

ALTERNATIVE FUELS FOR AUTOMOBILES**Course Code : 316348****Programme Name/s : Automobile Engineering.****Programme Code : AE****Semester : Sixth****Course Title : ALTERNATIVE FUELS FOR AUTOMOBILES****Course Code : 316348****I. RATIONALE**

The limited supply of fossil fuels, environmental pollution, and fluctuating crude oil prices have increased interest in alternative fuels. In the long run, the use of alternative energy sources and their impact on different markets, especially transportation, need more attention. Renewable alternative fuels, like biofuels, produce fewer greenhouse gases. Many countries, including India, are promoting them to reduce emissions and improve energy security. Therefore, it is important to educate diploma students about different alternative fuels, their key properties, production methods, and applications in the transportation industry.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to help the students to attend the following industry identified outcome through various teaching learning experiences: Evaluate the use of alternative fuels in automobiles based on cost, performance and environmental aspects.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Choose relevant alternative fuel based on engine type and its performance characteristics.
- CO2 - Analyze the impact of ethanol-gasoline blends on the performance and emission characteristics of spark ignition engines.
- CO3 - Evaluate the properties and performance of diesel and biodiesel blends through testing.
- CO4 - Analyze the performance of fuels LPG, CNG and Biogas based on environmental parameters.
- CO5 - Assess the feasibility of hydrogen as a fuel for IC engines based on safety aspects

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme						Credits	Assessment Scheme												Total Marks
				Actual Contact Hrs./ Week	SLH			NLH	Paper Duration		Theory				Based on LL & TL				Based on SL				
											Practical												
CL	TL	LL	FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA												
Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min												
316348	ALTERNATIVE FUELS FOR AUTOMOBILES	AFL	DSE	4	-	2	-	6	3	3	30	70	100	40	25	10	25#	10	-	-	150		

Total IKS Hrs for Sem. : 0 Hrs

Abbreviations: CL- Classroom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @\$ Internal Online Examination

Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.

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6. * Self learning hours shall not be reflected in the Time Table.
 7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's) aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe the current energy scenario in the India and world. TLO 1.2 Explain the necessity of alternative fuels for automobiles. TLO 1.3 Classify different types of alternative fuels based on their sources and properties. TLO 1.4 Identify the essential properties of alternative fuels for automotive applications. TLO 1.5 Compare alternative fuels with conventional fuels. TLO 1.6 Suggest a suitable alternative fuel for the given engine.	Unit - I Introduction to Alternative Fuels 1.1 Current energy scenario in world and India. 1.2 Necessity of the alternative fuels for an automobile. 1.3 Types of alternative fuels. 1.4 Essential properties of alternative fuels. 1.5 Comparison with conventional fuels 1.6 Alternative fuels for SI engines 1.7 Alternative fuels for CI engines. 1.8 Government policies and regulations.	Case Study Presentations Chalk-Board Cooperative Learning Collaborative learning
2	TLO 2.1 Define various properties of the alcohol. TLO 2.2 Describe emulsification process of alcohol and diesel. TLO 2.3 Describe effect of alcohol blending with gasoline on engine performance and emission characteristics. TLO 2.4 Describe fuel supply system modifications required to use a ethanol as an alternative fuel.	Unit - II Alcohols 2.1 Sources of methanol and ethanol, methods of its production. 2.2 Properties of methanol and ethanol as engine fuels. 2.3 Use of alcohols in SI and CI engines. 2.4 Engine performance by using blends of ethanol/methanol with gasoline. 2.5 Emulsification of alcohol and diesel. 2.6 Improvement/Change in emission characteristics with respect to percentage blending of alcohol with gasoline. 2.7 Recent advances in vehicles running on alcohols related to materials, fuel supply systems, and emission reduction system.	Case Study Collaborative learning Cooperative Learning Chalk-Board Lecture Using Chalk-Board
3	TLO 3.1 Define various properties of the biodiesel. TLO 3.2 List different sources of biodiesels. TLO 3.3 Compare various types of biodiesels on the basis of their chemical compositions. TLO 3.4 Describe effects of biodiesel as an alternative fuel on the engine performance. TLO 3.5 Describe various biodiesel production methods.	Unit - III Biodiesels 3.1 Sources of vegetable oils for engine applications. 3.2 Materials required for Biodiesel Production. 3.3 Methods of Biodiesel Production. 3.4 Properties of Diesel - biodiesel blends. 3.5 Effect of biodiesel and diesel - biodiesel blends on overall performance of an engine. 3.6 Recent advances in vehicles running on biodiesel related to material, fuel supply and emission reduction system. 3.7 Economics of Biodiesel Production.	Case Study Cooperative Learning Collaborative learning Lecture Using Chalk-Board Presentations
4	TLO 4.1 List the properties of LPG/CNG/ Biogas as a fuel for an automobile. TLO 4.2 Distinguish LPG and CNG on the basis of their chemical composition, fuel consumption, cost, emission etc. TLO 4.3 Describe effect of various properties of the CNG on engine performance.	Unit - IV LPG, CNG and Biogas 4.1 Properties of CNG as engine fuels. 4.2 Combustion and emission characteristics of the CNG. 4.3 Effect of CNG on the engine performance. 4.4 Storage, cost and safety of CNG. 4.5 Bio CNG - production, properties and	Case Study Lecture Using Chalk-Board Collaborative learning Presentations Cooperative Learning

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Sr.No	Theory Learning Outcomes (TLO's) aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
	TLO 4.4 Draw engine performance curves for CNG operated vehicles. TLO 4.5 Compare the properties of LPG, CNG and Biogas. TLO 4.6 Prepare the list of modifications required in engine systems to use LPG/ CNG/Biogas as an alternative fuel. TLO 4.7 Compare the engine performance using LPG, CNG and Biogas as a fuel.	its vehicular applications. 4.6 Properties of LPG as an engine fuel. 4.7 Combustion and emission characteristics of the LPG. 4.8 Effect of LPG on engine performance. 4.9 Storage, cost and safety of LPG. 4.10 Recent advances in vehicles running on LPG for enhancing performance, efficiency and environmental sustainability. 4.11 Comparison of LPG, CNG and biogas on the basis of various parameters and properties. 4.12 Introduction to Biogas plant. 4.13 Processes during biogas generation. 4.14 Factors affecting biogas formation. 4.15 Effect of Biogas on vehicle performance. 4.16 Modifications required in existing engine systems to use the biogas as a fuel.	Flipped Classroom
5	TLO 5.1 Enlist the properties of the hydrogen as a fuel for automobile. TLO 5.2 Describe various challenges associated with the hydrogen storage and transportation. TLO 5.3 Describe various safety precautions of the hydrogen storage.	Unit - V Hydrogen 5.1 Properties of hydrogen as an alternative fuel. 5.2 Production methods of hydrogen. 5.3 Challenges associated with hydrogen as a fuel for IC engine and its solutions. 5.4 Different methods of using hydrogen in SI and CI engines. 5.5 Performance, emission and combustion characteristics of hydrogen as a fuel. 5.6 Safety aspects of hydrogen storage.	Case Study Cooperative Learning Lecture Using Chalk-Board Presentations Collaborative learning Flipped Classroom

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Select most suitable alternative fuels for the given applications. LLO 1.2 Compare properties of given alternative fuels like colour, calorific values, specific gravity, density, volatility, fire point, flash point etc.	1	*Alternative fuels for SI and CI engines.	2	CO1
LLO 2.1 Prepare the ethanol gasoline blend on the basis of volume. LLO 2.2 Measure key fuel properties of the ethanol-gasoline blend and compare them with pure gasoline.	2	Preparation of the ethanol gasoline blends.	2	CO1
LLO 3.1 Conduct a performance test on a two or four wheeler engine using pure gasoline. LLO 3.2 Conduct a performance test on a two or four wheeler engine using ethanol-gasoline blends. LLO 3.3 Compare the performance, emissions, and efficiency results of pure gasoline and ethanol-gasoline blends.	3	*Performance and emission characteristics of two/four wheeler engine fuelled with ethanol gasoline blends.	2	CO2

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 4.1 Conduct a performance test on an engine using pure diesel LLO 4.2 Conduct a performance test on an engine using an alcohol-diesel emulsion. LLO 4.3 Compare the performance, emissions, and combustion characteristics of pure diesel and alcohol-diesel emulsion.	4	*Emulsification of alcohol and diesel.	2	CO3
LLO 5.1 Conduct a performance test on an engine using pure diesel. LLO 5.2 Conduct a performance test on an engine using diesel - biodiesel blends. LLO 5.3 Compare the performance, emission and combustion characteristics of pure diesel and diesel - biodiesel blends.	5	Performance and emission characteristics of four wheeler engine fuelled with diesel - biodiesel blends.	2	CO3
LLO 6.1 Measure properties of the biodiesel like density, viscosity, specific gravity, calorific value etc. LLO 6.2 Compare properties of biodiesel with conventional diesel fuel.	6	*Measurement of various properties of biodiesel.	2	CO3
LLO 7.1 Measure the vehicle performance with pure gasoline. LLO 7.2 Measure the vehicle performance with CNG. LLO 7.3 Compare the results of gasoline and CNG.	7	*Comparative performance analysis of CNG and Gasoline.	2	CO4
LLO 8.1 Measure the engine performance with LPG. LLO 8.2 Measure the engine performance with CNG. LLO 8.3 Compare the performance and emission characteristics of LPG and CNG.	8	Comparative performance analysis of LPG and CNG.	2	CO4
LLO 9.1 Identify the various components of the LPG kit. LLO 9.2 Draw a layout of LPG fuel supply system.	9	Demonstration of LPG Kit.	2	CO4
LLO 10.1 Identify the various components of the CNG kit. LLO 10.2 Draw a layout of CNG fuel supply system.	10	* Demonstration of CNG Kit.	2	CO4
LLO 11.1 Justify the necessity of the hydrotesting of the CNG tank. LLO 11.2 Identify the key equipment, tools, and safety precautions required for conducting hydrostatic testing.	11	*Hydrotesting of the CNG Storage Tank.	2	CO4
LLO 12.1 Identify the various components of the Biogas plants. LLO 12.2 Draw a layout of biogas plant.	12	Demonstration of biogas plant.	2	CO4
LLO 13.1 Conduct a performance test on an engine using pure diesel. LLO 13.2 Conduct a performance test on an engine using diesel blends. LLO 13.3 Compare the performance, emissions, and efficiency of pure diesel and blended fuels.	13	Performance and emission characteristics of small stationary dual fuel diesel engine.	4	CO4

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 14.1 Identify the various components of the hydrogen fueled vehicle. LLO 14.2 Draw a layout of hydrogen fuel supply system.	14	*Demonstration of hydrogen operated vehicle.	2	CO5
Note : Out of above suggestive LLOs - • '*' Marked Practicals (LLOs) Are mandatory. • Minimum 80% of above list of lab experiment are to be performed. • Judicial mix of LLOs are to be performed to achieve desired outcomes.				

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)**Micro project**

- Collect components of LPG kit and prepare a board model with its details.
- Prepare a report on safety practices and routine maintenance of the CNG/LPG operated vehicles.
- Prepare on a report on challenges related to utilization of the alternative fuels and suggest possible solutions
- Extract biodiesel from various sources and compare their properties.
- Collect components of CNG kit and prepare a board model with its details.

Assignment

- Prepare report on economic evaluation of biodiesel production.
- Prepare a report on policy for the production and utilization of the biofuels in India.
- Collect the details of biodiesels available in market and prepare a report.
- Prepare a report on modifications in SI and CI engine to utilize the alternative fuels.
- Prepare a report on processes used for biodiesel preparation.
- Prepare a report on engine material compatibility to use the alternative fuels.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Test rig of multicylinder SI/CI engine available in laboratory.	2,3,4
2	Test rig of single cylinder SI/CI engine available in laboratory.	2,3,4
3	CNG and LPG kits.	4

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to Alternative	CO1	8	4	4	0	8

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Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
		Fuels						
2	II	Alcohols	CO2	10	2	4	8	14
3	III	Biodiesels	CO3	14	2	4	8	14
4	IV	LPG, CNG and Biogas	CO4	18	4	8	8	20
5	V	Hydrogen	CO5	10	2	12	0	14
Grand Total				60	14	32	24	70

X. ASSESSMENT METHODOLOGIES/TOOLS**Formative assessment (Assessment for Learning)**

- Laboratory learning of 25 marks
- Two-unit tests of 30 marks and average of two-unit tests.

Summative Assessment (Assessment of Learning)

- End semester assessment of 25 marks for laboratory learning.
- End semester assessment of 70 marks.

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	3	3	3	-	3	2	2			
CO2	3	3	3	3	3	2	-			
CO3	3	3	3	3	3	2	3			
CO4	3	3	3	3	3	2	3			
CO5	3	3	3	-	3	2	-			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
 *PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Arumugam S. Ramadhas	Alternative Fuels for Transportation.	CRC Press Taylor & Francis Group 2016, ISBN: 978-1-4398-1958-6
2	M. K. Gajendra Babu K. A. Subramanian	Alternative Transportation Fuels Utilisation in Combustion Engines.	CRC Press Taylor & Francis Group, 2013, ISBN-13: 978-1-4398-7282-6
3	Zainal Ambri Abdul Karim Shaharin Anwar Bin Sulaiman	Alternative Fuels for Compression Ignition Engines	Springer Briefs in Energy, 2016, ISBN: 978-981-10-7754-8
4	S.S. Thipse	Alternative Fuels	Jaico Publishing House, 2010, ISBN-13: 978-8184950786
5	Venkateswarlu. K., Murthy, B.S.R.	Alternative Fuels And Advanced Vehicle Technologies	PHI Learning Pvt. Ltd., 2021, ISBN:9788194685173, 8194685176

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Sr.No	Author	Title	Publisher with ISBN Number
6	Richard L. Bechtold, RE.	Alternative Fuels Guidebook Properties, Storage, Dispensing, and Vehicle Facility Modifications.	SAE International, 1st Edition, ISBN 0-7680-0052-1

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.youtube.com/watch?v=VnGH2EScMDE	IC engine fuels - types, requirement and characteristics, Alternative Fuels
2	https://www.youtube.com/watch?v=iSfI_OtSKxs	Alternate Fuels and Sustainable Transportation
3	https://www.youtube.com/watch?v=k6JH0Jl7rx8	Bio-based Fuels
4	https://www.youtube.com/watch?v=5pL_3hKAr2U	Effects of ethanol/gasoline fuel blends on nitrogen oxides emissions in spark-ignition engines
5	https://www.youtube.com/watch?v=rrldwVGmmy4	Transesterification of Vegetable Oil and Alcohol to Produce Ethyl Esters (Biodiesel)
6	https://www.youtube.com/watch?v=8gpF8s915Gc	How CNG Fuel System Works?
7	https://www.youtube.com/watch?v=GdW2DtMQgJA	How does a Diesel LPG engine work?
8	https://www.youtube.com/watch?v=3bhMTDSPP7E	Upgrading Biogas for its application as a fuel for I C engine
9	https://www.youtube.com/watch?v=SRt1KOP9a2g	How Does A Hydrogen Car Work Future Technology
10	https://www.youtube.com/watch?v=shhrBXwEmTw	How Does A Hydrogen Car Work Future Technology Part 1
11	https://www.youtube.com/watch?v=nPsbolmB6Qo	https://www.youtube.com/watch?v=shhrBXwEmTw

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students