

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 part (answer to each part should not exceed 200 words):
 - (a) Discuss the requirements of fuel for spark ignition (SI) engines. In the light of these compare ethanol and methanol as alternate fuels for automotive SI engines. 20
 - (b) Show that when a gas expands behind a piston according to the law $P V^n = \text{constant}$, the heat transfer, change in internal energy and work done are in the ratio $(\gamma - n)(n - 1) : (\gamma - 1) [?]$ and that the effective specific heat C for an expansion of this kind is $[?]$ times its specific heat at constant volume C_v . 20
 - (c) What are the major pollutants in evaporative emissions blow by emission and exhaust emission from an automobile? Describe a suitable method for controlling evaporative emissions. 20
 - (d) Compare thermal, hydel and nuclear power plants from the point of view of (i) initial cost, (ii) operation cost, (iii) maintenance cost and (iv) environmental impact. What are their site selection considerations? 20
2. (a) Knocking in SI engine is due to auto-ignition of End charge while knocking in CI engine is due to auto ignition of the 'First charge. In the light of this show in a tabular form the effect of various engine operating parameters on knocking is SI and CI engines. 25
 - (b) An eight cylinder petrol engine is to deliver 160 b.h.p. at a piston speed 750 m per minute with an indicated thermal efficiency of 23 per cent. The stroke to bore ratio is 1.25 the volumetric efficiency is 85 per cent (1.0 kg/cm^2 and 40°C intake condition) and mechanical efficiency is 83 per cent Assume petrol contains 10,200 kcal of heat kcal of heat of combustion per kg and requires 14 kg of air per kg for complete combustion. The engine uses a mixture having 10 percent excess air. Calculate the diameter of the cylinder and stroke, the brake specific fuel consumption and the brake mean effective pressure. 35
3. (a) Heat is supplied to a perfect gas which is flowing through a parallel passage. Show that if friction is negligible $p(1 + \gamma M^2)$ is constant along the passage. Hence show that

$$\frac{T_0^{1/2}(1 + \gamma M^2)}{M \left(1 + \frac{\gamma - 1}{2} M^2\right)^{1/2}}$$

is also constant. Assume that the gas velocity is uniform over any cross-section. 30

- (b) Sketch Rayleigh line on Pressure-Specific Volume diagram and on Enthalpy-Entropy diagram. Prove that for Rayleigh line conditions.

$$\frac{V_2}{V_1} = \frac{(1 + \gamma M_2^2)}{(1 + \gamma M_1^2)} \frac{M_1^2}{M_2^2}$$

[?]

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4. (a) Discuss compressor stall on the basis of blade angle of attack. 15
- (b) Discuss the relative merits of axial-flow and centrifugal-flow compressors. 15
- (c) An axial-flow compressor takes in $1000 \text{ m}^3/\text{min}$ of free air at 0.7 kg/cm^3 and 5°C . The blades are of aerofoil type, having chord area 19.25 cm^2 and blade length 6.75 cm . The blade ring mean diameter is 60 cm and rotational speed is 6000 rpm . There are 50 blades on each blade ring and the blades occupy 10% of the axial area of flow. Taking values of C_L and C_D as 0.6 and 0.05 respectively at zero angle of incidence and assuming isentropic compression and axial inlet, calculate (i) the pressure rise per blade ring and (ii) theoretical horsepower per stage. 30

SECTION 'B'

5. Answer any three parts out of the following four parts of this compulsory question. Each part of the question must be answered briefly to the point, in not more than 200 words.
- (a) What are the special features in the design of high pressure high duty boilers? Discuss the advantages and disadvantages of forced circulation boilers as compared to natural circulation boilers. 20
- (b) Explain dropwise condensation and film condensation. Why heat transfer rate is higher in dropwise condensation than in film condensation? 20
- (c) Discuss the essential differences in working principles of heat pump refrigerating machine and heat engine. Describe a summer air conditioning system with ventilation. 20
- (d) Show by methods of dimensions that the volume rate of flow of a gas through a sharp edged orifice is given by

$$Q = d^2 \sqrt{\frac{p}{\rho}} \phi \left(\frac{v}{d} \right) \sqrt{\frac{p}{\rho}}$$

[?] where d is the diameter of the orifice, p is the pressure difference between the two sides of the orifice, ρ and v are the density and kinematic viscosity of the gas respectively. 20

6. (a) Explain why freon refrigerants are being phased out. Name any proposed substitute refrigerant and give its relevant properties as compared to freon-12
- (b) A 15 ton Freon refrigeration plant has twin cylinder single acting compressor having bore 1.5 times stroke and operating at 960 rpm . The temperature of the refrigerant sub-cooled as liquid in the condenser is 248 K while the temperature of the refrigerant superheated as gas in the evaporator is 268 K . The condenser temperature is 303 K . Using the refrigerant properties tabulated below, determine. (i) Mass of refrigerant circulated per minute (ii) Theoretical kilo-watt power required to operate the plant (iii) the theoretical COP of the plant (iv) Heat removed in the condenser (v) The compressor bore and stroke. Assume average liquid specific heat as 0.963 kJ/kg K and average vapour specific heat as 0.615 kJ/kg K . 40

Saturation Temp. t_s , K	Absolute pressure P (bar)	Specific volume v_g (m^3/kg)	Enthalpy of liquid h_f (kJ/kg)	Enthalpy of vapour h_g (kJ/kg)	Entropy of liquid S_f (kJ/kgK)	Entropy of vapour S_g (kJ/kg K)
263	2.19	0.0767	26.9	183.2	0.1080	0.7020

303	7.45	0.0235	64.6	199.6	0.2399	0.6854
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7. (a) Explain the terms fin efficiency and fin effectiveness. Derive the expressions for these for the fin which is insulated at the end. Discuss the conditions when installation of fins on a heat transfer surface will not necessarily increase heat transfer rate. **25**
- (b) The cylinder of an engine is 1 m [?] long and has an outside diameter of 6 cm. The outside surface temperature of the cylinder is 200°C when the ambient temperature is 30°C. The film coefficient of heat transfer is $25 \text{ W/m}^2 \text{ K}$. The cylinder is provided with 12 longitudinal straight fins of 0.1 cm thickness and 3 cm length. The thermal conductivity of cylinder and fin material is 75W/mk. Assuming that the fins have insulated tips, determine. (i) percentage increase in heat dissipation due to addition of fins. (ii) the temperature at the centre of the fin and (iii) find efficiency and fin effectiveness. **35**
8. During the trial of coal fired boiler plant producing steam at 40 bar pressure and 350°C temperature, the steam produced per kg of coal fired was found to be 9.18 kg. The dry coal analysis gave 84% carbon, 4% hydrogen, 7% oxygen and 5% ash. Moisture in coal used was 1.5%, carbon in ash was nil. The calorific value of dry coal was 32700 kJ/kg. The volumetric analysis of dry flue gases gave 12.3% carbon dioxide, 7.7% oxygen and 80% nitrogen. The feed water temperature at entry to economiser was 27° C and that at exit 150°C. The temperatures of flue gas entering and leaving air pre-heater were 280°C and 160°C respectively while temperature of air leaving preheater was 110°C and at entry 15°C. Determine (i) boiler efficiency, (ii) efficiency of heat transmission in air heater. Draw up a heat balance for the complete boiler plant in kJ/kg of dry coal using a datum of 15°C. Take C_p for air and dry flue gas as 1.005 kJ/kg°C, partial pressure of steam vapour and its specific heat as 0.07 bar and 2.01 kJ/kg°C respectively. **60**

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