Government of Karnataka
Department of Technical Education
Board of Technical Examinations, Bangalore

<table>
<tr><td rowspan="3"></td><td colspan="3">Course Title: BASIC THERMAL ENGINEERING</td></tr>
<tr><td>Scheme (L:T:P) : 4:0:0</td><td>Total Contact Hours: 52</td><td>Course Code: 15ME42T</td></tr>
<tr><td>Type of Course: Lectures, Self Study & Quiz</td><td>Credit :04</td><td>Core/ Elective: Core</td></tr>
<tr><td colspan="2">CIE- 25 Marks</td><td colspan="2">SEE- 100 Marks</td></tr>
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Prerequisites: Knowledge of basic mathematics and Applied Science

Course Objectives:

1. It is a science of energy transfer and its effect on physical properties of substances. It is based upon observations of common experiences of energy (mainly heat) transfer.
2. This course will provide an understanding of the basic principles of thermodynamics which is must for understanding of major fields of mechanical engineering system

Course Outcomes:

On successful completion of the course, the students will be able to attain CO:

Course Outcome		CL	Linked PO	Teaching Hrs
CO1	Apply basic concepts, laws and principles of thermodynamics to use and select equipments/devices/machines working on these basics	***R/U/A***	1,2,3,4,6, 10	**10**
CO2	Outline various Thermodynamic process and analyze them with respect to various parameters	***R/U/A/An***	1,2,3,4,6, 10	**10**
CO3	Understand the Limitations, applications and Comparison of Thermodynamic cycles based on different parameters.	***R/U/A***	1,2,3,4,10	**11**
CO4	Analyze performance of ICEs by operating them and observing changes in thermodynamic properties during each stroke of ICEs (and by using thermodynamic diagrams.)	***R/U/A/An***	1,2,3,4,6, 10	**12**
CO5	Calculate heat transfer for given heat transfer system	***U/A***	1,2,3,4,10	**05**
CO6	Identify the elements of gas turbines and processes of Jet propulsion system	***R/U***	1,2,3,4,10	**04**
		Total sessions		**52**

Legend: R; Remember, U: Understand A: Application

COURSE-PO ATTAINMENT MATRIX

Course	Programme Outcomes									
	1	2	3	4	5	6	7	8	9	10
BASIC THERMAL ENGINEERING	**3**	**3**	**3**	**3**	**-**	**3**	**-**	**-**	**-**	**3**

Level 3- Highly Addressed, Level 2-Moderately Addressed, Level 1-Low Addressed.
Method is to relate the level of PO with the number of hours devoted to the COs which address the given PO.
If ≥40% of classroom sessions addressing a particular PO, it is considered that PO is addressed at Level 3
If 25 to 40% of classroom sessions addressing a particular PO, it is considered that PO is addressed at Level 2
If 5 to 25% of classroom sessions addressing a particular PO, it is considered that PO is addressed at Level 1
If < 5% of classroom sessions addressing a particular PO, it is considered that PO is considered not-addressed.

COURSE CONTENT AND BLUE PRINT OF MARKS FOR SEE

Unit No	Unit Name	Hour	Questions to be set for SEE/Marks			Marks weightage	weightage (%)
			R	U	A		
1	BASIC CONCEPTS AND LAWS OF THERMODYNAMICS	10	5	5	15	25	17
2	THERMODYNAMIC PROCESSES	10	5	5	20	30	21
3	THERMODYNAMIC CYCLES	11	5	5	20	30	21
4	IC ENGINES-PERFORMANCE OF I.C ENGINES	12	5	10	20	35	24
5	HEAT TRANSFER	05	-	5	10	15	10
6	GAS TURBINE AND JET PROPULSION SYSTEMS	04	5	5	-	10	07
	Total	52	25	35	85	145	100

Legend: R; Remember, U: Understand A: Application

UNITI: BASIC CONCEPTS AND LAWS OF THERMODYNAMICS 10 Hrs

Basic concepts-Definitions :system - boundary, surrounding, working fluid and state of a system.-thermodynamic systems – closed, open and isolated systems with examples-Properties of system- Intensive and Extensive properties with examples.-Definitions for properties like Enthalpy (H), Entropy(s) Internal energy (U)- Specific heat at constant pressure(C_p), specific heat at constant volume(C_v) for a gas-Relation between C_p &C_v , characteristic gas equation, Universal gas constant, Definitions for quasi-static work flow-Law of thermodynamics-Zeroth, first & second laws of thermodynamics- simple problems on conversion of Heat into Work and vice versa., Problems on gas equations-Steady flow energy equation (without proof)

UNTII: THERMODYNAMIC PROCESSES 10 Hrs

Thermodynamic processes,- Explain with P-V and T-S diagram the Constant pressure, Constant volume, Isothermal, Isentropic, Polytrophic, Free expansion and throttling processes & equations representing the processes- Derivation for work done for the above processes- Calculation of change in internal energy, heat supplied or rejected, change in Entropy for the above processes. Simple problems on the above processes .

UNITIII: THERMODYNAMIC CYCLES 11Hrs

Thermodynamic cycle – reversible and irreversible cycles conditions for reversibility of a cycle-Explanation of Carnot cycle with P.V. and T-S diagrams, Air standard Efficiency - Problems on Carnot cycle-Explanation of Otto cycle with P.V. and T-S diagrams, Air standard Efficiency - Simple problems on Otto cycle-Explanation of Diesel cycle with P.V. and T-S diagrams, Air standard Efficiency - Simple problems on Diesel cycle.-Explanation of Dual cycle with P.V. and T-S diagrams, Air standard Efficiency - Simple problems on dual cycle.

UNIT IV: IC ENGINES- PERFORMANCE OF I.C ENGINES 12Hrs

IC engine -definition-classification- Terminology of IC engine - Working principle of Two Stroke petrol & Diesel engine - Working principle of Four Stroke petrol & Diesel engine. Testing of IC engines-Rope brake Dynamometer-Formulae for Brake power, Indicated power Mechanical efficiency, Indicated thermal efficiency, Brake thermal efficiency, Air standard efficiency, Relative efficiency, Volumetric efficiency-Concept of Heat balance sheet for an engine-Simple problems on testing of I.C. engines and heat balance sheet

UNIT V:HEAT TRANSFER 05Hrs

Introduction -Methods of heat transfer-- Conduction, convection and radiation -Fourier's law of heat conduction-Newton law of cooling- Stefan-Boltzmann law -Heat transfer by conduction through slab and composite wall- Heat transfer by Radiation: -Thermal Radiation, Absorptivity, Transmissivity, Reflectivity, Emissivity, black and gray bodies, Radial heat transfer by conduction through thick cylinder-Simple problems on above (conduction only)

UNIT VI: GAS TURBINE AND JET PROPULSION SYSTEMS 04 Hrs

Gas turbines- classification of gas turbines-Closed cycle gas turbine-Schematic diagram-explanation-Open cycle gas turbine-schematic diagram-explanation-Comparison of open cycle and closed cycle gas turbines.-Jet propulsion-Ram–jet engine ,turbojet engines and Rocket engine- principle of working & application.

TEXT BOOKS AND REFERENCES

Sl.No.	Title of Books	Author	Publication
1.	Heat Engines	Pandya and Shah	Charotar Publishing House
2.	Thermodynamics and Heat power Engg.	Mathur and Mehta	Tata Mcgraw- Hill
3	A Text book of Thermal Engineering	R S Khurmi& J K Gupta	S Chand
4.	Thermal Engineering	P.L.Ballaney	Khanna.Publishers
5	Thermal Engineering	A. S. Sarao	SatyaPrakashan
6	Thermal Engineering	R K Rajput	Laxmi.Publications
7	Practical Thermodynamics	G D Rai	Khanna Publisher

LIST OF SOFTWARES/ LEARNING WEBSITES:

a. http://www.nptel.iitm.ac.in/video.php?subjectId=112105123 (IIT-B Video lectures)
b. http://www.thermofluids.net/
c. http://www.learnerstv.com/Free-Engineering-Video-lectures-ltv301-Page1.htm
d. http://www.grc.nasa.gov/WWW/k-12/airplane/thermo.html
e. http://www.youtube.com/watch?v=Xb05CaG7TsQ
f. http://www.youtube.com/watch?v=aAfBSJObd6Y
g. http://www.youtube.com/watch?v=DHUwFuHuCdw
h. http://www.youtube.com/watch?v=kJlmRT4E6R0
i. http://www.youtube.com/watch?v=GKqG6n6nAmg

SUGGESTED LIST OF STUDENT ACTIVITYS

Note: the following activities or similar activities for assessing CIE (IA) for 5 marks (Any one)

- Each student should do any one of the following type activity or similar activity related to the course and before take up, get it approved from concerned Teacher and HOD.
- Each student should conduct different activity and no repeating should occur

1	Identify and list real situations which works on: a: Zeroth law. b: First law of thermodynamics. c: Second law of thermodynamics.
2	Identify different Thermodynamic process in real situations.
3	Prepare charts of diesel, duel and gasoline cycles. Tabulate main points of differences between them.
4	Write the specifications of I.C.Engine of any two wheelers. Also Construct & explain cycle on which that I.C.Engine works.
5	*Arrange visit to any gas turbine power plant/Diesel engine power plant, study the operational features of Gas turbines/Diesel engines*

Course Delivery:

- The course will be delivered through lectures and Power point presentations/ Video

- **MODEL OF RUBRICS /CRITERIA FOR ASSESSING STUDENT ACTIVITY**

RUBRICS MODEL

RUBRICS FOR ACTIVITY(5 Marks)						
Dimension	**Unsatisfactory**	**Developing**	**Satisfactory**	**Good**	**Exemplary**	**Student Score**
	1	**2**	**3**	**4**	**5**	
Collection of data	Does not collect any information relating to the topic	Collects very limited information; some relate to the topic	Collect much information; but very limited relate to the topic	Collects some basic information; most refer to the topic	Collects a great deal of information; all refer to the topic	Ex: 4
Fulfill team's roles & duties	Does not perform any duties assigned to the team role	Performs very little duties but unreliable.	Performs very little duties	Performs nearly all duties	Performs all duties of assigned team roles	5
Shares work equally	Always relies on others to do the work	Rarely does the assigned work; often needs reminding	Usually does the assigned work; rarely needs reminding	Normally does the assigned work	Always does the assigned work without having to be reminded.	3
Listen to other Team mates	Is always talking; never allows anyone else to speak	Usually does most of the talking; rarely allows others to speak	Talks good; but never show interest in listening others	Listens, but sometimes talk too much	Listens and speaks a fair amount	2
Average / Total marks=(4+5+3+2)/4=14/4=3.5=4						

Note: This is only an example. Appropriate rubrics/criteria may be devised by the concerned faculty (Course Coordinator) for assessing the given activity.

Course Assessment and Evaluation Scheme:

	What		To whom	When/Where (Frequency in the course)	Max Marks	Evidence collected	Course outcomes
Direct Assessment	CIE	IA	Students	Three IA tests (Average of three tests will be computed)	20	Blue books	1,2,3,4,5,6
				Student activities	05	Activities sheets	
	SEE	End Exam		End of the course	100	Answer scripts at BTE	1,2,3,4,5,6
Indirect Assessment	Student Feedback on course		Students	Middle of the course		Feedback forms	1 & 2,3 Delivery of course
	End of Course Survey			End of the course		Questionnaires	1,2,3,4,5,6 Effectiveness of Delivery of instructions & Assessment Methods

Note: I.A. test shall be conducted for 20 marks. Average marks of three tests shall be rounded off to the next higher digit.

***Note to IA verifier**: The following documents to be verified by CIE verifier at the end of semester*

1. Blue books (20 marks)
2. Student suggested activities report for 5 marks
3. Student feedback on course regarding Effectiveness of Delivery of instructions & Assessment Methods.

FORMAT OF I A TEST QUESTION PAPER (CIE)

Test/Date and Time	Semester/year	Course/Course Code	Max Marks
Ex: I test/6 th weak of sem 10-11 Am	I/II SEM	**BASIC THERMAL ENGG.**	20
	Year:	Course code:15ME42T	

Name of Course coordinator : Units:__
CO's:_____

Question no	Question	MARKS	CL	CO	PO
1					
2					
3					
4					

Note: Internal choice may be given in each CO at the same cognitive level (CL).

MODEL QUESTION PAPER (CIE)

Test/Date and Time	Semester/year	Course/Course Code	Max Marks
Ex: I test/6 th weak of sem 10-11 Am	IVSEM	BASIC THERMAL ENGG.	20
	Year: 2016-17	Course code:15ME42T	

Name of Course coordinator : Units:1,2 Co: 1,2

Note: Answer all questions

Question no	Question	MARKS	CL	CO	PO
1	Differentiate between intensive and extensive properties of a system. Give three examples for each.	04	U	1	1,2, 3,6, 10
2	A volume of 0.5 m^3 of gas at a pressure of 10 bar and 200ºC is expanded in a cylinder to 1.2 m^3 at constant pressure. Determine the amount of work done by the gas and the increase in internal energy. Assume C_p = 1.005 kJ/kg K and C_v = 0.712 kJ/kg K. **OR** A closed system undergoes a change in process in which 5 kJ of heat energy is supplied to the system. Determine the change in internal energy under the following conditions. i) 1 kJ of work is done on the system. ii) 1.25 kJ of work is done by the system.	06	A	1	1,2, 3,4, 6,10
3	Derive an expression for work done during polytrophic process.	04	U	2	1,2, 3,4, 6,10
4	One kg of gas expands reversibly and adiabatically. Its temperature during the process falls from 515K to 390K, while the volume is doubled. The gas does 92 kJ of work in this process Calculate: The value C_p and C_v **OR** A gas has a molecular mass of 26.7. The gas is compressed through a ratio of 12 according to the law $PV^{1.25}$ = C, from initial conditions of 0.9 bar and 333 K. Assuming specific heat at constant volume C_v = 0.79 kJ/kg K. Calculate per kg of mass, work done and heat flow across the cylinder walls. Gas constant and ratio of specific heat.	06	A	2	1,2, 3,4, 6,10

MODEL QUESTION PAPER

IV- Semester Diploma Examination

Course Title: **BASIC THERMAL ENGINEERING**

Time: **3 Hours**] [Max Marks**: 100**

Note: Answer any **SIX from PartA** and any **SEVEN from Part B**

PART-A

6x5=30 marks

1. Define the terms: (i) system (ii) boundary and (iii) surroundings.
2. A closed system received a heat transfer of 120 kJ and delivers a work transfer of 150 kJ. Determine the change of internal energy.
3. Derive expression for work done in constant temperature process with PV diagram.
4. A volume of 0.5 m^3 of gas at a pressure of 10 bar and 200°C is expanded in a cylinder to 1.2 m^3 at constant pressure. Determine the amount of work done by the gas and the increase in internal energy. Assume C_p = 1.005 kJ/kg K and C_v = 0.712 kJ/kg K.
5. List the assumptions made in thermodynamic air standard cycle.
6 Define IC engine and give the classification of IC engines.
7. Explain following terms:
 a) Volumetric efficiency b) Mechanical efficiency
8. State and derive Fourier's law of heat conduction.
9. State the applications and limitations of gas turbine.

PART-B

1. a. Differentiate between intensive and extensive properties of a system. Give three examples for each. 04

   b. A cold storage is to be maintained at -5° while surroundings are at 35°C. The leakage from the surroundings into the cold storage is estimated to be 29 kW. The actual C.O.P. of the refrigeration plant is one - third of an ideal plant working between the same temperatures. Determine the power required to drive the plant. 06

2. a) Prove that C_p-C_v=R 04

   b) A piston - cylinder containing air expands at a constant pressure of 150 KPa from a temperature of 285 K to a temperature of 550 K. The mass of air is 0.05 kg. Determine the heat transfer, work transfer and change in internal energy during the process C_p = 1.01 kJ/kg K and C_v = 0.72 kJ/kg K. 06

3. a) List the thermodynamic processes on gases. 04

   b)A piston cylinder containing air expands at a constant pressure of 150 kpa from a temperature of 285 K to a temperature of 550 K. The mass of air is 0.05 kg. Determine the heat transfer, work transfer and the change in internal energy during the process. Take C_p = 1 kJ/kg K, R = 0.287 kJ/kg K. 06

4. a. Derive an expression for work done during polytrophic process. 04

b. A gas of mass 0.56 kg is expanded adiabatically from a pressure at 8 bar to 1 bar adiabatically. Initial temperature of the gas is 200°C. Determine the work done and change in internal energy. Take C_p = 1 kJ/kg K and C_v = 0.714 kJ/kg K. 06

5. Explain with the help of P-V and T-S diagrams working of Otto cycle and derive an expression for the air standard efficiency of it. 10

6. A certain quantity of air at a pressure of 1 bar and temperature 70°C is compressed reversibly and adiabatically until the pressure is 7 bar in an Otto cycle engine. 460 kJ of heat per kg of air is now added at constant volume.

Determine:

i)Compression ratio of the engine. ii)Temperature at the end of compression.

iii)Temperature at the end of heat addition.Take for air, C_p = 1 kJ/kg K and

C_v = 0.707 kJ/kg . 10

7. a) Compare petrol and diesel engines. 04

b) A heat engine has a piston diameter of 150 mm, length of stroke 400 mm and mean effective pressure 5.5 bar. The engine makes 120 explosions per minute. Determine the mechanical efficiency of the engine, if the engine BP is 5 kW. 06

8. The following data refers to a four stroke diesel engine, speed 300 rpm cylinder diameter 200 mm, stroke 300 mm, effective brake load 500 kg, circumference of the brake drum 400 mm, mean effective pressure 6 bar. Diesel oil consumption 0.1 litres/min, specific gravity of diesel 0.78, calorific value of oil = 43900 kJ/kg.

Determine : i) Brake power ii) Indicated power iii) Frictional power 10

9. a) Define : (i) Conduction (ii) Radiation. 03

b) Heat is conducted through a wall of room made of composite plate with a conduction of 134 W/mK and 60 W/mK and thickness 36 mm and 42 mm respectively. The temperature at the outer face is 96 0C and 8 0C. Determine the temperature at the interface of the two materials. 07

10. a) Explain closed cycle gas turbine with schematic diagram. 06

b) State the applications and limitations of gas turbine 04

MODEL QUESTION BANK

Diploma in Mechanical Engineering

IV Semester

Course title: MECHANICS OF MACHINES

BASIC THERMAL ENGINEERING

CO1:APPLY BASIC CONCEPTS, LAWS AND PRINCIPLES OF THERMODYNAMICS TO USE AND SELECT EQUIPMENTS/DEVICES/MACHINES WORKING ON THESE BASICS

REMEMBERING

1. Define the terms: (i) system (ii) boundary and (iii) surroundings.
2. Define the terms: i) Cycle (iv) Enthalpy (v) Entropy.
3. State the comparison between closed system and open system.
4. Define intensive and extensive property.
5. Define specific heat at constant pressure and specific heat at constant volume.
6. State the zeroth law and first law of thermodynamics.
7. State first law and second law of thermodynamics.
8. Define heat and work. Are these quantities a path function or point function? Explain.
9. Define the following :
    i) Quasi-static process
    ii) Internal energy
10. Define steady flow process & write steady flow energy equation with notations.

UNDERSTANDING

1. Explain open system with example.
2. Explain the closed system with example.
3. Differentiate between intensive and extensive properties of a system. Give three examples for each.
4. Derive the characteristic gas equation.
5. Establish that C_p-C_v=R.

APPLICATION

1. A closed system received a heat transfer of 120 kJ and delivers a work transfer of 150 kJ. Determine the change of internal energy.
2. During the compression stroke of an engine, the work done on the working substance in the engine cylinder is 80 kJ/kg and the heat rejected to the surrounding is 40 kJ/kg. Determine the change of internal energy.
3. A closed system undergoes a change in process in which 5 kJ of heat energy is supplied to the system. Determine the change in internal energy under the following conditions.
    a. i) 1 kJ of work is done on the system. ii)1.25 kJ of work is done by the system.

4. A piston - cylinder containing air expands at a constant pressure of 150 KPa from a temperature of 285 K to a temperature of 550 K. The mass of air is 0.05 kg. Determine the heat transfer, work transfer and change in internal energy during the process C_p = 1.01 kJ/kg K and C_v = 0.72 kJ/kg K.
5. A cold storage is to be maintained at -5° while surroundings are at 35°C. The leakage from the surroundings into the cold storage is estimated to be 29 kW. The actual C.O.P. of the refrigeration plant is one - third of an ideal plant working between the same temperatures. Determine the power required to drive the plant.
6. In a compressor, the air has an internal energy at beginning of the expansion is 200 kJ/kg and after expansion the internal energy becomes 510 kJ/kg. The work done by the air during expansion is 150 kJ/kg. Determine the heat flow.
7. Determine the coefficient of performance and heat transfer rate in a condenser of a refrigerator in kJ/hr whose refrigeration capacity is 11000 kJ/hr if the power input is 1.5 kW.
8. The net work output of a cyclic process is 45 kN-m. If the heat input is 125 kJ, determine the efficiency of the cycle.
9. One litre of hydrogen at 0°C is suddenly compressed to one-half its volume. Determine the change in temperature of the gas if the ratio of two specific heats for hydrogen is 1.4.

CO2: OUTLINE VARIOUS THERMODYNAMIC PROCESS AND ANALYZE THEM WITH RESPECT TO VARIOUS PARAMETERS

REMEMBERING

1. List out the different thermodynamic processes on gases.
2. State characteristics of throttling process

UNDERSTANDING

1. Explain reversible and irreversible process.
2. Explain free expansion process with sketch.
3. Explain throttling process
4. Construct the PV and TS diagram for i) Constant pressure process ii) Constant volume process iii) Constant temperature process.
5. Derive expression for work done in constant temperature process with PV diagram.
6. Derive expression for work done in constant entropy (Isentropic) process with PV diagram.
7. Derive an expression for work done during polytrophic process.

APPLICATION

1. A quantity of gas occupies a space of $0.3m^3$ at a pressure of 2 bar and a temperature of 77ºC which is heated at a constant volume, until the pressure is 7 bar. Determine (i) Temperature at the end of the process (ii) mass of the gas (iii) change in internal energy and (iv) change in enthalpy during the process.
   Assume: C_p = 1.005 kJ/kg K, Cv = 0.714 kJ/kg K, R = 287 J/kg K.
2. A quantity of gas has a volume of 0.14 m^3, pressure 1.5 bar and temperature 100ºC. If the gas is compressed at a constant pressure, until its volume becomes 0.112 m^3, determine :
   a. i)Temperature at the end of the compression ii)Work done in compressing the gas
   b. iii) Decrease in internal energy iv)Heat given out by the gas.
3. If the values of C_p = 0.984 kJ/kg K and C_v = 0.728 kJ/kg K for an ideal gas. Determine the characteristic gas constant and ratio of specific heats for the gas. If one kg of this gas is heated at constant pressure from 25ºC to 200ºC. Estimate the heat added, ideal work done and change in internal energy. Also Determine the pressure and final volume if the initial volume was 2 m^3.
4. A volume of 0.5 m^3 of gas at a pressure of 10 bar and 200ºC is expanded in a cylinder to 1.2 m^3 at constant pressure. Determine the amount of work done by the gas and the increase in internal energy. Assume C_p = 1.005 kJ/kg K and C_v = 0.712 kJ/kg K.
5. A quantity of air has a volume of 0.4 m^3 at a pressure of 5 bar and a temperature of 80ºC. It is expanded in a cylinder at a constant temperature to a pressure of 1 bar. Determine the amount of work done by the air.
6. 0.1 m^3 of air at a pressure of 1.5 bar is expanded isothermally to 0.5 m^3 Determine the final pressure of the gas and heat supplied during the process.
7. 0.5 kg of gas is compressed isentropically in such a manner that the ratio of final pressure to initial pressure is 5.25. If the initial temperature is 100ºC Determine; (i) work done (ii) change in internal energy. Assume: γ= 1.4 and R = 287 J/kg K.
8. One kg of gas expands reversibly and adiabatically. Its temperature during the process falls from 515K to 390K, while the volume is doubled. The gas does 92 kJ of work in this process Calculate: The value C_p and C_v
9. A gas of 0.15 m^3 at NTP is expanded adiabatically in a cylinder to a volume of 0.3 m^3, Determine the pressure at the end of expansion and the work during expansion. Take C_p=1.4 KJ/Kg K
10. A certain quantity of air has a volume of 0.028 m^3 at a pressure of 1.25 bar and 25ºC. It is compressed to a volume of 0.0042 m^3 according to the law $PV^{1.3}$= C. Determine the final temperature and work done during compression. Also determine the reduction in pressure at a constant volume required to bring the air back to its original temperature.
11. A gas has a molecular mass of 26.7. The gas is compressed through a ratio of 12 according to the law $PV^{1.25}$ = C, from initial conditions of 0.9 bar and 333 K.

Assuming specific heat at constant volume C_V = 0.79 kJ/kg K. Determine per kg of mass, work done and heat flow across the cylinder walls. Gas constant and ratio of specific heat.

CO3: UNDERSTAND THE LIMITATIONS, APPLICATIONS AND COMPARISON OF THERMODYNAMIC CYCLES BASED ON DIFFERENT PARAMETERS.

REMEMBERING

1. Define: Air standard cycle, Reversible cycle.
2. List the assumptions made in thermodynamic air standard cycle.

UNDERSTANDING

1. Give the comparison between Otto, diesel and dual combustion cycles.
2. Derive efficiency of Carnot cycle with PV diagram.
3. Derive the efficiency of Otto cycle with PV diagram.
4. With the help of P-V and T-S diagrams, derive an expression for the air standard efficiency of a diesel cycle.
5. Derive an equation for the air standard efficiency of dual cycle.
6. Explain with the help of P-V and T-S diagrams working of Carnot cycle .
7. Explain with the help of P-V and T-S diagrams working of Otto cycle.
8. Explain with the help of P-V and T-S diagrams working of Diesel cycle.
9. Explain with the help of P-V and T-S diagrams working of Dual cycle .

APPLICATION

1. A Carnot engine working between 655 K and 320 K, produces 150 kJ of work. Determine thermal efficiency and heat added during the process.
2. A Carnot engine operates with a thermal efficiency of 70%. The minimum temperature of the cycle is 30ºC. Determine the maximum temperature of the cycle.
3. An engineer claims his engine to develop 3.75 kW. On testing, the engine consumes 0.44 kg of fuel per hour having a calorific value of 42000 kJ/kg. The maximum temperature recorded in the cycle is 1400ºC and minimum is 350ºC. Determine whether the engineer is justified in his claim.
4. A Carnot cycle receives heat at 900ºC and rejects at 50ºC. Determine the efficiency of the cycle. If the cycle receives 4600 kJ of heat per minute, Determine the power developed by the engine.
5. A Carnot cycle works with isentropic compression ratio of 5 and isothermal expansion ratio of 2. The volume of air at the beginning of the isothermal expansion is 0.3 m^3. If the maximum temperature and pressure is limited to 550 K and 21 bar. Determine; Minimum temperature in the cycle, Thermal efficiency of the cycle. Pressure at all salient points. Take ratio of specific heats as 1.4

6. In an Otto cycle, the beginning and end temperatures of a isentropic compression are 316 K and 596 K respectively. Determine the air standard efficiency and the compression ratio. Take γ= 1.4.

7. A certain quantity of air at a pressure of 1 bar and temperature 70ºC is compressed reversibly and adiabatically until the pressure is 7 bar in an Otto cycle engine. 460 kJ of heat per kg of air is now added at constant volume. Determine: Compression ratio of the engine. Temperature at the end of compression. Temperature at the end of heat addition. Take for air, C_p = 1 kJ/kg K and C_v = 0.707 kJ/kg K.

8. An Otto cycle has a cylinder diameter of 150 mm and a stroke of 225 mm. The clearance volume is $1.25X10^{-3}$ m^3. Calculate the air standard efficiency of the cycle. Take γ= 1.4.

9. In an air standard Otto cycle, the compression ratio is 6.5 and the compression begins at 1 bar and 313 K. The heat added is 2520 kJ/kg. Determine: The maximum temperature and pressure of the cycle. Work done per kg of air. Cycle efficiency. Take for air C_v = 0.713 kJ/kg K, R = 287 J/kg K = 0.287 kJ/kg K.

10. In an Otto cycle, air at 1 bar and 290 K is compressed isentropically until the pressure is 15 bar. The heat is added at constant volume until the pressure rises to 40 bar. Determine the air standard efficiency and work done during the cycle. Take C_v = 0.717 kJ/kg K and R_u = 8.314 kJ/kg mol K.

11. A diesel engine with a compression ratio is 13:1 and fuel cut off ratio is at 8% of the stroke. Determine the air standard efficiency of an engine. Take, for air γ= 1.4.

12. A diesel cycle operating with the temperatures at the beginning and end of compression are 57ºC and 603ºC respectively. The temperatures at the beginning and end of expansion are 1950ºC and 870ºC respectively. Determine the ideal efficiency of the cycle. Take γ = 1.4. If the compression ratio is 14 and the pressure at the beginning of compression is 1 bar. Determine the maximum pressure of the cycle.

13. An ideal diesel engine has a diameter 150 mm and stroke 200 mm. The clearance volume is 10 percent of the swept volume. Determine the compression ratio and the air standard efficiency of the engine if the cut-off takes place at 6 percent of the stroke.

14. A diesel engine has a compression ratio of 15. Heat addition at constant pressure takes place at 10% of the stroke. Determine the air standard efficiency of the engine. Take γ = 1.4 for air.

15. The compression ratio of an ideal air standard diesel cycle is 15. The heat transfer is 1465 kJ/kg of air. Determine the pressure and temperature at the end of each process and determine the cycle efficiency, if the inlet conditions are 300 K and 1 bar. Take γ= 1.4 and C_v = 0.712 kJ/kg K, C_p = 1 kJ/kg K for air.

16. An engine working on dual combustion cycle, has a compression ratio 10 and cut off takes place at of the stroke. If the pressure at the beginning of compression is 1 bar and maximum pressure 40 bar, determine the air standard efficiency of the cycle. Take γ= 1.4.

17. An engine working on dual combustion cycle with cylinder diameter of 30 cm and a stroke of 42 cm. The clearance volume is 1800 cm^3 and cut off takes place at 6% of the stroke. The explosion pressure ratio is 1.4. Determine the air standard efficiency of the engine. Assume γ= 1.4 for air.

CO4: ANALYZE PERFORMANCE OF ICES BY OPERATING THEM AND OBSERVING CHANGES IN THERMODYNAMIC PROPERTIES DURING EACH STROKE OF ICES (AND BY USING THERMODYNAMIC DIAGRAMS.)

REMEMBERING

1. Define IC engine and give the classification of IC engines.
2. Define the following terms i) cylinder bore ii) swept volume iii) compression ratio.
3. Define brake power, indicated power, mechanical efficiency.
4. Define: Indicated thermal efficiency, Brake mean effective pressure, Brake thermal efficiency.
5. Define : Air standard efficiency, Volumetric efficiency, Relative efficiency

UNDERSTANDING

1. Explain with diagram internal combustion engine indicating the component parts.
2. Explain with neat diagram the working of two stroke petrol engine.
3. Explain with neat diagram the working of four stroke petrol engine.
4. Explain with neat diagram the working of two stroke Diesel engine.
5. Explain with neat diagram the working of four stroke diesel engine.
6. Explain with diagram Rope brake dynamometer
7. Explain the concept of heat balance sheet.

APPLICATION

1. A heat engine has a piston diameter of 150 mm, length of stroke 400 mm and mean effective pressure 5.5 bar. The engine makes 120 explosions per minute. Determine the mechanical efficiency of the engine, if the engine BP is 5 kW.
2. A diesel engine uses 6.5 kg of oil per hour of calorific value 30000 kJ/kg. If the BP of the engine is 22 kW and mechanical efficiency 85%. Determine : 1) Indicated thermal efficiency, 2) Brake thermal efficiency 3) Specific fuel consumption in kg/BP/hr.
3. During the test on single cylinder diesel engine, working on the four stroke cycle and fitted with a rope brake, the following readings are taken:
   Effective diameter of brake wheel = 360 mm; Dead load on brake = 200 N; Spring balance reading = 30 N; Speed = 450 rpm; Area of indicator diagram = 420 m^2; Length of indicator diagram = 60 mm; Spring scale = 1.1 bar per mm; Diameter of cylinder = 100 mm; Stroke = 150 mm; Quality of oil used = 0.815 kg/hr; Calorific value of oil = 42000 kJ/kg.Determine brake power, indicated power, mechanical efficiency, brake thermal efficiency and brake specific fuel consumption.

4. A test is carried out on a single cylinder four stroke petrol engine gave the following results :

   Cylinder diameter = 0.3 m; piston movement = 0.52 m; clearance volume = 0.0092 m3; explosions per minute = 110, indicated mean effective pressure = 7 bar; mass of the fuel = 28 kg/hr; calorific value of fuel = 19228 kJ/kg and take γ = 1.4 for air. Determine :i) Indicated thermal efficiency ii) Air standard efficiency iii) Relative efficiency.

5. The following observations were made during a test on a single cylinder 4 stroke cycle diesel engine.

Speed	-	150 rpm
Circumference of brake drum	-	920 rpm
Load on brake drum	-	150 mm
Spring balance reading	-	25 N
Area of indicated diagram	-	950 mm2
Length of indicated diagram	-	60 mm
Spring constant	-	0.035 N/mm2/mm
Cylinder diameter	-	80 mm
Length of stroke	-	110 mm
C.V. of fuel	-	45430 kJ/kg
Fuel consumed	-	0.85 kg/hr

6. Determine : i) Mechanical efficiency ii) Indicated thermal efficiency iii) BMEP

7. A four stroke diesel engine has a cylinder bore of 150 mm and a stroke of 250 mm. The crank shaft speed is 300 rpm and fuel consumption is 1.2 kg/hr, having a calorific value of 39900 kJ/kg. The indicated mean effective pressure is 5.5 bar. If the compression ratio is 15 and cut off ratio is 1.8. Determine the relative efficiency. Assuming = 1.4 for the air.

8. A four stroke four cylinder petrol engine gave the following details:

   i. Stroke = 95 mm; Bore = 65 mm; Speed = 3000 rpm; Clearance volume = 65 cm3; Relative efficiency on brake thermal efficiency is 45%; CV of petrol is 46300 kJ/kg. Torque developed is 70 N-m. Determine i) Specific fuel consumption, ii) Brake power, iii) BMEP. Take = 1.4 and = 80%.

9. A petrol engine consumes 0.28 kg of fuel per BP-hr, calorific value of fuel is 44000 kJ/kg, mechanical efficiency is 80% and compression ratio is 5.8. Determine (a) Brake

thermal efficiency, (b) Indicated thermal efficiency, (c) air standard efficiency, (d) Relative efficiency, take = 1.4 for air.

10. An I.C. engine uses 6 kg of fuel having calorific value 44000 kJ/kg in one hour. The I.P developed is 18 kW. The temperature of 11.5 kg of cooling water was found to rise through 25 ^{0}C per minute. The temperature of 4.2 kg of exhaust gas with specific heat 1 kJ/kgK was found to rise through 220 ^{0}C. Construct heat balance sheet for the engine.

8. A gas engine working on four stroke constant volume cycle, gave the following results when loaded by friction brake during a test of an hour's duration :

   Cylinder diameter 240 mm; Stroke length 480 mm; Clearance volume 445010--6 m3; Effective circumference of the brake wheel 3.86 m; Net load on brake 1260 N at overall speed of 226.7 rpm; Average explosions/min 77; mep of indicator card 7.5 bar; Gas used 13 m3/hr at 15 0C and 771 mm of Hg; Lower calorific value of gas 49350 kJ/m3 at NTP; Cooling jacket water 660 kg raised to 34.2 0C; Heat lost to exhaust gases 8%. Determine: i) IP ii) PB, iii) Indicated thermal efficiency iv) Efficiency ratio. Also Construct a heat balance sheet for the engine.

9. 31. A test on a single cylinder 4 stroke oil engine having bore 18 cm and stroke 36 cm yielded the following results : Brake torque 0.44 kN-m, MEP 7.2 bar, fuel consumption 3.5 kg/min, cooling water flow 4.5 kg/min, water temperature rise 36^{0}C, A/F ratio 25, exhaust gas temperature 415^{0}C, Room temperature 21^{0}C, Specific heat of exhaust gases 1.05 kJ/kgK, calorific value 45200 kJ/kg, speed = 286 rpm. Construct up a heat balance sheet on kJ/min basis.

CO5: CALCULATE HEAT TRANSFER FOR GIVEN HEAT TRANSFER SYSTEM

UNDERSTANDING

1. Derive an expression for heat transfer through a slab.
2. Derive an expression heat transfer through a composite wall.
3. Derive an expression for the quantity of heat flow through boiler tubes.
4. Explain with line diagram thermal conductivity and thermal resistance of a material.
5. Explain with line diagram radial heat transfer by conduction through thick cylinder.

APPLICATION

6. A boiler is made of iron plates 12 mm thick, if the temperature of the outside surface be 120 ^{0C} and that of the inner is 100 ^{0C}, Determine (i) heat transfer per hr and (ii) mass of water evaporated per hour. Assume that the area of heating surface is 5 m2. Take K for iron as 84 W/mK and latent heat of water at 100 ^{0C} is hfg = 2260 kJ/kg.
7. Heat is conducted through a wall of room made of composite plate with a conduction of 134 W/mK and 60 W/mK and thickness 36 mm and 42 mm respectively. The temperature at the outer face is 96 ^{0C} and 8 ^{0C}. Determine the temperature at the interface of the two materials.

8. A furnace wall is made up of bricks of 200 mm thick. The inner and outer surfaces of the wall have temperature of 800 ^{0C} and 200 ^{0C}. Determine the heat loss. If the outside temperature becomes 25 ^{0C}, after the furnace wall is covered with insulator of 100 mm thick, Determine the reduction in heat loss.
   a. Take Kbrick = 4.5 W/mK, Kinsulator = 0.5 W/mK.

9. Glass windows of a room have a total area of 10 m2 and the glass is 4 mm thick. Determine the quantity of heat that escapes from the room by conduction per second when the inside surfaces of windows are at 25 ^{0} and the outside surfaces at 10^0 The value of K is 0.84 W/mK.

10. The walls of a room having the parallel layers in contact of cement, brick and wood of thickness 20 mm, 300 mm and 10 mm respectively. Determine the quantity of heat that passes through each m2 of wall per minute. If the temperature of air in contact with the wall is 5 ^{0C} and 30^0 C inside. The values of K for cement, brick and wood are 0.294, 0.252 and 0.168 W/mK respectively.

11. Determine the rate of heat flow per square metre through the furnace wall made of 3 cm thick iron metal and covered with an insulating material of 0.4 cm thick. Take K iron = 51 W/mK and K insulator = 0.15 W/mK. The temperatures of the outside and inside surfaces of the wall are 400 ^{0} and 64 ^{0}C respectively.

CO6: IDENTIFY THE ELEMENTS OF GAS TURBINES AND PROCESSES OF JET PROPULSION SYSTEM

REMEMBERING

1. List the classification of gas turbine.
2. State the applications and limitations of gas turbine.
3. State the application of gas turbine and fuel used in gas turbine.
4. Identify the difference between the closed cycle gas turbine and a open cycle gas turbine.

UNDERSTANDING

1. Explain closed cycle gas turbine with schematic diagram.
2. Explain open cycle gas turbine with schematic diagram.
3. Explain with neat diagram closed cycle gas turbine with intercooling and reheating
4. Explain with neat diagram the turbo-jet engine.
5. Explain with neat diagram the working of Ram-jet engine.
6. Explain the working principle of rocket engine with line diagram.