Program Name	: **Diploma in Automobile Engineering**
Program Code	: **AE**
Semester	: **Fourth**
Course Title	: **Advanced Automobile Engines**
Course Code	: **22440**

1.   RATIONALE

This is a technology course. This course forms the basis for the Vehicle Systems Maintenance. Contemporary automotive vehicles have advanced technology for engine systems. Hence this course is essential for an auto technician. This course will enable the students in understanding procedure of inspection and maintenance of various types of engine systems, diagnosis of engines and other systems.

2.   COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Maintain different types of Petrol and Diesel automotive engines.**

3.   COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a.   Identify factors responsible for abnormal combustion.
b.   Use diagnostic equipment to test and diagnose MPFI and CRDI engine systems.
c.   Select fuel and alternative energy option for given engine.
d.   Maintain gaseous fuel supply system of an engine.
e.   Use advanced technological information for marketing a vehicle.
f.   Tune I.C. engine to meet emission norms.

4.   TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
					Theory						Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	-	2	6	3	70	28	30*	00	100	40	25#	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment 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, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

5.   COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.
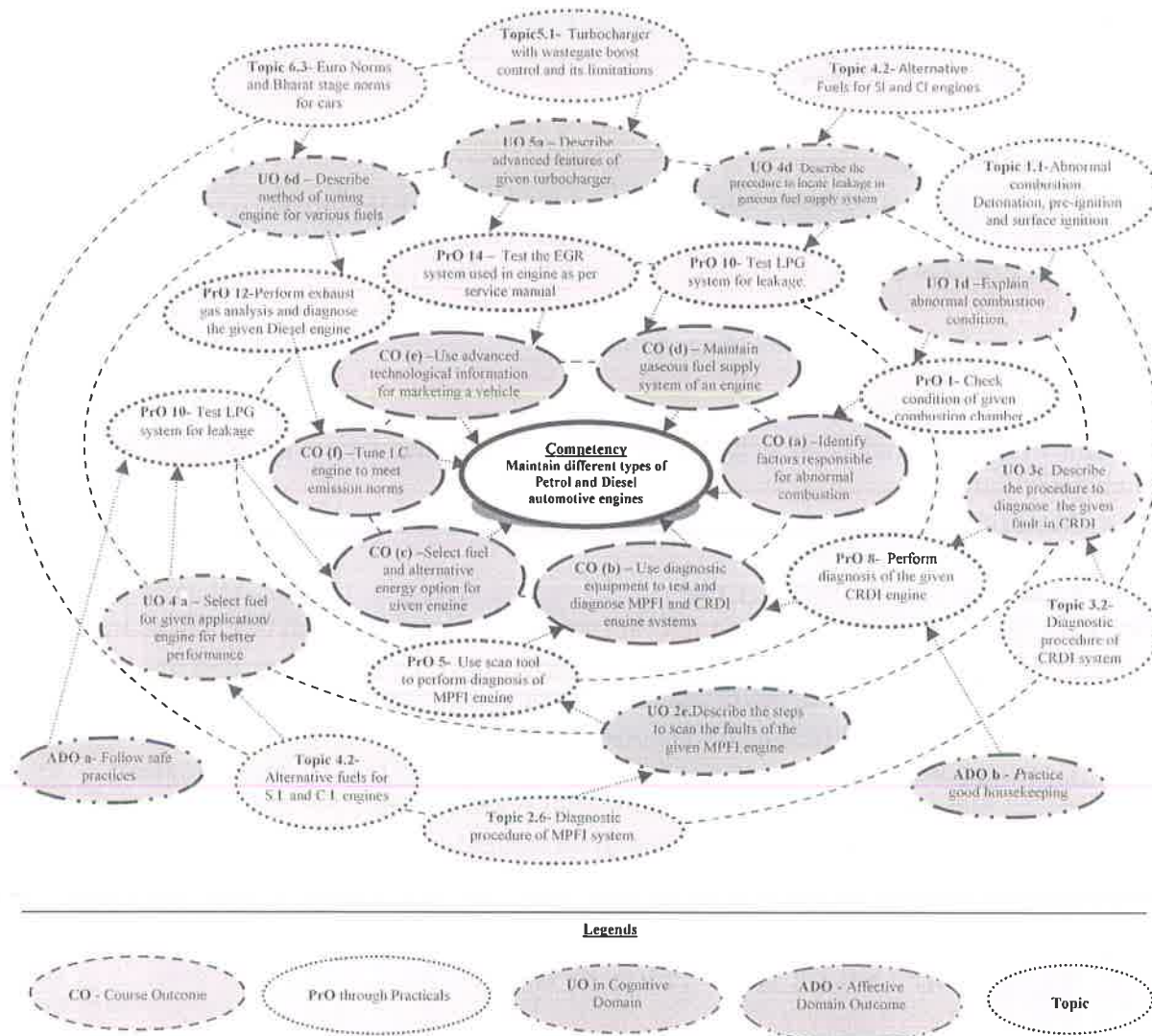

Figure 1 - Course Map

6.   SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1.	Check condition of given combustion chamber of a multicylinder S.I. Engine.	I	02*
2.	Check given combustion chamber of a multicylinder C.I. Engine for valve leakage and deposits.	I	02*
3.	Perform diagnosis of the identified sensor in the given MPFI engine.	II	
4.	Dismantle and assemble electrical fuel feed pump of the given MPFI	II	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	System.		
5.	Use scan tool to perform diagnosis of MPFI engine.	II	02*
6.	Perform diagnosis of the given MPFI engine as per service manual.	II	02*
7.	Identify the components of the given Common Rail Direct Injection (CRDI) System.	III	02*
8.	Perform diagnosis of the given CRDI engine.	III	02*
9.	Perform maintenance of the given CRDI engine as per manufacturer's service manual.	III	02*
10.	Test the given LPG system for leakage.	IV	02*
11.	Perform exhaust gas analysis and diagnose the given S.I. engine condition using Exhaust gas analyzer.	VI	02*
12.	Perform exhaust gas analysis and diagnose the given Diesel engine condition. (Part I)	VI	02
13.	Perform exhaust gas analysis and diagnose the given Diesel engine condition. (Part II)	VI	02
14.	Test the EGR system used in an engine as per service manual.	VI	02*
15.	Test the PCV system used in an engine as per service manual.	VI	02*
16.	Test Exhaust-Gas recirculation valve.	VI	02
	Total		**32**

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and recording	10
5	Interpretation of result and conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safe practices
b. Practice good housekeeping
c. Practice energy conservation
d. Demonstrate working as a leader/a team member
e. Maintain tools and equipment

f. Follow ethical practices

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:
- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7.   MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Four-stroke S.I. and C.I. engines: Make: Maruti/ Greaves Cotton/ Tata and alike, Power: 25 KW to 100 KW, Cubic Capacity: 800 CC to 2500CC	1,2
2	Multiport Fuel Injection engine with sensors, actuators and Electronic Control Module, Exhaust Gas Regulation valve and Positive Crankcase Ventilation valve; Make: Maruti/ Tata/ Ford/ Honda/ Hindustan Motors and alike Power: 25 KW @ 5000 rpm to 55KW@ 5000 rpm, Cubic Capacity: 800 CC to 2000 CC	3,4,5,6, 14,15
3	Scan tool: Make: BOSCH and alike; On Board Diagnostics (OBD) IInd Generation Scan Tool, Controller area network enabled, Colour Display, Operating Temperature: 0 to 50°C, Internal Storage: 4 AAA batteries, External Power: 7 to 18 volts; Generic tool; Accessories: Extender cable, OBD II Cable; Relevant optional accessories;	5,6,8
4	Digital Multimeter: LCD Display, 0 to 50°C Operating Temperature, DC voltage- 200mV to 1000 V DC, 2 to 1000 V Alternating Current, Current: 2mA to 20 A DC, Diode Test,Continuity Test- Audible buzzer, Resistance: 200 Ω to 200 MΩ; Accessories: Test leads, Current Clamp 300 A, Current Clamp Adapter.	5,6,8
5	Direct Current Clamp meter: Make: MECO/ FLUKE and alike, Current measurement – 400 Amperes DC / AC.	5,6,8
6	Tachometer: Make: MEXTECH/ KUSAM- MECO; Non contact or contact type, Speed range: upto 20000 rpm	5,6,8
7	Timing Gun: Make: ESEL/ ASAL/ Kennedy and alike; Ignition Advance: 0 to 45°, 12V DC system, Reverse polarity protection, Bright flash for daylight use	5,6,8
8	Common Rail Direct Injection Engine with sensors, actuators and Electronic Control Module: Make: Fiat/ Hyundai/ Tata/ Honda and alike; Cubic Capacity:1300 cc to 2200 cc ; Power: 55 KW to 100 KW @ 4000 rpm.	7,8,9
9	A car equipped with Liquified Petroleum Gas/ Compressed Natural Gas fuel supply system; Make: Maruti/ Hyundai; Power: 26 KW to 41KW; Cubic	10,12

S. No.	Equipment Name with Broad Specifications	PrO. No.
	Capacity: 800cc; Fuel: LPG/ Petrol; Make: Maruti; Power: 40 KW to 65 KW ; Cubic capacity: 800 to 1350 cc; Fuel : CNG	
10	Exhaust Gas analyzer: ARAI Approved Device with relevant accessories; Measurement Range: CO- 0 to 10 %, HC- 0 to 10000 ppm, CO2- 0 to 20 %, O2- 0 to 25 %, A/F ratio- 7.35 to 29.40, Lambda- 0.500% to 2.000 % .	12,13

8.   UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Engine combustion	1a. Describe stages of combustion in the given I.C. Engine. 1b. Compare S.I. and C.I. engines on the basis of given parameters with justification. 1c. Select a combustion chamber for the given I.C. engine with justification. 1d. Explain abnormal combustion condition, its control and effects in the given engine. 1e. Identify factors responsible for abnormal combustion in the given engine.	1.1 Combustion in S.I. Engines i. Ignition limits ii. Stages of combustion in SI engine iii. Abnormal combustion: Detonation, pre-ignition, and surface ignition. iv. Effects of detonation and Control of detonation. 1.2 SI engine combustion Chambers: Wedge type, Inverted bath tub and Hemispherical combustion chambers. 1.3 Combustion in CI engine i. Stages of CI engine combustion. ii. Air Fuel ratio in Diesel engines iii. Diesel knock and its control. iv. CI engine combustion chambers.: DI and IDI combustion chambers. v. SI and CI engines on the basis of thermodynamic and operating variables, performance characteristics.
Unit-II Computer controlled Petrol engines	2a. Explain the construction and working of given Fuel injection system. 2b. Explain function and location of sensors, actuators and ECM of the given MPFI engine. 2c. Explain the working of the given pressure regulators and fuel injector. 2d. Describe the steps to scan the faults of the given MPFI engine	2.1 Drawbacks of carbureted (SI) engines: Fuel distribution, Emission, Drivability, Power out- put, Fuel consumption, Air fuel ratio. 2.2 Throttle body injection (TBI) and Port fuel injection (PFI) systems; Methods of fuel Injection: Sequential, Continuous, grouped, simultaneous injection. 2.3 Sensors and Actuators of MPFI engine. 2.4 Pressure regulators, fuel injector. and fuel pump. 2.5 Electronic Control Module: input and output control functions as fuel

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		injection, idle speed control, EGR, canister purge. 2.6 Diagnostic procedure of MPFI system: Use of Scan tool and reading fault codes
Unit– III Computer Controlled Diesel Engines	3a. Prepare block diagram of the given CRDI system and label the given components 3b. Describe operation of the given component of CRDI system with the help of schematic sketch/ circuit diagram. 3c. Describe the manufacturer's diagnostic procedure to diagnose the given fault in CRDI system using scan tools 3d. Interpret the given fault codes for the CRDI engine.	3.1 Features of Common rail direct injection system (CRDI): i. Major Components- Solenoid operated Fuel injector, High pressure fuel pump, High pressure accumulator. Introduction to Piezo injector. ii. Block diagram of Electronic diesel control unit (EDC). iii. CRDI System operation and advantages. 3.2 Diagnostic procedure of CRDI system;Use of Scan tool and reading fault codes 3.3 Diesel Engine Glow plugs: Construction. Circuit and operation of glow plug
Unit– IV Fuels and Alternative Energy Options for Automobile Engines	4a. Select fuel for the given application/ engine for better performance. 4b. Select alternative energy option for given application / engine for better performance. 4c. Construct fuel supply system layout for given fuel. 4d. Describe the procedure to locate leakage in gaseous fuel supply system of the given type of engine.	4.1 Properties of various fuels used in IC engines- Gasoline, Diesel, LPG, CNG, Hydrogen, Alcohol, Bio diesel. Fuels used in modern vehicles. 4.2 Alternative Fuels for SI and CI engines- i. LPG, CNG, Alcohol, Bio- diesel (Merits and demerits with respect to performance and emission) ii. LPG and CNG conversion kit block diagram. Leak detection procedure. 4.3 Electric cars and hybrid vehicles – need, advantages. limitations and working with block diagram
Unit –V Advances in Automobile Engines	5a. Describe advanced features of the given turbocharger. 5b. Select the engine with technology/ features suitable for the given application 5c. Compare the salient features of the given turbochargers. 5d. Compare the salient features of the given injection engine.	5.1 Turbocharger with wastegate boost control and its limitations 5.2 Variable Geometric Turbocharger (VGT) 5.3 Variable Valve Timing mechanism (VVT). 5.4 Gasoline Direct Injection (GDI) and Stratified-charge injection.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit –VI Fuel Economy, Air pollution and Emission control	6a. Describe the properties of the exhaust emission for the given engine and the given fuel. 6b. Describe methods of emission control for the given engine. 6c. Describe Bharat Stage (BS) norms and Euro norms for given cars and two-wheelers. 6d. Describe emission control norms of the given engine based on prevailing norms.	6.1 Fuel economy and Air pollution i. Methods of improving fuel economy. ii. Pollutants from gasoline engines. iii. Gasoline engine emission control - engine design modification. treatment of exhaust gas, fuel modification. iv. Diesel emission, Diesel smoke and control 6.2 Emission control i. Exhaust-Gas recirculation (EGR) – EGR valve and control system ii. Positive crankcase ventilation (PCV) system iii. Evaporation emission control system 6.3 Euro Norms and Bharat stage Norms for cars.

Note: *To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Engine combustion	12	4	4	4	12
II	Computer controlled Petrol engines	16	4	4	8	16
III	Computer controlled Diesel engines	12	-	4	8	12
IV	Fuels and alternative energy options for automobile engines	8	4	4	4	12
V	Advances in automobile engines	6	-	4	-	4
VI	Fuel economy, air pollution and emission control	10	-	6	8	14
	Total	**64**	**12**	**26**	**32**	**70**

Legends: R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)
Note: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.

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:

   a. Observe videos relevant to practical task. Prepare a list of appropriate tool/ equipment considering its range/ application. For following applications, tools should be listed:
      i. Cylinder head dismantling, combustion chamber scrapping, spark plug checking, fit between valve guide and valve stem.
      ii. Electric fuel pump dismantling and assembly tools.
      iii. Diagnostic tools for MPFI engine
      iv. Diagnostic tools for CRDI engine
      v. LPG/ CNG leak detection tools
      vi. Exhaust gas analysis and engine tuning
      vii. EGR valve service procedure
      viii. PCV valve service procedure
   b. Refer I.C. engine service manual/s during/before practicals. Follow relevant safety precautions. Carry out Library / Internet survey of maintenance procedures and operation of engine systems.
   c. Prepare power point presentation or animation for understanding different components/ aggregates and systems.
   d. Visit a modern garage to observe testing of EGR, PCV and observation of catalytic converter.
   e. Visit https://www.youtube.com/watch?v=60P3aCNPtjk link for Throttle Body Injection system. Note your observations regarding relevant parameters like Injection pressure, Injector location, operation under different conditions.
   f. Collect videos relevant to MPFI, GDI, CRDI, Catalytic converter, PCV, EGR, Hybrid vehicles and Electric vehicle operation. Note your observations as regards to specifications, service data, precautions and preventive measures to be taken for trouble free operation.
   g. Select an I.C. engine for a car application: Consider requirements of a customer. Select an engine among the available engines, with relevant features and advanced technology to suit particular application. Recommend an engine to the customer and justify your choice.

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/sub topics.
   b. *'L' in item No. 4* does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
   c. About *15-20% of the topics/sub-topics* which is relatively simpler or descriptive in nature is to be given to the students for *self-directed learning* and assess the development of the COs through classroom presentations (see implementation guideline for details).
   d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for *co-curricular activities*.
   e. Guide student(s) in undertaking micro-projects.

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-project are group-based. However, in the fifth and sixth semesters, it should be preferably be *individually* undertaken to build up the skill and confidence in every student to become problem solver so
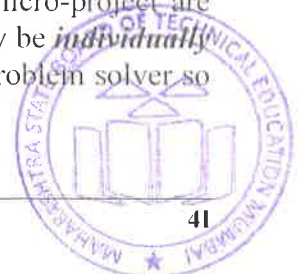
that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should *not exceed three.*

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 contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than *16 (sixteen) student engagement hours* during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. **S.I. engine combustion chamber comparison**: Visit a modern garage/ internet source. Observe combustion chamber of an engine. Refer manufacturer's workshop manual for engine specifications. Use internet/ other sources to compare the combustion chamber design with other designs. Sketch the same. Prepare a report.

b. **C.I. engine combustion chamber comparison**: Visit a modern garage/ internet source. Observe combustion chamber of an engine. Refer manufacturer's workshop manual for engine specifications. Use internet/ other sources to compare the combustion chamber design with other designs. Sketch the same. Prepare a report.

c. **Maintenance of LPG kit**: Visit a dealer/ Internet source to observe LPG/ CNG kit fitment procedure. List troubles arising in the same. Prepare a table containing Symptoms causes and remedies for the troubles. Prepare a list of precaustions to taken while using it during normal use and in event of leakage. Prepare a report.

d. **Maintenance of CNG kit**: Visit a dealer/ Internet source to observe LPG/ CNG kit fitment procedure. List troubles arising in the same. Prepare a table containing Symptoms causes and remedies for the troubles. Prepare a list of precaustions to taken while using it during normal use and in event of leakage. Prepare a report.

e. **Diagnosis of MPFI engine systems:** Diagnose a system of an engine using scan tool/ multimeter. List out the steps of diagnosis. State limiting conditions (Range of variables like voltage, resistance, pressure temperature) for normal operation of the referred system. Prepare a report.

f. **Diagnosis of CRDI engine systems:** Diagnose a system of an engine using scan tool/ multimeter. List out the steps of diagnosis. State limiting conditions (Range of variables like voltage, resistance, pressure temperature) for normal operation of the referred system. Prepare a report.

g. **DTC Identification:** Refer Scan tool/ Internet source for diagnostic trouble codes relevant to a system of engine. List commonly observed DTCs with relevant procedures to rectify the fault and to restore the system. State the methods of erasing the trouble code. Prepare a report.

h. **Modern engine technology:** Identify a modern technology used in an engine. Collect relevant information on the technology and its features. Compare the same with older/ modern technologies adopted in other vehicles. Refer internet/ reference books/ manufacturer published literature for the same. Prepare a report.

i. **Customer Demand identification:** Visit a showroom/ modern garage to identify needs of customer as regards engine features and capabilities. Identify engine availing similar / certain features from a manufacturer. Prepare a report.

j. **Emission testing:** Visit a PUC testing center. Refer procedure of preparing the PUC tester for test. List steps in PUC test. List latest emission norms applicable to cars/ two wheelers. Test emission of a vehicle and record the same. Prepare a report

13.   SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	A Course in Internal Combustion engine	Mathur M.L, Sharma R.P.	Dhanpat Rai Publication, New Delhi, 2016, ISBN 13:9789383182428
2	Internal Combustion engines	Ganeshan V.	Tata McGraw – Hill, New Delhi, 2013 ISBN 13 : 9781259006197
3	Internal Combustion engines	Haywood	Tata McGraw Hill, USA, 2013, ISBN 13: 9780070286375
4	Automotive Principles Volume –I	Knowles Don	Prentice Hall, US, New Jersey, 1988 ISBN 13: 9780130545459
5	Internal Combustion Engines	Ramalingam K.K.	SCITECH, Chennai, 2011, ISBN13: 9788183711029

14.   SUGGESTED SOFTWARE/LEARNING WEBSITES

a. https://www.araiindia.com/services_RnD_services_powertrain.asp
b. http://saeindia.org/magazine-mobility-engineering/
c. http://www.cirtindia.com/Safety_Homologation.html
d. http://nptel.ac.in/courses/112104026/
e. http://www.aa1car.com/common_car_problems.htm
f. https://www.youtube.com/watch?v=-rz4IcMg0Ng for combustion chamber designs
g. https://www.youtube.com/watch?v=jAqC0qxIiL8 for MPFI system
h. https://www.youtube.com/watch?v=LjJSbHxIvnM for GDI system
i. https://www.youtube.com/watch?v=KzF8ieiJ9UY for CRDI system
j. https://www.youtube.com/watch?v=M9dZUOr6n4g for camshaft and crankshaft sensor testing
k. https://www.youtube.com/watch?v= 8q6qZQJQEIU for automotive sensors and actuators
l. https://www.youtube.com/watch?v=qB8b8CCJdfg Glow plug checking video.
m. https://www.youtube.com/watch?v=RR8LsMBwL2I for Scan tool video
n. https://www.youtube.com/watch?v=NUvWnOd5lFw for Common Rail Diesel Injector Working and Common Failure Points
o. https://www.youtube.com/watch?v=ZMa0nom1iwc for cleaning a throttle body and Idle air control valve (iac)
p. https://www.youtube.com/watch?v=lnK00rtWf68 for Throttle Position sensor cleaning
q. https://www.youtube.com/watch?v=_skVHdgtMTU for Throttle Position sensor testing with or without wiring diagram
r. https://www.youtube.com/watch?v=JIa0nsrQXI0 to read car fault codes and to clear them.