

MECHANICAL ENGINEERING (Paper II)

Time Allowed : Three Hours	Maximum Marks : 300
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QUESTION PAPER SPECIFIC INSTRUCTIONS

(Please read each of the following instructions carefully before attempting questions)

There are EIGHT questions divided in two Sections.

Candidate has to attempt FIVE questions in all.

Question Nos. 1 and 5 are compulsory and out of the remaining, any THREE are to be attempted choosing at least ONE question from each Section.

The number of marks carried by a question/part is indicated against it.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Word limit in questions, wherever specified, should be adhered to.

SECTION 'A'

1. Answer any three of the following parts (answer to each part should not exceed 200 words): **20×3=60**

(a) (i) What is the perpetual motion machine of the second kind [?] (ii) Why is a reversible adiabatic process one of constant entropy? (iii) Show that the irreversibility for an adiabatic steady state process is given by $I = m T_0 (S_2 - S_1)$

(b) Air at 100 KPa and 300° C is contained in a piston cylinder arrangement as shown in fig.(1):

[Figure: Fig. 1. Horizontal cylinder closed at the left end containing Air, with a piston held in position; arrow “Q = 0” pointing to the cylinder wall (insulated); arrow P acting on the right face of the piston towards the air; two pairs of stops on the cylinder walls to the right of the piston, the nearer pair marked A and the farther pair marked B]

The cylinder is perfectly insulated and piston is held in position, by stops at A. The outside pressure is atm. The stops A are suddenly removed and the air allowed to expand till the piston stops at stops B. The volume increases to 1.5 times the initial value. Assume that the friction between piston and cylinder is zero. Calculate the final pressure and temperature of air. State your assumptions clearly.

(c) Explain the process of heat exchange by radiation between two bodies. Define the various laws and terms used in estimation

(d) Describe the method of determining calorific value of a solid fuel using a Bomb calorimeter, the following results were recorded during evaluation of a coal sample: Mass of coal 1 gm; Mass of water in calorimeter 2500 gm; Water equivalent of apparatus 744 gm; Initial temperature of water 17.48° C; Maximum observed temperature of water 20.07° C; Specific heat of water 4.187 J/g°C. What are the calorific values of this fuel?

2. (a) Discuss with suitable graphs, how the efficiency of the Otto cycle varies with (i) compression ratio and (ii) ratio of specific heats of the working medium. **25**

(b) What is the percentage change in the efficiency of Otto cycle having a compression ratio 7, if the specific heat at constant volume increases by 1%? **35**

3. A two stroke engine subjected to full [?] load test gave the following results: cylinder dia 22 cm; stroke 27 cm; brake dia 1.5 m; speed 450 rev/min; brake load 4.6 kg; imep 2.9 kgf/cm^2 ; fuel consumption 5.4 kg/hr; rise in temperature of jacket water 36°C; jacket water flow 440 kg/hr; air/fuel ratio by mass 31; temperature of exhaust gas 355° C; room temperature 20°C; atmospheric pressure 76 cm Hg; calorific value of fuel 10500 kcal/kg; proportion of hydrogen by mass in fuel 15. Take $R = 29.27$ for air, $C_p = 0.24$ for exhaust gas, $C_p = 0.49 \text{ kcal/kg K}$ for the [?] steam. Determine (i) the indicated thermal efficiency (ii)

the specific fuel consumption in gm/BHP hr (iii) the volumetric efficiency. Draw up the heat balance on percentage basis. **60**

4. (a) Define the terms (i) over all heat transfer coefficient (ii) log mean temperature difference (iii) effectiveness of heat exchangers **15**
- (b) A counter flow double pipe heat exchanger is used to heat water using oil as the heating fluid. The heat exchanger area is 16 sq.m and it is observed that water inlet and outlet temperatures are 35°C and 75°C while the corresponding oil temperatures are 110°C and 75°C. If water flows at the rate of 68 kg/min calculate the overall heat transfer coefficient for the heat exchanger. Take specific heat of oil as 1.9 kJ/kg°C. **20**
- (c) Estimate the exit water temperature for the above heat exchanger if the water flow rate is reduced to 40 kg/min with oil continuing to flow at the earlier rate. Assume the effectiveness of the heat exchanger under these conditions to be 0.74. **25**

SECTION 'B'

5. Answer any three parts out of the following four parts. Answer to each part should not exceed 200 words:
- (a) Discuss the desirable thermodynamic properties of a working fluid for a power plant operating on Rankine cycle. **20**
- (b) Discuss the influence of modification used in Rankine cycle on the operational performance of power plants. **20**
- (c) What do you understand by the term “binary vapour cycle”? Discuss its advantages and limitations. **20**
- (d) State the factors considered in selection of a refrigerant and compare the two commonly used refrigerants viz, ammonia and freon. **20**
6. An ammonia ice plant operates between a condenser temperature of 35°C and evaporator temperature of -15°C. It produces 10 tons of ice per day from water at 30°C to ice at -5°C. Assuming simple saturation cycle, determine (i) the capacity of the refrigerating plant (ii) the mass flow rate of refrigerant (iii) the discharge temperature (iv) the compressor cylinder diameter and stroke (v) the power of compressor motor and (vi) the theoretical and actual COP. Take volumetric efficiency of compressor = 0.65; speed of compressor = 1200 rpm; Stroke/ Bore ratio of compressor = 1.2; adiabatic efficiency of compressor = 0.85; mechanical efficiency of compressor = 0.95. Use the properties of Ammonia as given below:

Saturation temp. t (°C)	Saturation pressure p (bar)	Saturated liquid & vapour v_f (m/kg)	v_g (m/kg)	h_f (kJ/kg)	h_g (kJ/kg)	s_f (kJ/kgK)	s_g (kJ/kgK)	Vapour superheated 50° C: h (kJ/kgK)	50° C: s (kJ/kgK)	100° C: h (kJ/kgK)	100° C: s (kJ/kgK)
-15	2.36	1.52	0.509	112.3	1426	0.457	5.549	1543	5.963	1656	6.3
35	13.5	1.7	0.096	3417.5	1476	1.282	4.93	1616	5.368	1744	5.7

7. (a) Define “strength of shock wave” and explain its significance. **20**
- (b) Air available at standard atmospheric conditions flows through a heated constant area pipe. If the flow is decelerated from Mach number 1.5 to Mach number 1.0 determine (i) the change in temperature (ii) the heat addition to air **40**
8. A simple gas turbine with heat exchanger has a compressor and a turbine having respective isentropic efficiencies η_c and η_t . Show that the combined effect of small pressure drops ΔP_{hg} in gas side heat exchanger and Δp in combustion chamber and air side of heat exchanger is to reduce the specific work output by an amount given by

$$\left(\frac{\gamma-1}{\gamma}\right) \frac{C_p T_3 \eta_t}{r_p^{\frac{\gamma-1}{\gamma}} p_1} \left[\Delta P_{hg} + \frac{\Delta p}{r_p} \right]$$

[?] where T_3 = turbine inlet temperature; P_1 = compressor inlet pressure; R_p = pressure ratio in compressor **60**
