This question paper contains 7 printed pages]

Code No. : 16 (II) *Roll No. .....*

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MECHANICAL ENGINEERING

Paper : II

Time Allowed : 3 hours] *[Maximum Marks : 300*

Note : (i) *Answers must be written in* ***English.***

(ii) *Number of marks carried by each question are indicated at the end of the question.*

(iii) *Part/Parts of the same question must be answered together and should not be interposed between answers to other questions.*

(iv) ***The answer to each question or part thereof should begin on a fresh page.***

(v) ***Your answers should be precise and coherent.***

(vi) *Candidates should attempt Q. Nos.* **1** *and* **5** *which are compulsory and any* ***three*** *out of the remaining questions, selecting at least* ***one*** *question from each Section.*

P. T. O.

SECTION – A

1. Answer any *three* of the following :

(a) Derive the General Steady Flow Energy Equatio for a control volume and hence deduce its form a applicable to an adiabatic nozzle. 2

(b) Explain the Carnot Cycle with the help of T ~ and P ~ v diagrams. Discuss its signficance. Als derive an expression for the thermal efficiency c a Carnot heat engine. 2

(c) What is a black body ? Define total emissiv power and monochromatic emissive power of body, hence state and explain Stefan-Boltzman law of radiation. 2

(d) Explain different Turbulence models. Deriv Darcy-Weisbach equation for loss of head in pipe due to friction. 2

2. (a) What do you mean by thermal boundary layer How does the ratio of velocity boundary layer thermal boundary layer (δ/δ_t) vary with Prand number ?

(b) What is the physical significance of Grash number with reference to heat transfer by natu convection ? What is Rayleigh number ?

(c) A steel pipe of 100 mm bore and 7 mm wall thickness, carrying steam at 260°C, is insulated with 40 mm of a high temperature diatomaceous earth covering. This covering is in turn insulated with 60 mm of asbestos felt. If the atmospheric temperature is 15 °C, calculate the rate at which heat is lost by the steam per metre length of the pipe. The heat transfer coefficients for the inside and outside surfaces are 550 and 15 W/m^2 k, respectively and the thermal conductivities of steel, diatomaceous earth and asbestos felt are 50, 10.09 and 0.07 W/mk respectively. Calculate also the temperature of the outside surface. 30

3. (a) Explain the modes of condensation which can occur on a cooling surface. In which case the rate of heat transfer would be higher and why ? 15

(b) Describe the different types of heat exchanger, with the help of neat sketch. 15

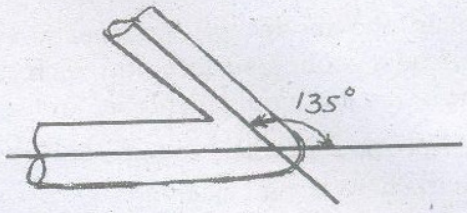
(c) Exhaust gases flowing through a tubular heat exchanger at the rate of 0.3 Kg/s are cooled from 400 to 120 °C by water initially at 10 °C. The specific heat capacities of exhaust gases and water may be taken as 1.13 and 4.19 kJ/Kg k respectively, and the overall heat transfer coefficient from gases to water is 140 W/m^2 k. Calculate the surface area required when the cooling water flow is 0.4 Kg/s.

(i) for parallel-flow,

(ii) for counter-flow. 30

4. (a) The space between two very long parallel plates separated by a distance 'h' is filled with fluid of constant viscosity 'μ'. The upper plate moves steadily at a velocity 'V' relative to the lower plate and pressure is constant everywhere. Establish equations which give velocity distribution between the plates and the shear stress variation in the fluid. 30

(b) Water is flowing at the rate of 250 litres/s in a pipe having a diameter of 30 cm. If the pipe is bent by 135°; find the magnitude and direction of resultant force on the bend. The pressure of water flowing in the pipe is 400 kPa. 30



SECTION – B

5. (a) Elaborate the methods to improve the thermal efficiency of simple ideal Rankine cycle. Use T ~ s diagrams in support of your answer. 30

(b) In a closed cycle gas turbine, there is two stage compressor and a two stage turbine. All the components are mounted on the same shaft. The pressure and temperature at the inlet of the first stage compressor are 1.5 bar and 20 °C. The maximum cycle temperature and pressure are

limited to 750 °C and 6 bar. A perfect intercooler is used between the two-stage compressors and a reheater is used between the two turbines. Gases are heated in the reheater to 750 °C before entering into the L.P. turbine. Assuming the compressor and turbine efficiencies as 0.82, calculate :

(i) the efficiency of the cycle without regenerator.

(ii) the efficiency of the cycle with a regenerator of effectiveness 0.70.

(iii) The mass of the fluid circulated, if the power developed by the plant is 350 kW.

The working fluid used in the cycle is air for air, $r = 1.4$ and $C_p = 1.005$ kJ/kg k. 30

6. (a) What do you understand by compounding of steam turbines ? Discuss various methods of compounding steam turbines with the help of neat sketch. 30

OR

Derive an expression for the blade height of an impulse turbine. How will you modify it for a reaction turbine ? 30

(b) A group of convergent-divergent nozzles are supplied with steam at a pressure of 2 MN/m^2 and a temperature of 325 °C. Supersaturated expansion according to the law $PV^{1.3}$ = constant,

occurs in the nozzle down to an exit pressure of 0.36 MN/m^2. Steam is supplied at the rate of 7.5 kg/s. Determine :

(i) the required throat and exit areas,

(ii) the degree of undercooling at exit. 30

7. (a) Describe the physics and working of solar photovoltaic systems. Differentiate between global, direct and diffused radiation. With a neat sketch, explain the working of a solar still, and derive the instantaneous efficiency of the solar still. 30

(b) What is the function of a pressurizer in a PWR ? What do you understand by breeder reactor. Explain with neat sketch, the working of a liquid-metal fast breeder reactor. 30

8. (a) Explain the phenomena of normal combustion in SI engines. Discuss the factors which affect the flame speed. 15

(b) "Factors tending to increase detonation in SI engines tend to reduce knock in CI engines." Discuss the validity of the above statement in the light of the differences in nature of knock phenomena in these two types of engines. (SI & CI engines). 15

(c) A vapour compression refrigerator uses methyl chloride and operates between the pressure limits of 177 kN/m^2 and 967 kN/m^2. At entry to the compressor the methyl chloride is dry-saturated and after compression has a temperature of 102 °C.

The compressor has a bore and stroke of 75 mm and runs at 8 rev/s with a volumetric efficiency of 80%. The temperature of the liquid refrigerant as it leaves the condenser is 35 °C and its specific heat capacity is 1.62 kJ/kg k. The specific heat capacity of the superheated vapours may be assumed constant.

Determine :

(i) the coefficient of performance of the refrigerator,

(ii) the mass flow of refrigerant in kg/h,

(iii) The cooling water required by the condenser in kg/h if the cooling water temperature rise is limited to 12 °C.

Take the specific heat capacity of water = 4.187 kJ/kg k. The relevant properties of methyl chloride are given below : 30

Sat. temp. °C	Pressure kN/m^2	Sp. Vol m^3/kg		Sp. enthalpy kJ/kg		Sp. entropy kJ/kg k	
		v_f	v_g	h_f	h_g	s_f	s_g
–10	177	0.00102	0.233	45.4	460.7	0.183	1.762
45	967	0.00115	0.046	133.0	483.6	0.485	1.587