GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Automobile Engineering
Subject Code: BE05002061
Subject Name: Alternate Fuel and Power System

w. e. f. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Elective Course - 02

Prerequisite:	Basics of Automobile Systems
Rationale:	This course is designed to provide a comprehensive understanding of alternative fuels such as biofuels, gaseous fuels, hydrogen, and synthetic fuels, along with their production methods, properties, performance characteristics, and environmental impacts. The course also introduces advanced automobile technologies, including electric vehicles, hybrid vehicles, and fuel cell systems, which are essential for future mobility solutions. Additionally, it covers solar-powered vehicles and non-conventional engine systems to broaden the perspective of emerging energy-efficient technologies. By studying this course, students will gain the necessary knowledge and skills to analyze, evaluate, and apply alternative fuel technologies and modern power systems in automobile engineering, thereby contributing to sustainable development and reduced environmental impact.

Course Outcomes:

Sr. No.	CO statement	Marks% weightage
CO-1	Explain the global and national energy scenario, the need for alternative fuels, and their properties in comparison with conventional fuels, along with relevant standards and policies.	07
CO-2	Describe the production methods, properties, usage, performance, and emission characteristics of liquid biofuels and synthetic alternative fuels for IC engines.	33
CO-3	Analyze the production, properties, storage, combustion characteristics, performance, safety aspects, and required engine modifications of gaseous fuels (biogas, LPG, CNG, and hydrogen), along with the challenges associated with their use in automobile applications.	32
CO-4	Analyze the working principles, components, propulsion systems, energy storage technologies, and configurations of electric energy-powered vehicles for automobile applications.	18
CO-5	Illustrate the working principles, construction, advantages, limitations and applications of solar-powered vehicles and non-conventional engine power systems.	10

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL	Total no of hours per semester		ESE (E)	PA (M)	PA (I)	PBL (I)	ESE (V)	
45	00	30	15	90	03	70	30	20	30	50	200

Content:

Sr. No.	Content	Total Hrs
1	**Introduction:** Current energy scenario in the world and India, Estimation of petroleum reserves, Necessity of alternative fuels for an automobile, Types of alternative fuels, Essential properties of alternative fuels, Comparison with conventional fuels, Government policies and regulations, A.S.T.M. standards	03
2	**Biofuels: Alcohol:** Sources and production methods of methanol and ethanol, Properties of methanol and ethanol as engine fuels, Use of alcohols in SI and CI engines, Engine performance by using blends of ethanol/methanol with gasoline, Improvement/Change in emission characteristics with respect to percentage blending of alcohol with gasoline, Recent advances in alcohol-fueled vehicles (materials, fuel systems, emissions).	05
3	**Biofuels:** **Bio-diesels:** Sources and production materials for biodiesel, Production methods and production economics of biodiesel, Properties of Diesel - biodiesel blends, Engine performance with biodiesel blends, Recent advances in biodiesel vehicles (materials, fuel systems, emissions) **Vegetable Oils:** Various vegetable oils and their important properties, Problems with Neat Vegetable Oil Fuel, Different methods of using vegetable oils engines – Blending - Micro emulsification – Pyrolysis – Transesterification - Esterification, Performance and combustion emission characteristics in diesel engines. **Synthetic Alternative Fuels:** Di-Methyl Ether (DME), Pyrolysis gas/oil, Synthetic gas/oil from plastic, rubber, coal, wood etc., Eco-Friendly Plastic fuels (EPF).	10
4	**Gaseous Fuel Powered Vehicle:** **Biogas:** Introduction to biogas plant/system, Process during gas generation, Factors affecting biogas formation, Effect of biogas on vehicle performance, Modifications required in existing engine systems to use the biogas as a fuel **LPG & CNG:** Properties of L.P.G. & C.N.G. as engine fuels, Fuel metering systems, Combustion characteristics of the CNG & LPG, Effect of CNG & LPG on the engine performance, Storage, cost, and safety of CNG & LPG, Comparison of LPG, CNG and biogas based on various parameters and properties, Modifications required in existing engine systems to use LPG and CNG..	10
5	**Hydrogen Fuel Powered Vehicle:** History**,** Properties of hydrogen as an alternative fuel, Production methods of hydrogen, Describe various methods and challenges associated with the hydrogen storage and transportation, Challenges associated with hydrogen as a fuel for IC engine and its solutions, Hydrogen storage for automobile applications (I.C. Engine, Fuel Cell)	4
6	**Electric Energy Powered Vehicle:** **Battery Electric Vehicles (BEVs):** Definition, Types of EV, Advantages of EV over IC engine vehicle, Components of BEV, Electric Batteries (Advance lead-acid, Sodium-sulphur, Nickel–metal hydride, Sodium chloride/nickel, Lithium-ion, Supercapacitors), Analysis of electrical drive trains, Electric Propulsion system, List/example of Battery Electric Vehicles. **Fuel Cell Electric Vehicles (FCEVs):** Definition and working principle of fuel cell, Types of fuel cell, Thermodynamic analysis of fuel cell, Components of FCEV, Architecture of FCEV, List/example of FCEVs. **Hybrid Electric Vehicles (HEVs):** Definition, Components of IC engine-based HEV, IC	8

	engine-based HEV Propulsion system, Types of hybrid drive train structure (Series configuration, Parallel configuration, Series-parallel configuration), Electric motors/generators for HEV, Electric-Fuel cell hybrid configurations, CNG-electric hybrid configuration, List/example of HEVs.	
7	**Solar Powered Vehicles:** Solar cells for energy collection. Layout of solar-powered automobiles, Advantages and limitations.	**2**
8	**Non-Conventional Engine Power System:** Introduction, Construction and working of Stratified charge engine, Adiabatic engine, Variable compression ratio engine, Free piston engine, Sterling engine, Wankel engine	**3**
	Total	**45**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	**40**	**40**	**10**	**00**	**00**

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 the above table.

The syllabus of the Alternate Fuel and Power System directly contributes to

Chapter / Topic	**SDG No.**	**Sustainable Development Goals**
Chapter-1 and Capter-2	**SDG-7** **SDG-13**	**Ensure access to affordable, reliable, sustainable and modern energy:** Promotes alternative fuels (biofuels, hydrogen, electricity). Reduces dependence on petroleum reserves. **Take urgent action to combat climate change and its impacts:** Focus on reducing emissions and global warming. Lower CO and HC emissions with alcohol blending. It supports the transition from fossil fuels.
Chapter-3	**SDG-7** **SDG-9** **SDG-12** **SDG-13**	**Ensure access to affordable, reliable, sustainable and modern energy:** Use of renewable fuels from vegetable oils and waste biomass. **Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation:** Students are able to achieve sustainable industrialization and foster innovation by innovation in fuel production (DME, plastic fuels, pyrolysis oil). **Ensure sustainable consumption and production patterns:** It can be achieved by the use of waste cooking oil, non-edible oils and waste-to-energy conversion (plastic, rubber, biomass). Sustainable production

		methods (transesterification). **Take urgent action to combat climate change and its impacts:** Lower carbon footprint and particulate emissions.
Chapter-4 and Chapter-5	**SDG-11** **SDG-13**	**Make cities and human settlements inclusive, safe, resilient and sustainable:** Reduction of urban air pollution by the use of cleaner fuel like CNG, hydrogen, and biogas. It supports a clean and safer life environment. **Take urgent action to combat climate change and its impacts:** This goal can be achieved by using CNG and biogas, which lower emissions than diesel/petrol engines. Zero carbon emissions can be achieved by using hydrogen as fuel in an automobile (water as by-product).
Chapter-6 and Chapter-7	**SDG-3** **SDG-7** **SDG-9** **SDG-11** **SDG-13**	**Ensure healthy lives and promote well-being for all at all ages:** This goal can be achieved by reducing harmful emissions (NOx, CO, PM) by hybrid vehicle and zero carbon emissions using battery BEV, FCEV and solar-powered automobiles. It improves air quality, leading to better public health outcomes. **Ensure access to affordable, reliable, sustainable and modern energy:** This chapter promotes the use clean and renewable energy sources through electric propulsion systems (BEVs, HEVs, FCEVs) and solar based vehicle. Encourages development and use of advanced batteries and fuel cells for efficient energy storage and solar cell. **Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation:** Drives innovation in electric drivetrains, battery technologies, fuel cell systems and solar cell for energy collection. Enhances development of EV charging infrastructure and hydrogen refueling systems. Encourages research in hybrid configurations and advanced propulsion technologies. **Make cities and human settlements inclusive, safe, resilient and sustainable:** Promotes adoption of electric, hybrid vehicles and solar powered vehicle to reduce urban air pollution. Supports cleaner public and private transportation systems. Contributes to noise reduction and improved urban living conditions. **Take urgent action to combat climate change and its impacts:** Reduces greenhouse gas emissions through electrification of vehicles. Supports climate mitigation strategies by replacing IC engine vehicles by adapting fuel cell, hybrid and solar energy-based technologies with

		low/zero-emission alternatives.
Chapter-8	**SDG-7** **SDG-9**	**Ensure access to affordable, reliable, sustainable and modern energy:** This chapter promotes development of energy-efficient engine technologies such as stratified charge, Stirling engines and adiabatic engines. Encourages better fuel utilization and use of alternative/clean fuels. **Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation:** Drives innovation in advanced engine designs such as variable compression ratio (VCR), Wankel, and free piston engines. Encourages research and development in high-efficiency propulsion systems. Supports modernization of automotive and power generation technologies.

Reference Books:

1. Alternate Fuels by Dr. S. Thipse, Jaico Publications.
2. Alternative Fuels Guidebook by Bechtold R.
3. Hydrogen and Fuel Cells by Bent Sorensen, 3rd Edition, Academic Press, UK, 2018
4. Electric and Hybrid Vehicles: Design Fundamentals by Iqbal Hussein, CRC Press, 2003
5. Automotive Engineering by David A. Crolla, Elsevier Inc., 2009
6. Fuel Cells – Principles and Applications by Viswanathan, B and M Aulice Scibioh, Universities Press, India. 2006
7. Hydrogen and Fuel Cells: A Comprehensive Guide, Rebecca L. Busby, Penn Well Corporation, USA, 2005
8. Fuel Cell and Their Applications by Karl Kordesch and Günter R. Simader, Wiley-VCH, Germany
9. Fuel Cells: From Fundamentals to Applications by Supramaniam Srinivasan, Springer
10. The Hydrogen Economy, Jeremy Rifkin, Penguin Group, USA
11. Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design by Mehrdad Ehsani, CRC Press, 2004
12. Electric Vehicle Technology Explained by James Larminie and John Lowry, Wiley, 2003

List of Experiments: (At least ten experiments from the following list should be performed)

1. Determine the flash point, fire point, and density of alcohol-based biofuels (methanol/ethanol).
2. Determine the flash point, fire point, and density of biodiesel.
3. Evaluate the performance and emission characteristics of two/four-wheeler engine fueled with ethanol-gasoline blends.
4. Evaluate the performance and emission characteristics of a four-wheeler engine fueled with diesel–biodiesel blends.
5. Demonstrate the working of an LPG and CNG fuel system kit used in automobiles.
6. Demonstrate the operation of a biogas generation plant/system.
7. Compare the performance characteristics of an engine operated with CNG and gasoline.
8. Compare the performance characteristics of an engine operated with CNG and biofuels.

9. Demonstrate the working of a hydrogen fuel system or hydrogen-operated vehicle.
10. Examine the components of Battery Electric Vehicles (BEV) and Hybrid Electric Vehicles (HEV).
11. Demonstrate the working principle of fuel cell systems used in Fuel Cell Electric Vehicles (FCEVs).
12. Demonstrate the components of fuel cell systems used in Fuel Cell Electric Vehicles (FCEVs).
13. Analyze the configurations and propulsion systems of electric–fuel cell hybrid vehicles.
14. Demonstrate the layout and working of solar cells and components of solar-powered vehicles.
15. Demonstrate the construction and working of non-conventional engines (Wankel engine, VCR engine, Stirling engine etc.).

Major Equipment:

1 Multi/single cylinder four-stroke petrol engine
2 Multi/single cylinder four-stroke diesel engine
3 Exhaust gas analyzer

Minor Equipment: LPG fuel system kit, CNG fuel system kit, Hydrogen-Oxygen Fuel Cell Kit, Solar cell kit, Biogas generation model, Stirling engine demonstration model, Wankel engine (Rotary engine) cut-section model, Biogas plant working model.

List of Open-Source Software/learning website:

1. https://onlinecourses.nptel.ac.in/noc26_de12/preview
2. https://nptel.ac.in/courses/108103009
3. https://nptel.ac.in/courses/115107116
4. https://onlinecourses.nptel.ac.in/noc25_ch92/preview
5. https://onlinecourses.nptel.ac.in/noc19_bt16/preview
6. https://onlinecourses.nptel.ac.in/noc25_ch09/preview
7. https://nptel.ac.in/courses/121106014
8. https://onlinecourses.nptel.ac.in/noc22_ch66/preview
9. https://nptel.ac.in/courses/103101215
10. SAE Paper nos. 840367, 841333, 841334
11. "The properties and performance of modern alternative fuels" – SAE Paper No. 841210.
12. Automotive Industry Standards (AIS) : https://hmr.araiindia.com/storage/ais-details/0_List_of_AIS_published-23_09_2025_b1a1420c-f80f-4c08-aea3-32d1509c2345.pdf
13.

List of course-related Indian standards: Faculty members are required to give an introduction about various Automotive Industry Standards (AIS) related to the course during theory and/or practical sessions. Students may be asked to prepare a report on one or more related Automotive Industry Standards (AIS) under PBL.

1. AIS-024 and AIS-028 (Rev.1) (Part A): Safety and Procedural Requirements for Type Approval of Gaseous Fuelled Vehicles - Part A (Automotive Application) and Code of Practice for Use of Gaseous Fuels in Internal Combustion Engine Vehicles - Part A (Automotive Application).
2. AIS-024 and AIS-028 (Rev.1) (Part B): Safety and Procedural Requirements for Type Approval of Gaseous Fuel Agricultural Tractors - Part B (Agricultural Tractors Application) and Code of Practice for Use of Gaseous Fuels in Internal Combustion Engine Agricultural Tractors - Part B (Agricultural Tractors Application).
3. AIS-024 and AIS-028 (Rev.1) (Part C): Safety and Procedural Requirements for Type Approval of

Gaseous Fuel Vehicles - Part C (CEV's Application) and Code of Practice for Use of Gaseous Fuels in Internal CombustionEngine Construction Equipment Vehicles (CEV's) - Part C (CEV's Application).

4. AIS-025 (Version 3) and Amd. 1 to 8: Safety and Procedural requirements for Type Approval of LPG Operated Vehicles.
5. AIS-026 (Version 3) and Amd. 1: Code of Practice for use of LPG Fuel in Internal Combustion Engine to Power 4 Wheeled Vehicles.
6. AIS-027 (Version 3) and Amd. 1: Code of Practice for use of LPG Fuel in Internal Combustion Engine to Power 2 & 3 Wheeled Vehicles.
7. AIS-028 (Version 3) and Amd. 1 & Amd. 2: Code of Practice for use of CNG Fuel in Internal Combustion Engined Vehicles.
8. AIS -038: Battery Operated Vehicles -Requirements for Construction and Functional Safety
9. AIS-038 (Rev.1):2015 and Amd.1 Electric Power Train Vehicles- Construction and Functional Safety Requirements
10. AIS-038 (Rev. 2) and Amd. 1 to 4: Specific Requirements for Electric Power Train of Vehicles Part I: Requirements of a Vehicle with Regard to Specific Requirements for the Electric Power Train Part II: Requirements of a Rechargeable Electrical Energy Storage System (REESS) with Regard to its Safety
11. AIS-039: Battery Operated Vehicles - Measurement of Electrical Energy Consumption
12. AIS-039 (Rev.1) & Corri. 1 and Amd. 1 & 2: Electric Power Train Vehicles - Measurement of Electrical Energy Consumption
13. AIS-040: Battery Operated Vehicles - Method of Measuring the Range
14. AIS-040 (Rev.1):2015 and Amd.1 to 3: Electric Power Train Vehicles - Method of Measuring the Range
15. AIS-041: Battery Operated Vehicles -Measurement of Net Power and the Maximum 30 Minute Power and speed
16. AIS-041 (Rev.1):2015 and Amd. 1: Electric Power Train Vehicles Measurement of Net Power and The Maximum 30 Minute Power
17. AIS-048 & Amd. 1 and Amd 2: Battery Operated Vehicles - Safety Requirements of Traction Batteries
18. AIS-049 and Amd. 1 & 2: Battery Operated Vehicles - CMVR Type Approval for Battery Operated Vehicles
19. AIS-049 (Rev. 1): 2016 and Amd. 1: Electric Power Train Vehicles - CMVR Type Approval for Electric Power Train Vehicles
20. AIS-055: 2004 and Amd 1: Automotive CNG/LPG Vehicles - Test Method to Evaluate the Range
21. AIS-102 (Part 1) and Amd. 1 to 3: CMVR Type Approval for Hybrid Electric Vehicles of M and N Category with GVW - 3500 kg and L category vehicles
22. AIS-102 (Part 2) & Amd. 1: CMVR Type Approval for Hybrid Electric Vehicles of M and N Category with GVW > 3500 kg
23. AIS-123(Part 1) & Amds. 1 to 5: CMVR Type Approval of Hybrid Electric System Intended for Retro-fitment on Vehicles of M and N Category having GVW - 3500 kg
24. AIS-123(Part 2) and Amd. 1 & 2: CMVR Type Approval of Hybrid Electric System Intended for Retro-fitment on Vehicles of M and N Category having GVW exceeding 3500 kg
25. AIS-131: Type Approval Procedure for Electric and Hybrid Electric Vehicles introduced in market for Pilot / Demonstration Projects intended for Government Scheme
26. AIS-137 (Part 1) and Amd.1 to 4: Test Method, Testing Equipment and Related Procedures for Type Approval and Conformity of Production (COP) Testing of L2 category Vehicles for Bharat Stage VI emission norms as per CMV Rules 115, 116 and 126
27. AIS-137 (Part 2) and Amd.1 to 4: Test Method, Testing Equipment and Related Procedures for Type

Approval and Conformity of Production (COP) Testing of L5 Category Vehicles for Bharat Stage VI (BS VI) Emission Norms as per CMV Rules 115, 116 and 126

28. AIS-137(Part 3) with Amendments 1 to 9: Test Method, Testing Equipment and Related Procedures for Type Approval and Conformity of Production (COP) Testing of M and N Category Vehicles having GVW not exceeding 3500 kg for Bharat Stage VI (BS VI) Emission Norms as per CMV Rules 115, 116 and 126
29. AIS-137 (Part 5) and Amd 1: Test Method, Testing Equipment and Related Procedures for Internal Combustion Engines and Electric Drive Trains intended for the Propulsion of Motor Vehicles of Categories L, M and N with regard to the Measurement of Net Power and the Maximum 30 Minutes Power of Electric Drive Trains and Emission of Visible Pollutants of Motor Vehicles of Categories L, M and N equipped with Compression-Ignition Engines
30. AIS-137 (Part 8): Document on Test Method, Testing Equipment and Related Procedures for 4 Gas Analyzer & Diesel Smoke Meter : Testing Type Approval and Conformity of Production (COP) of PUC Equipment as per CMV Rules 115, 116 :PART 8 (4 Gas Analyzer & Diesel Smoke Meter)
31. AIS-138 (Part 1): Electric Vehicle Conductive AC Charging System
32. AIS-138 (Part 2): Electric vehicle conductive DC charging system
33. AIS-156 and Amd. 1 to 4: Specific Requirements for L Category Electric Power Train Vehicles Part I: Requirements of a Vehicle with Regard to its Electrical Safety Part II: Requirements of a Rechargeable Electrical Energy Storage System (REESS) with Regard to its Safety
34. AIS-157 & Amd. 1 and 2: Safety and Procedural Requirements for Type Approval of Compressed Gaseous Hydrogen Fuel Cell Vehicles
35. AIS-157 A: Safety and Procedural Requirements for Type Approval of Hydrogen Powered Construction Equipment Vehicles (Liquid / Compressed Gaseous Hydrogen)

List of suggested activities for Problem-based Learning (PBL):

Sr. No.	PBL category	Name of the activity	No. of hours	Evaluation Criteria
1.	Complex Problem-Solving targeting relevant SDGs / Mini Project	Mini Project	15h (need to be changed as per total PBL hours)	Based on the novelty of project, technical understanding, report quality and presentation
2.	Case Study Analysis / Seminar	Seminar	15h (need to be changed as per total PBL hours)	Based on the quality of report and presentation, technical understanding
3.	Micro project	Micro project	8h (need to be changed as per total PBL hours)	Based on the novelty of project, technical understanding, quality of report and demonstration
4.	Industry/Researc	Industry/Research	Visit = 5h,	Based on report

	h laboratory visit	laboratory visit	Report preparation = 5h Total = 10h	submitted. Report should contain observations and calculations based on industry/ lab data.
5.	Video Based Learning	Technical video-based learning related to the subject	Duration of video = 5h Report preparation = 5h Total = 10h	Report /presentation based on the video learning outcomes.
6.	Assignment / Technical Writing / Research Writing	Assignment writing. Numerical based assignment is preferable.	5 assignments of 4 h each Total = 20h	Based on the correctness of submitted assignment
7.	Group Discussion / Quiz / Simulation	Problem solving/Coding using C, C++, MATLAB, Python, SCILAB, modeling and Analysis software or any other software	5 small coding-based assignment of 2h each Total = 10h	Based on the coding solution submitted.
8.	Video Based Learning	Self-learning online course	Minimum duration of the course should be 10h	Examination based assessment at the end of course. Based on the certificate produced.
9.	Complex Problem-Solving targeting relevant SDGs / Mini Project	Identification and solution of Complex problem	Maximum 2 problems. Study of the problem and solution finding, Total = 10h	Based on the depth of the solution submitted.
10.	Video Based Learning	Videos on Industrial safety/Disaster Management aspects based on subject	Duration of video = 5h Report preparation = 5h Total = 10h	Based on quiz/report submitted
11.	Research Paper Review / Analysis	Technical paper reading and summarization of research papers based on relevant subject	5 research papers = 20h	Summarize research paper and evaluation critical parameters
12.	Poster / Chart / PowerPoint presentation	Poster/chart/power point preparation on technical topics	Duration = 6h	Based on poster/chart preparation and presentation skills
13.	Industry/Research laboratory visit	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health /sustainability/any other	Duration = 15h for industrial exposure Problem identification and tentative solution = 10h	Based on evaluation of critical problems and solutions

		issue	Total = 20h	
14.	Group Discussion / Quiz / Simulation	Group Discussion on emerging/trending technical topics based on subject	Duration = 1h – 3h per topic	Based on performance in group discussion, technical depth, knowledge etc.
15.	Case Study Analysis / Seminar	Real world case studies-based learning	Duration of data collection/study = 5h Report preparation = 5h Total = 10h	Based on in-depth study, technical depth, data collected, fact finding, etc.
16.	Group Discussion / Quiz / Simulation	Application/Software development	Duration = 10h	Depending on the complexity of the Application/Software
17.	Assignment / Technical Writing / Research Writing	Research paper publication	Duration = 10h	Based on submission of proof of publication
18.	Micro project	Upgradation/Reverse engineering studies of existing equipment of the laboratory	Duration 10h	Based on the performance of the equipment
19.	Industry/Research laboratory visit	Expert lecture/session	Duration 3h For attending the lecture/session– 2h and for report writing 1h	Based on the proof of attendance and report submitted
20.	Video Based Learning	Annotated Video Explanation of Concept/Problem	10h (Preparation + Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
21.	Assignment / Technical Writing / Research Writing	Patent Search and Innovation Gap Identification	10h (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.
22.	Assignment / Technical Writing / Research Writing	Preparation of a report on Indian Standard(s)	10h (study of Indian Standard(s) + report	Based on report quality and understanding of the relevant Indian Standard(s).

Note:

1. In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject **Alternate Fuel and Power System compulsorily incorporates Micro Project and 5 marks as PBL activities for PEC and Seminar and Mini Project for PCC.**

These activities are incorporated as integral Project-Based Learning (PBL) components. These activities are designed to foster experiential learning, encourage innovation, and strengthen problem-solving skills by engaging students in practical applications of power converter design, simulation, and analysis. The inclusion of PBL ensures that learners develop higher-order cognitive abilities mapped to Bloom's taxonomy, while simultaneously enhancing teamwork, communication, and research competencies essential for professional engineering practice.

2. The hours allocated to specific activities should be proportionate to the total no. of PBL hours and marks.
3. All the suggested activity should be related to the subject.
4. The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
5. Rubrics for the evaluation can be prepared by the faculty.
6. Subject teacher can add the relevant activities other than those listed above, with the consent of head of the department and DQAC.

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