GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2022 (COGC-2022)
Semester-V

Course Title: Marine Internal Combustion Engine-I
(Course Code: 4351801)

Diploma programme in which this course is offered	Semester in which offered
Marine Engineering	5th Semester

1. RATIONALE

Knowledge of engine working principles enables engineers to optimize engine performance, maximizing fuel efficiency and minimizing emissions. Allows engineers to troubleshoot and rectify problems onboard, minimizing downtime and ensuring smooth operations. Comprehending engine working principles enhances safety by enabling engineers to identify potential hazards and respond effectively during emergencies. Ensures adherence to environmental regulations and emissions standards set by relevant authorities. Keeps engineers updated with the latest technology and innovations in marine engine systems.

2. COMPETENCY

The course content should be taught and curriculum should be implemented with the aim to develop different types of skills leading to the achievement of the following competency.

The competency of marine internal combustion engines encompasses reliable power generation, fuel efficiency, durability, emission control, system integration, diagnostic skills, safety measures, and adaptability to changing industry trends. Apply the knowledge of construction and working of IC-engine components and its associated systems

- Differentiate between 4 strokes & 2 strokes.
- Understand the working of Marine propulsion system.
- Study about scavenging & its types.
- Acquire broader ideas about working of turbocharger
- Study of fuels & lubricants used in combustion.

2. COURSE OUTCOMES (COs)

The underpinning knowledge and the relevant skills associated with this competency are to be developed in the student to display the following COs:

1. To study 2 stroke and 4 stroke marine IC engines, its parts and timing diagram.
2. Discuss scavenging and supercharging and its importance
3. Demonstrate combustion, penetration atomization of fuels and designs of modern fuel injectors.
4. Illustrate various fuel their properties and testing methods for IC Engine.
5. Discuss various Medium speed engine and compressor.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	2	4	30*	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-projectto facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** -End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the sub-components of the COs. Some of the PrOs marked '*' are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Organize practical demonstrations of engine components, such as piston-cylinder assemblies, intake and exhaust systems, and fuel injection systems marine engine.	I	4
2	Conduct hands-on experiments to illustrate the scavenging process in a two-stroke engine and compare it with the supercharging system in a four-stroke engine.	II	4
3	Demonstrate fuel quality tests and lubricant analysis to emphasize the importance of proper fuel and lubricant selection.	III, IV	4
4	To study and draw actual valve timing diagram of 4 stroke and port timing diagram of 2 stroke marine engine.	I	4
5	Load test on single cylinder 4 stroke diesel engine,	I.II	4
6	Demonstration of construction and working of centrifugal compressor.	V	2
7	Micro Project as suggested in section no. 4	ALL	4
8	Industrial visit Visit near by marine ic engine based industry.	ALL	2
	Total hours		**28 Hrs.**

Note

i. *More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*
ii. *The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.*

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Identify components (Knowledge)	10
2	Prepare experimental setup. (Procedure followed)	20
3	Perform the experiment with accuracy. (Quality of job/report)	40
4	Follow safety practices. (Safety followed)	10
5	Submit the report. (Timely submission / Quality of report)	20
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practicals in all institutions across the state.

Sr. No.	Major Equipments	PrOs. No.
1	Ic engine test rig.	1,2
2	IC engine components	1,4
3	Centrifugal compressor	6
4	Repairing and maintenance tool(different size spanners, pipe benders , pressure guage, NDT kit etc.)	all

7. AFFECTIVE DOMAIN OUTCOMES

The following sample Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs and PrOs. More could be added to fulfill the development of this competency.

a) Work as a leader/a team member.
b) Follow safety practices while using equipment.
c) Realize the importance of green energy. (Environment related)

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below: i. 'Valuing Level' in 1st year ii. 'Organization Level' in 2nd year. iii. 'Characterization Level' in 3rd year

8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit – I **Introduction & Characteristics of IC Engine:**	1.a 2 stroke & 4 stroke ic engine. 1.b Timing diagrams of 2 & 4 stroke cycles. 1.c I.C engines & parts	1.1 Design Features of marine diesel Engine 2-stroke and 4-stroke cycles, deviation from ideal condition in actual engines. 1.2 Timing diagrams of 2-stroke timing diagrams of 4-stroke. 1.3 Comparative study of slow speed, medium speed and high speed diesel engines - suitability and requirements for various purposes Mean Piston speed. 1.4 Constructional Details of IC Engines Principal Components: Fuel Injectors, Air Starting Valves, Relief Valves, Hydraulic exhaust valves, Air distributors, Jackets and Liners, Cylinder heads ,Piston, Cross heads, Connecting rods, Bed Plates, A-frames, Welded construction for Bed plates & frames, Tie rods.
Unit – II **Scavenging and Supercharging System**	2.a Scavenging& Types 2.b Supercharging using turbochargers & its importance.	2.1 Scavenging arrangements in 2-Stroke engines; Air charging and exhausting in 4-Stroke engines; 2.2 Various types of Scavenging in 2-stroke engines; Uni-flow, loop, cross loop and reverse loop scavenging, their merits and demerits. 2.3 Scavenge pumps for normally aspirated engines; under piston scavenging, Scavenge manifolds. 2.4 Pulse and constant pressure type; their relative merits and demerits in highly rated marine propulsion engine. 2.5 Air movements inside the cylinders. Turbocharger and its details. Two stage, un-cooled, radial turbochargers.
Unit – III **Combustion & Dissociation**	3.a Fuel & its combustion 3.b Fuel injectors & injection timings. 3.c Various pressures during combustion..	3.1 Definition of Fuel, combustion. Combustion Equation, Analysis of the Products of Combustion, 3.2 Stoichiometric combustion, Actual combustion, Excess Air, Mixture strength. 3.3 Dissociation. Effect of Dissociation on IC-Engines.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
		3.4 Combustion of Fuels: Grades of suitable fuels, Preparation of fuels for efficient combustions ,fuel atomization, ignition quality, fuel injectors and its details, ignition delay, afterburning 3.5 Compression Pressure Ratio and its effects on Engine. Reasons for variation in compression pressure and peak pressure. Design aspects of combustion chamber. Control of NOX and SOX in Exhaust emission.
Unit – IV **Fuels & Lubricants**	4.a Grades of fuels and properties. 4.b Testing for various parameters. 4.c Lubricants properties , various types of engine lubricants	4.1 Composition, properties and characteristics of different fuels and lubricants, additives used flash point & viscosity as applicable to petrol, kerosene, marine diesel oil, boiler fuel oil, lube oil. 4.2 Sampling and testing procedure, storage and transfer of fuel and lubricants. 4.3 Contamination of fuel and Lubricants including microbes. 4.4 Lubrication arrangement in diesel engines including Cooling System, Merits and demerits of different cooling mediums, cylinder lubrication, liner wear and preventive measures.
Unit -V **Medium speed Engines & Compressors**	5a. Medium speed engine & details. 5b. Combustion process. 5c. Consequences & improvements. 5d. Centrifugal compressors	5.1 Different types of medium speed marine diesel engines, couplings, and reduction gear used in conjunction with medium speed Engine, Development in exhaust valve design, V-type engine details. 5.2 Use of poor quality residual fuels and their consequences. 5.3 Improvements in designs for higher power output. 5.4 Fuels, combustion process – fundamentals. 5.5 Principle of centrifugal compression and pressure rise in centrifugal

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
		compressor, change in Angular Momentum. Pre-whirl and pre-whirl vanes. 5.6 Mach number at inlet to a centrifugal compressor, slip and slip factor, multi-stage centrifugal compressor.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	**Introduction & Characteristics of IC Engine:**	10	05	08	03	16
II	**Scavenging and Supercharging System**	10	05	08	03	16
III	**Combustion & Dissociation**:	06	04	04	02	10
IV	**Fuels and lubricants**	06	04	04	02	10
V	**Medium speed Engines & Compressors**	10	04	06	08	18
Total		**42**	**22**	**30**	**18**	**70**

10. SUGGESTED STUDENT ACTIVITIES

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 conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

Sr. No.	Activity.
1	Procedure for dismantling Main Bearings i.e Engine bearings, Cross Head bearings & Bottom end bearings. Check its clearance.
2	Carry out Crankcase inspection.
3	Do valve grinding using Grinding Paste.
4	Removing & Renewing cylinder head ,cylinder liner, Fuel pump.& injectors.
5	Procedure for dismantling & assembling Diesel engine unit including all cylinder head mountings.
6	Overhauling of Turbocharger, dry washing & wet washing.

7	Overhauling of Heat exchangers & replacing glands packing.
8	Carry out overhauling of centrifugal compressor.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/subtopics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4*** : Use different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.
e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Guide students on how to address issues on environment and sustainability.

12. SUGGESTED MICRO-PROJECTS

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 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should ***not exceed three.***

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 contributions in the project work and give a seminar presentation of it before submission. The duration of the micro-project should be about **10**-**16** ***(ten 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 can be added by the concerned course teacher:

a) Prepare Report and presentation on various marine engine system (construction drawing working…)
b) Prepare model for testing methods of fuel and lubrication system of engine
c) Prepare a model of various engine systems and compressor
d) Supercharging model preparation
e) …….
f) …….

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1.	Marine Diesel Engine	Deven Arhana	Shroff; First Edition (28 November 2009)
2.	Principles & practice of Marine Diesel Engines	D.K. Sanyal.	2d Edition, Bhandarkar Publication, Mumbai, 1998.
3.	Pounder's Marine Diesel Engines	Wood yard, Goug	8th Edition, Butter Worth Heinemann Publishing, London 2001
4.	Lamb's Marine diesel Engine	John Lamb	Butterworth-Heinemann; 8th edition (19 April 1990)
5.	Marine Diesel Engines and Gas Turbines	Pounders	Butterworth-Heinemann Ltd; 10th edition (7 December 2020)
6.	Diesel Engines	A.J.Wharton	Butterworth-Heinemann Ltd; 3rd edition (23 September 1991)

14. PO-COMPETENCY-CO MAPPING

Semester IV	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency							
CO-1 : To study 2 stroke and 4 stroke marine IC engines, its parts and timing diagram	3	2		3			
CO-2: Discuss scavenging and supercharging and its importance	3			3			
CO-3: Demonstrate combustion, penetration atomization of fuels and designs of modern fuel injectors	3	2	2	3	2		
CO-4 : Illustrate various fuel their properties and testing methods for IC Engine	3			3	2		
C0-5 : Discuss various Medium speed engine and compressor	3			2			

15. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email
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17. BOS Resource Persons

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