# ENGINEERING THERMODYNAMICS ( SEMESTER - 4 )

## CS/B.Tech (ME/PWE)/SEM-4/ME-402/09

1. ..... *Signature of Invigilator*

2. ..... *Signature of the Officer-in-Charge*

***Reg. No.*** | | | | | | | | | | | | | | |

***Roll No. of the Candidate*** | | | | | | | | | | | | | | |

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**CS/B.Tech (ME/PWE)/SEM-4/ME-402/09**

**ENGINEERING & MANAGEMENT EXAMINATIONS, JUNE – 2009**

**ENGINEERING THERMODYNAMICS ( SEMESTER - 4 )**

Time : 3 Hours ] [ Full Marks : 70

***INSTRUCTIONS TO THE CANDIDATES :***

1. This Booklet is a Question-cum-Answer Booklet. The Booklet consists of **32 pages**. The questions of this concerned subject commence from Page No. 3.
2. a) In **Group – A**, Questions are of Multiple Choice type. You have to write the correct choice in the box provided **against each question**.
   b) For **Groups – B** & **C** you have to answer the questions in the space provided marked 'Answer Sheet'. Questions of **Group – B** are Short answer type. Questions of **Group – C** are Long answer type. Write on both sides of the paper.
3. **Fill in your Roll No. in the box** provided as in your Admit Card before answering the questions.
4. Read the instructions given inside carefully before answering.
5. You should not forget to write the corresponding question numbers while answering.
6. Do not write your name or put any special mark in the booklet that may disclose your identity, which will render you liable to disqualification. Any candidate found copying will be subject to Disciplinary Action under the relevant rules.
7. **Use of Mobile Phone and Programmable Calculator is totally prohibited in the examination hall.**
8. You should return the booklet to the invigilator at the end of the examination and should not take any page of this booklet with you outside the examination hall, **which will lead to disqualification**.
9. Rough work, if necessary is to be done in this booklet only and cross it through.

**No additional sheets are to be used and no loose paper will be provided**

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**FOR OFFICE USE / EVALUATION ONLY**

Marks Obtained

| | Group – A | | | | | | | | | | Group – B | | | Group – C | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Question Number*** | | | | | | | | | | | | | | | | | ***Total Marks*** | ***Examiner's Signature*** |
| ***Marks Obtained*** | | | | | | | | | | | | | | | | | | |

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**Head-Examiner/Co-Ordinator/Scrutineer**

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**ENGINEERING & MANAGEMENT EXAMINATIONS, JUNE – 2009**

# ENGINEERING THERMODYNAMICS

## SEMESTER - 4

Time : 3 Hours ] [ Full Marks : 70

### GROUP – A

**( Multiple Choice Type Questions )**

1. Choose the correct alternatives for any *ten* of the following : 10 × 1 = 10

i) The constant pressure gas turbine works on

a) Rankine cycle b) Carnot cycle

c) Brayton cycle d) any of these. ☐

ii) At 100% relative humidity

a) dew point temperature equals wet bulb temperature

b) saturation and dew point temperatures become equal

c) dry bulb temperature equals wet bulb temperature

d) all of these. ☐

iii) Air standard efficiency of a diesel cycle is dependent upon

a) ratio of specific heats b) adiabatic compression ratio

c) cut off ratio d) all of these. ☐



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iv) Bomb calorimeter is used to determine calorific value of

a) Solid fuels only b) Gaseous fuels

c) Liquid fuels only d) Solid as well as liquid fuels. ☐

v) The absorption refrigeration cycle employs which of the following devices for raising pressure of refrigerant ?

a) Compressor b) Pump

c) Generator d) Absorber. ☐

vi) With ideal regenerative heat exchanger, the thermal efficiency of gas turbine cycle is

a) equal to work ratio b) less than work ratio

c) more than work ratio d) unpredictable. ☐

vii) In multistage compressor, the isothermal compression is achieved by

a) constantly cooling the cylinder

b) employing intercooler

c) insulating the cylinder

d) running compressor at very slow speed. ☐

viii) The effective way of increasing the efficiency of a Carnot engine is to

a) increase the upper temperature

b) decrease the upper temperature

c) increase the lower temperature

d) decrease the lower temperature. ☐



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ix) Triple point of a pure substance is a point at which

a) liquid and vapour exist together

b) solid and vapour exist together

c) solid and liquid exist together

d) all states exist together. ☐

x) Optimum pressure ratio for maximum work output of air standard Brayton cycle is

a) $\left(T_{max}/T_{min}\right)^{\gamma/2(\gamma-1)}$ b) $\left(T_{max}/T_{min}\right)^{\gamma/(\gamma-1)}$

c) $\sqrt{\left(T_{max}/T_{min}\right)}$ d) $\left(T_{max}/T_{min}\right)$ . ☐

xi) A heat engine is supplied heat at the rate of 30000 J/s and gives an output of 9 kW. The thermal efficiency of the engine will be

a) 30% b) 33%

c) 40% d) None of these. ☐

xii) One tonne of refrigeration is equal to

a) 21 kJ/min b) 210 kJ/min

c) 420 kJ/min d) 42 kJ/min. ☐

## GROUP – B

### ( Short Answer Type Questions )

Answer any *three* of the following. 3 × 5 = 15

2. a) What are pure substances ? 2

b) What is critical point ? State the critical pressure and temperature of water. 3

3. For the same maximum temperature and pressure which cycle is most efficient — Otto, diesel or Dual ? Explain with PV and TS diagrams. 5



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4. A diesel engine has a compression ratio of 14 and cut off takes place 6% of the stroke. Find the air standard efficiency. 5

5. What are the effects of regeneration on Brayton cycle efficiency ? Define the effectiveness of a regenerator. 5

6. With a neat sketch, describe the working principle of an "aqua-ammonia" vapour absorption refrigeration cycle and define how its COP can be calculated. 5

## GROUP – C

**( Long Answer Type Questions )**

Answer any *three* of the following. 3 × 15 = 45

7. a) Give limitations of Carnot vapour power cycle and explain how Rankine cycle helps in overcoming them.

   b) Discuss the advantages of binary vapour cycles over single vapour cycle.

   c) A reheat cycle operates between 80 bar and 0·075 bar. Temperture of steam entering turbine is 600°C and first stage of expansion is carried out till the steam becomes dry saturated. Subsequently steam is reheated up to intial temperatue at inlet. Neglecting pump work, determine efficiency and specific steam consumption in kg/kW-hr. 4 + 3 + 8

8. a) Explain the effect of (i) intercooling (ii) reheating on Brayton cycle.

   b) In a gas turbine plant working on the Brayton cycle with a regenerator of 75% effectiveness, the air at the inlet to the compressor is at 0·1 MPa, 30°C. The pressure ratio is 6 and the maximum cycle temperature is 900°C. If the turbine and compressor each have an efficiency of 80% find the % in the cycle efficiency due to regeneration.

   c) Discuss the merits and demerits of Brayton and Otto cycles applied to reciprocating and rotating plant. 4 + 8 + 3



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9. a) Define calorific value of fuel. Differentiate between higher and lower calorific values of fuel.

b) A hydrocarbon fuel with chemical formula $C_{10}H_{22}$ is burnt with an air-fuel ratio of 13 : 1 by mass. The carbon burns to $CO_2$ and CO and the whole amount of hydrogen burns to form water vapour. There is no evidence of any free $O_2$ or any free carbon in the exhaust. Determine the complete volumetric analysis of the products.

c) What is the heat of reaction ? When is it positive and when negative ? 4 + 8 + 3

10. a) Define FAD and volumetric efficiency.

b) Show that for reciprocating compressor working between pressures $p_1$ and $p_2$, $\eta_{vol} = 1 + CR\left\{1 - \left(p_2/p_1\right)^{1/n}\right\}$, where $CR$ = clearance ratio.

c) A single acting two-stage compressor with complete intercooling delivers 5 kg/min of air at 16 bar. Assuming intake state of 1 bar and 15°C and compression and expansion processes are reversible polytropic with $n$ = 1·2, calculate power required, isothermal efficiency and FAD. If the clearance ratio of low pressure and high pressure cylinders are 0·04 and 0·06 respectively, calculate swept volume and clearance volume for each cylinder. The speed is 400 rpm. 2 + 4 + 9

11. a) Explain the following terms : $4 \times 1\frac{1}{2} = 6$

i) Relative humidity

ii) Wet bulb temperature

iii) Enthalpy of combustion

iv) Adiabatic flame temperature.

b) A vapour compression refrigeration cycle uses $R$-12 and operates between pressure limits 0·745 MPa and 0·15 MPa. The vapour enters the compressor at 10°C and the liquid leaves the condenser at 28°C.

Find :

i) Refrigerant flow rate in kg/s

ii) The COP

iii) Swept volume of the compressor having 76% volumetric efficiency at 600 rpm. 9



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12. a) An engine working on the Otto cycle has an air-standard cycle efficiency of 56% and rejects 544kJ/kg of air. The pressure and temperature of air at the beginning of compression are 0·1. MPa and 60°C respectively.

Compute

i) The work done per kg of air

ii) The maximum pressure and temperature of the cycle

iii) The mean effective pressure.

b) A binary vapour cycle operates on the mercury and steam. Saturated mercury vapour at 4·5 bar is supplied to the mercury turbine from which it exhausts at 0·04 bar. The mercury condenser generates saturated steam at 15 bar which is expanded to 0·04 bar.

i) Find the overall efficiency of the cycle.

ii) If 50,000 kg/h of steam flows the steam turbine, what is the flow rate through mercury turbine ?

The properties of saturated mercury are given below :

| $P$ (bar) | $t$ (°C) | $h$ | hg (kJ/kg) | $S$ | Sg(kJ/kg) | $V_f$ (m$^3$/kg) | $V_g$ (m$^3$/kg) |
|---|---|---|---|---|---|---|---|
| 4·5 | 450 | 62·93 | 355·98 | 0·1352 | 0·5397 | 79·9 ∞10 | 0·068 |
| 0·04 | 216·9 | 29·98 | 329·85 | 0·0808 | 0·6925 | 76·5 ∞10 | 5·178 |

6 + 9

END



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