Program Name : **Diploma in Automobile Engineering**

Program Code : **AE**

Semester : **Fourth**

Course Title : **Heat Power Engineering**

Course Code : **22441**

1. RATIONALE

Heat energy is the basis for most of the power producing and power absorbing devices. In order to apply the principles of these devices, it is essential to inculcate the students with basic laws, concepts of thermodynamic processes, gas cycles, properties of steam, steam generators, steam condensers, turbines, air compressors, refergeration and air conditioning. Due to energy crunch of petroleum products worldwide hunt for alternative energy sources is being done for the last three decades. Hence students should also have comparative brief idea about various conventional non-conventional energy sources, calorific values, carbon value and evaporative power of fuels and exploration of various alternative energy sources.

2. COMPETENCY

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

- **Apply principles of thermodynamics and energy conservation techniques in equipment such as IC engine, steam-boiler/turbine/condenser and air compressor.**

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. Apply thermodynamic processes to analyse the performance of engine.
b. Select relevant fuels to control emmissions from vehicles.
c. Interpret the working of the steam related equipment.
d. Interpet relevant parameters related to the performance air compressors..
e. Evaluate the use of renewable energy sources for a sustainable environment.
f. Assess the situation for energy conservation.

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.

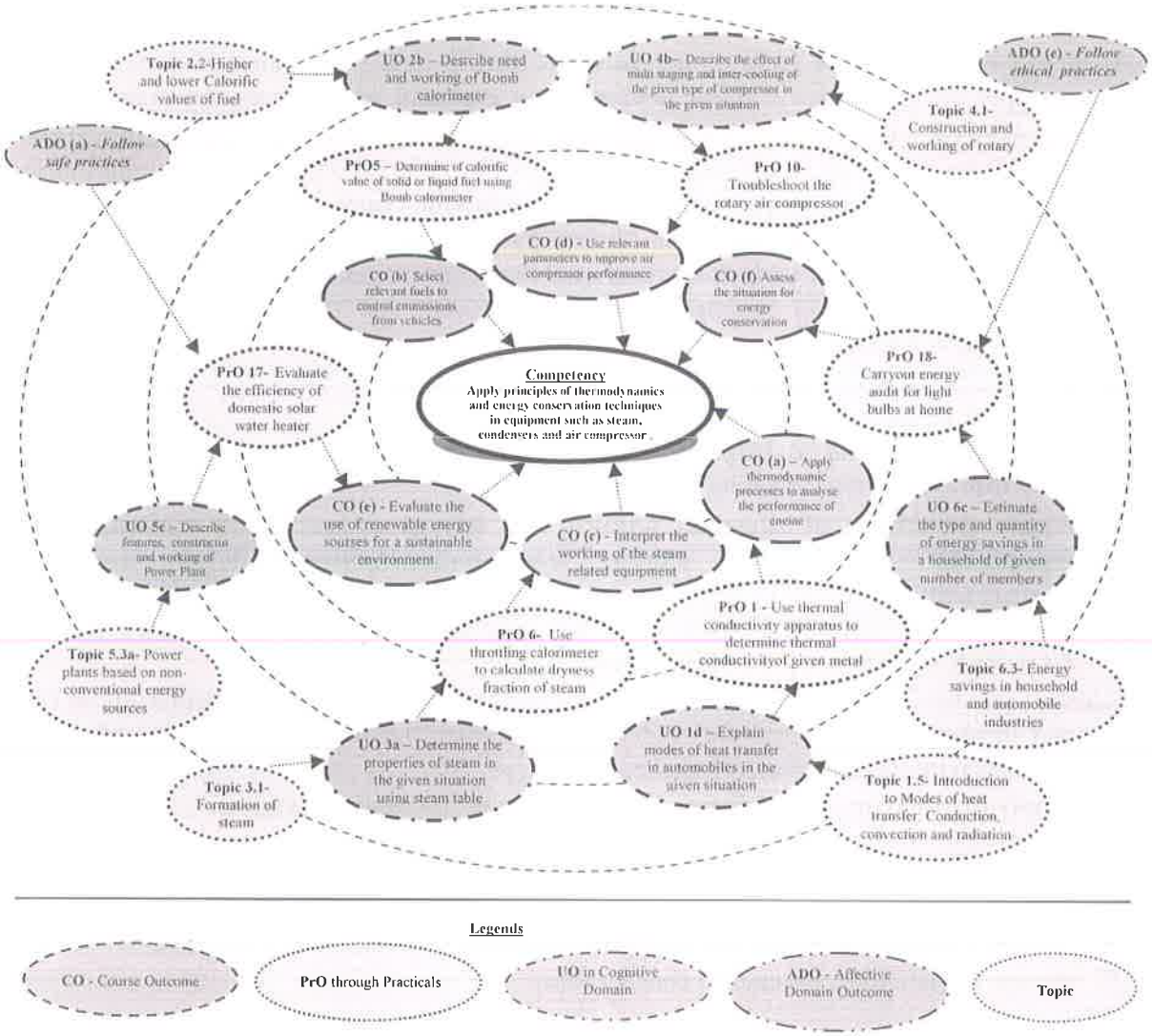

Figure 1 - Course Map

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.	Use thermal conductivity apparatus to determine thermal conductivity of the given metal rod.	I	02*
2.	Determine calorific value of solid or liquid fuel using Bomb	II	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	Calorimeter.		
3.	Make a comparative study of energy efficient turbines, boilers used in industries on the basis of energy effieiency, cost, life, energy saving and saving in energy bill.	III	02
4.	Use the boiler model to trace the flue gas path and water steam circuit.	III	02*
5.	Use throttling calorimeter to calculate dryness fraction of steam.	III	02
6.	Use separating calorimeter to calculate dryness fraction of steam.	III	02
7.	Use steam turbine to calculate its power output and efficiency.	III	02
8.	Use the given condenser to calculate condenser efficiency.	III	02
9.	Dismantle the reciprocating or rotary air compressor.	IV	02*
10.	Troubleshoot the reciprocating or rotary air compressor.	IV	02
11.	Assemble the reciprocating or rotary air compressor to make bill of material.	IV	02*
12.	Determine the volumetric efficiency of single reciprocating air compressor.	IV	02
13.	Determine the volumetric efficiency of two stage reciprocating air compressor.	IV	02
14.	Determine the isothermal efficiency of single stage reciprocating air compressor.	IV	02
15.	Determine the isothermal efficiency of two stage reciprocating air compressor.	IV	02
16.	Performance measurement of photovoltaic array making use of energy instruments.	V	02
17.	Evaluate the efficiency of domestic solar water heater.	V	02*
18.	Carryout energy audit for light bulbs at institute/ house/industry.	VI	02*
	Total		**35**

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	Air compressor test rig.	7 to 9
2	Domestic solar water heater: Either small 10-25 liters per day working model or commercial 100 liters per day model along with temp gauges fitted at various locations.	12
3	Bomb calorimeter: 300 ml capacity and as per the requirement of IP 12/63 T of institute of petroleum codes.	15
4	Thermal conductivity apparatus	1

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below 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 Thermodynamic systems and their applications.	1a. Apply relevant laws of thermodynamics in the given situation. 1b. Compare the processes of the ideal gas in the given situation. 1c. Interpret the processes of the given gas cycles. 1d. Explain modes of heat transfer in automobiles in	1.1 Thermodynamic systems, Classification of thermodynamic systems, Properties of system, State of system, thermodynamic process and cycles. 1.2 Laws of Thermodynamics- Zeroth Law, law of conservation of energy, First law of Thermodynamics, Second Law of Thermodynamics- Kelvin Planks, Clausius statements. 1.3 Represent Isobaric, Isochoric

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	the given situation.	Isothermal, Adiabatic and polytrophic processes on P-V and T-S diagram, formulae of work done, change in internal energy and change in enthalpy.(simple numericals on above processes) 1.4 Air cycles: P-V,T-S diagram and equations for air standard efficiency of Carnot, Otto, Diesel and Dual combustion cycle. 1.5 Introduction to Modes of heat transfer: Conduction, convection and radiation.
Unit –II Fuels and Combustion	2a. Describe minimum requirements of fuel for the given situation. 2b. Calculate different calorific values of fuels using the specified calorimeter. 2c. Describe the working of the Bomb calorimeter. 2d. Calculate minimum air required for complete combustion of fuel in the given situation. 2e. Estimate the contents of fuel using the given type of analysis.	2.1 Types of fuels – Definition, classification, properties, Calorific value of fuels.Ultimate analysis and proximate analysis of solid fuels. Liquid fuels- Comparative information about composition, specific gravity and gross calorific values of liquid fuel. Gaseous fuels- natural, LPG, CNG, and other artificially prepared gaseous fuels. 2.2 Higher and lower Calorific values of fuel and it's estimation, carbon value, evaporative power of fuel. Dulong's formula, construction and working of Bomb calorimeter. 2.3 Combustion of fuels – combustion chemistry of carbon, hydrogen and methane. Mass of air required for complete combustion of fuel, excess air.
Unit-III Steam and Steam Power	3a. Determine the properties of steam in the given situation using steam table. 3b. Identify specified components of the given chart/sketch of the given type of boiler 3c. Represent the steam path and the flue gases in the given situation using the relevant sketch. 3d. Calculate efficient use of heat energy stored in the steam into mechanical work for the given data. 3e. Describe the effect of air	3.1 Formation of steam at constant pressure with representation on various charts such as T-S, H-S. Properties of steam and use of steam table, Dryness fraction, Degree of superheat. 3.2 Steam Boilers: Classification, construction and working of Fire-tube and water-tube boiler. 3.3 Steam turbine: Classification of turbines, construction and working of Impulse and Reaction turbine. 3.4 Steam condenser: Function, locations in steam power plant, construction and working of two pass down flow Surface condenser, condenser efficiency and sources of air leakage in condenser.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	leakages in a condenser in a given situation. 3f. Prepare the report using the provisions of Indian boiler act with reference to duties of the given personnnel.	
Unit– IV Air compressors	4a. Compare given types of compressors based on the given parameters. 4b. Describe the effect of multi staging and inter-cooling of the given type of compressor in the given situation. 4c. Calculate the efficiencies and work done in the given situation and given data. 4d. Describe the applications of compressed air in the given type of automobile engines.	4.1 Classification of air compressor - Construction and working of single stage and two stage reciprocating air compressors with P-V. diagram. Necessity of multi-staging and inter cooling. Construction and working of rotary compressors i) Centrifugal compressor ii) Axial flow compressor iii) Screw compressor, Comparison of various compressors. 4.2 Overview of air compressor terminologies: i) Free air delivered, ii) Capacity of Compressor, iii) Piston displacement, iv) I. P., v) B. P., vi) Volumetric efficiency, vii) Isothermal efficiency, viii) Overall Isothermal or Compressor efficiency. Factors affecting volumetric Efficiency of reciprocating air compressors.
Unit – V Renewable Energy and environment	5a. Describe the strengths and limitations of the specified renewable energy in relation to human aspects of the environment. 5b. Describe the potential value of the specified renewable energy in India and the government policy for its harness . 5c. Estimate the efficiency of the specified solar energy system.	5.1 Strengths and limitations of solar energy, Wind power, biomass power, ocean energy and Geo-thermal energy in relation to human aspects of the environment. 5.2 Potential power of the above in India and government policy (MNRE) for harnessing of the above renewable energies 5.3 Solar energy: a. Power saved due to solar water heating, b. Power saved by solar lighting methods, c. Power saved due to concentrated solar power d. Power saved due to electricity generation through photovoltaic system.
Unit – VI Energy conservation and audit.	6a Identify the energy losses and wastage in given situation. 6b Suggest the energy conservation techniques in given sector.	6.1 Energy conservation: Definition, Importance of energy conservation, Impact on environment and economy. 6.2 Energy Audit: Energy flow diagram and its significance, Energy audit instruments and their use, Energy audit procedures.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	6c Estimate the type and quantity of energy savings in a household of given number of members. 6d Sketch energy flow diagram for given sector. 6e Suggest the suitable instrument for energy audit for given situation of plant.	6.3 Energy savings in household and automobile industries. 6.4 Energy conservation by cogeneration: Definition, need for cogeneration, classification on the basis of : sequence of energy use, technology 6.5 Factors governing the selection of cogeneration system, Advantages of cogeneration.

***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	Thermodynamic systems and their Applications.	14	02	06	06	14
II	Fuels and Combustion	10	02	04	04	10
III	Steam and Steam Power.	12	02	06	06	14
IV	Air compressors	12	02	06	04	12
V	Renewable Energy and Environment	08	02	06	04	12
VI	Energy Conservation and Energy Audit	08	---	04	04	08
Total		**64**	**10**	**32**	**28**	**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. Prepare journals based on practical performed in laboratory.
b. Follow the safety precautions.
c. Use various meters to test electric/electronic equipment and component.
d. Library / Internet survey of electrical circuits and network
e. Prepare power point presentation or animation for understanding different circuits behavior.

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.
f. Use Flash/Animations to explain various theorems in circuit analysis
g. 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. Visit to any industry where boiler is installed with reference to observations of locations of boiler, mountings like safety valve and pressure gauge and boiler accessories like a) economizer b) super-heater. Prepare report containing specifications of boiler, mountings and accessories with their sketches and functions, and also make scale model of any one.
b. Visit to cogeneration plant of sugar factory or any other thermal power plant with reference to observation of components, path of steam, minimum and maximum r.p.m., governing, bleeding and maintenance schedule of steam turbine. Prepare report containing specifications of turbine, path of the steam, maximum and minimum r.p.m., governing, bleeding and maintenance schedule of steam turbine from collected data of visit, and make model of any power plant.
c. Build a solar water heater.
d. Build a parabolic solar dish.
e. Build a parabolic solar trough.
f. Visit to solar power plant with reference to the observations of components and their specifications. Prepare a report containing specifications of collector, generation capacity, maintenance schedule and make working model based on solar energy e.g.: (Solar car, solar robot, solar battery charger, solar boat, solar toys, solar inverter etc.)
g. Visit a wind power plant to study the various features containing specification, materials, operating speed range, wind speed data, locking mechanism, protective

coatings and efficiency. Prepare a report containing specification, materials, operating speed range, wind speed data, locking mechanism, protective coatings and efficiency for a wind mill, and make working model of wind mill.

h. Collect information about global and indian energy market from the websites and prepare the reports.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	A text book of Thermal Engineering	Khurmi R.S., Gupta J.K.	S.Chand and Co., New Delhi, 2005 ISBN: 978-81-219-2573-0
2	Thermal Engineering	Kulshrestha S.K.	Vikas Publishing house Pvt.ltd, New Delhi, 2001, ISBN: 9780706977585
3	Wind Power Technology	Earnest, Joshua	PHI Learning, New Delhi, 2015
4	A Course in Thermal Engineering	Domkundwar S., Kothandaraman. C.P.; Domkundwar A.V.	Dhanpat Rai & co.(P) Ltd, New Delhi 2004. ISBN 13: 9788177000214
5	Thermodynamics An Engineering Approach	Cengel Yunus A. & Boles Michael A.	McGraw-Hill companies, Avenue of the Americas, New York, NY 10020. 2008 ISBN: 978-0-07-352932-5
6	Thermal Engineering	Sarkar B.K.	McGraw Hill Education pvt. Ltd, New Delhi, 2004; ISBN 13: 9780074633632
7	Thermal Engineering	Rajput R.K.	Laxmi Publications; New Delhi, 2017 ISBN-13: 978-8131808047

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://mnre.gov.in/schemes/grid-connected/solar-thermal-2/
b. http://mnre.gov.in/file-manager/grid-wind/guideline-wind.pdf
c. http://mnre.gov.in/schemes/grid-connected/solar/
d. http://mnre.gov.in/schemes/grid-connected/biomass-powercogen/
e. http://mnre.gov.in/schemes/grid-connected/biomass-gasification/
f. http://mnre.gov.in/schemes/grid-connected/biogas/
g. http://mnre.gov.in/schemes/new-technologies/biofuels/
h. http://mnre.gov.in/schemes/grid-connected/small-hydro/
i. http://mnre.gov.in/schemes/new-technologies/geothermal/
j. http://mnre.gov.in/schemes/new-technologies/tidal-energy/
k. http://mnre.gov.in/schemes/new-technologies/hydrogen-energy/
l. www.livescience.com/50776-thermodynamics.html
m. www.youtube.com/thermodynamic-laws
n. www.nptelvideos.in/2012/12/basic-thermodynamics.html
o. www.learnerstv.com/Free-Engineering-Video-lectures-ltv301-Page1.htm
p. www.teachertube.com/video/renewable-and-non-renewable-resources-342237
q. www.directindustry.com/industrial-manufacturer/steam-generator-132382.html