks and Exploration Challenges • High Initial Costs and Financial Barriers **4.2** Environmental Impacts of Geothermal Energy: • Greenhouse Gas Emissions • Land Use Considerations • Water Consumption **4.3** Economic Implications of Geothermal Energy • Initial Investment Costs • Operational Costs • Economic Benefits

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
50%	**40%**	**5%**	**3%**	**1%**	**1%**

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:

1. Ocean Energy Laura K. Murray · 2016
2. Fundamentals of Ocean Renewable Energy: Generating Simon P. Neill, M Reza Hashemi
3. Ocean Energy: Tide and Tidal Power R. H. Charlier, Charles W. Finkl
4. Handbook of Ocean Wave Energy 2016 by Arthur Pecher, Jens Peter Kofoed
5. Wave Energy Conversion 2003 by John Brooke
6. Ocean Wave Energy Conversion 2013 by Michael E. McCormick
7. Electricity from Wave and Tide: An Introduction to Marine Energy 2013 by Paul A. Lynn
8. Geothermal Energy: Utilization and Technology 2013 by Mary H. Dickson, Mario Fanelli
9. Geothermal Energy: An Alternative Resource for the 21st Century 2006 by Harsh K. Gupta, Sukanta Roy
10. Geothermal Energy 2019 by Christine Elizabeth Eboch

(b) Open source software and website:

1. https://wec-sim.github.io/WEC-Sim/main/index.html
2. https://www.fortum.com/blog/enext/building-simulation-model-geothermal-power-plant

Suggested Course Practical List:

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify country wise Marine Energy Generation across the world and specifically identify Marine Energy Generation in India	1	4
2	Identify various parts of a Tidal Energy Generator	1	2
3	Identify various parts of a Wave Energy Generator	1	2
4	Prepare a report on the Environmental challenges of Marine Energy Generation	2	2

5	Prepare a report on the Economic challenges of Marine Energy Generation	2	4
6	Identify country wise Geothermal Energy Generation across the world and specifically identify Geothermal Energy Generation in India	3	2
7	Identify various parts of a Dry Steam Power Plants	3	2
8	Identify various parts of a Flash Steam Power Plants	3	2
9	Prepare a report on the Environmental challenges of Geothermal Energy Generation	4	4
10	Prepare a report on the Economic challenges of Geothermal Energy Generation	4	4

List of Laboratory/Learning Resources Required:

Sr. No.	Equipment Name with Broad Specifications	Pr. No.
1	Wave Oscillometer	2, 3
2	Thermometer	7, 8

Suggested Project List:

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects are group-based (group of 4 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should ***not exceed four.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Design and create miniature Demo Marine Energy Generator using various materials.
b) Design and create miniature Demo Geothermal Energy Generator using various materials.
c) Explore the electrical components of a Marine Energy Generator.
d) Explore the electrical components of a Geothermal Energy Generator.
e) Build a device to measure Marine Energy using sensors.
f) Build a device to measure Geothermal Energy using sensors.
g) Investigate the materials commonly used in Marine Energy Generators.
h) Investigate the materials commonly used in Geothermal Energy Generators.
i) Create an educational presentation or workshop on Marine energy and Geothermal Energy for local schools or community group.

Suggested Activities for Students:

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course. Students should perform following activities in group (or individual) and prepare reports of about 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

a. Create a quiz to test students' understanding of fundamental concepts related to Marine energy, including terminology, principles, and historical developments.
b. Ask students to create detailed diagrams or models illustrating the different parts of a Oscillating Water Columns, explaining the function of each component.
c. Use online simulation tools or software to allow students to virtually design and test their own Wave Energy Converters
d. Provide data on Geothermal Energy and Dry Steam Power Plant specifications.

e. Invite a professional from the Geothermal Energy Generation industry to speak to the class. Allow students to ask questions and learn about current trends, challenges, and career opportunities.

f. Explore the environmental impact of Wave Energy Generation on Marine Energy.

CO- PO Mapping:

Semester 5th	Course Name (Course Code: 4356405)						
	POs						
Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solution	PO 4 Engineering Tools, Experimentation Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
CO1	2	-	-	-	1	-	-
CO2	-	2	-	-	-	-	-
CO3	2	-	-	-	1	-	-
CO4	-	2	-	-	-	-	-

*Legend: '**3**' for high, '**2**' for medium, '**1**' for low and '**-**' for no correlation of each CO with PO.*

No	Course Outcomes
CO1	Gain knowledge about various technologies related to Marine Energy
CO2	Understand Challenges in Marine Energy
CO3	Gain knowledge about various technologies related to Geothermal Energy
CO4	Understand Challenges in Geothermal Energy

GTU Resource Person

Sr. No.	Name and Designation	Institute	Contact No.	Email
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