JYL

460067

2011

MECHANICAL ENGINEERING (Optional)
Paper – II

Standard : Degree | **Total Marks : 200**

Nature : Conventional (Essay) type | **Duration : Three hours**

N.B. : 1) Answers must be written in English.

*2) Question **No. 1** is **compulsory**. Of the remaining questions, attempt **any Four** selecting one question from **each section**.*

*3) Figures to the **RIGHT** indicate marks of the respective question.*

4) Use of log table, Non-Programmable calculator is permitted, but any other Table/Code/Reference book are not permitted.

5) Make suitable assumptions, wherever be necessary and state the same.

6) Number of optional questions upto the prescribed number in the order in which they have been solved will only be assessed. Excess answers will not be assessed.

7) Credit will be given for orderly, concise and effective writing.

8) Candidates should not write roll number, any name (including their own), signature, address or any indication of their identity anywhere inside the answer book otherwise he/she will be penalised.

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Answer **any four** of the following :

1. (a) (i) Define an ideal gas. Write the value and unit of universal gas constant. 3

(ii) Draw the p-v and T-s diagram of an otto cycle. Write the equation of efficiency for otto cycle. 3

(iii) What is mean effective pressure ? How it is measured ? What are the indicated power and the brake power of an engine ? 4

(b) What is co-generation ? Explain any one method of cogeneration i.e. Back pressure turbine or pass out turbine with help of schematic and T-s diagram. 10

(c) An open cycle gas turbine power plant has a maximum pressure ratio 8 and temperature of 1080°C. It operates with a regenerative heat exchanger. The pressure and temperature of air at the inlet to air compressor are 1 bar and 300 k. The use of regenerative heat exchanger is made to increase the temperature before entering into the combustion chamber. The effectiveness of a heat exchanger is 0.6. The air flow through the compressor is 8.33 kg/Sec.

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Draw the cycle on T-s diagram. Find the temperatures at the salient points of the cycle. Further find fuel saved per hour on account of regenerative heat exchanger.

(Data : Cp for air = 1kJ /kg. K, γ = 1.4, both for air and gases, calorific value of fuel = 33600 kJ / kg. The isentropic efficiency of compressor and turbine is 0.8). **10**

(d) i) Define 'gauge factor' and derive the relationship between the gauge factor and Poisson's ratio of the material for a resistive strain gauge. **6**

ii) For a certain thermistor, β = 3140 k and the resistance at 27°C is known to be 1050 ohm. The thermistor is used for temperature measurement and the resistance measured is 2330 ohm . Find the measured temperature. **4**

(e) Define and explain terms used for power plants : **10**

(i) Connected load

(ii) Load factor

(iii) Plant capacity factor

(iv) Plant use factor

(v) Diversity factor.

SECTION – A

2. Answer the following sub-questions :

(a) (i) What is qualitative difference between heat and work ? Why they are not completely interchangeable forms of energy ? **4**

(ii) Give the 'Kelvin-Plank' and 'Clausius' statements of the second law of thermodynamics. Establish the equivalence of these two statements. **6**

(b) Draw the schematic diagram of a simple steam power plant. What is the reversible cycle that represents the simple steam power plant ? Draw the flow, p-v, T-s and h-s diagrams of this cycle. What do you understand by steam rate and heat rate ? What are their units ? **10**

(c) A fin 5 mm thick and 45 mm long has its base on a base plate at 125°C. The ambient temperature is 25°C. The conductivity of fin materials is 55 W/mk and the heat transfer coefficient is 145 W/m^{2}k.

Determine :

(i) Temperature at the end of the fin,

(ii) Temperature at the middle of the fin, and

(iii) Heat dissipated by the fin.

Assume the tip of the fin is insulated and the fin has unit width. 10

(d) Define the terms absorptivity, reflectivity and transmissivity of radiation heat transfer. What is 'black body' ? How does it differ from a 'gray body' ? State and prove Kirchhoff's law of radiation. 10

3. (a) (i) Draw the p-v and T-s diagram of Carnot cycle. Explain the processes of Carnot cycle. Explain the significance of Carnot cycle in thermodynamics. 5

(ii) What is entropy ? What are the causes of increase in entropy ? Why is an isentropic process not necessarily an adiabatic process ? 5

(b) Steam at 20 bar, 360°C is expanded in a steam turbine to 0.08 bar. It then enters a condenser, where it is condensed to saturated liquid water. The pump feeds back the water into the boiler.

(i) Assuming ideal processes, find per kg of steam the net work and the cycle efficiency.

(ii) If the turbine and the pump have each 80% efficiency, find the percentage reduction in the net work and cycle efficiency.

Take property values at different points from steam table as :

$h_1 = 3159.3$ kJ/kg; $h_3 = h_{fp2} = 173.88$ kJ/kg ;

$h_{fgp2} = 2403.1$ kJ/kg; $U_{fp2} = 0.001008$ m^3/kg ;

$S_1 = 6.9917$ kJ/kg K; $S_3 = S_{fp2} = 0.5926$ kJ/kg K ;

$S_{gp2} = 8.2287$ kJ/kg K. 10

(c) A metal (k = 45 W/mK) steam pipe of 5 cm inner diameter and 6.5 cm outer diameter is lagged with 2.75 cm radial thickness of high temperature insulation having thermal conductivity of 1.1 W/mk. Convective heat transfer coefficients on the inside and out side surfaces are h_i = 4650 W/m^{2}k and h_0 = 11.5 W/m^{2}K, respectively. If the steam temperature is 200°C and the ambient temperature is 25°C, calculate :

(i) heat loss per metre length of pipe,

(ii) temperature at the interfaces, and

(iii) overall heat transfer coefficients referred to inside and outside surfaces 10

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(d) A counterflow double pipe heat exchanger using superheated steam is used to heat water at the rate of 10500 kg/h. The steam enters the heat exchanger at 180°C and leaves at 130°C. The inlet and exit temperatures of water are 30°C and 80°C respectively. If overall heat transfer coefficient from steam to water is 814 W/m^{2}k, calculate the heat transfer area. What would be the increase in area if the fluid flows were parallel ? **10**

SECTION – B

4. Answer the following sub-questions.

(a) Derive "Darcy Weistach equation for friction factor. Also explain how friction factor varies with type of flow. **10**

(b) Find velocity of water in delivery line, manometric head and power required to drive a centrifugal pump, which delivers 40 litres per second of water to a height of 20 m, through a 150 mm diameter, 100 m long pipeline. The overall efficiency of pump is 70% and friction factor is 0.6 for pipeline. Assume inlet losses in suction line equal to 0.33 m. **10**

(c) What is a F-R-L unit in pneumatics ? Explain necessity of each in pneumatic circuit. List different methods used to dry the compressed air supplied. **10**

(d) Discuss advantages and disadvantages of Nuclear Power Plant. Justify the site selection of Tarapur Atomic Power Station. **10**

5. Answer the following sub-questions.

(a) What is dimensional analysis ? What are its applications ? Explain the Rayleigh method in details. **10**

(b) A single stage single acting reciprocating air has tore and stroke of 150 mm. Clearance volume is 6% of stroke volume and speed of operation is 8 rev/sec. Intake pressure is 100 kN/m^2 and delivery pressure 550 kN/m^2. The index of compression is 1.32 through out and inlet air temperature is 27°C

Find out :

(i) Theoretical volumetric efficiency

(ii) Temperature of air at outlet

(iii) Volume of air delivered per minute at 550 kN/m^2

(iv) Power required to drive compressor if mechanical efficiency is 85%

(v) Isothermal efficiency. 10

(c) A pneumatic cylinder is required to move 200 kg mass, 600 mm upon 60° incline. Coefficient of friction is 0.15, load velocity is 0.6 m/s and distance travelled 3.0 mm. Maximum pressure on piston 5.0 bar gauge. Determine

(i) Total resistive force

(ii) Cylinder diameter

(iii) Air consumption if cylinder operates at 15 cycles / min and piston rod is $\frac{1}{4}$ diameter of cylinder. Assume internal frictional resistance and other losses 10% of total for available. 10

(d) Derive expression for thermal efficiency of Brayton cycle in terms of pressure ratio. Obtain relation for maximum pressure ratio when Tmax and Tmin are fixed with help of T-s diagram, explain why this pressure ratio is not used in practice. 10

SECTION – C

6. Answer the following sub-questions :

(a) Draw air-standard diesel cycle (4-stroke) on P-v and T-s diagram. Derive an equation for thermal efficiency of a diesel engine in terms of compression ratio and fuel cut-off ratio. 10

(b) A diesel engine is assumed to work on air-standard diesel cycle. The pressure and temperature at the beginning of the cycle are 1.03 bar and 300 k respectively. The maximum pressure of the cycle is 47 bar. The heat supplied is 550 kJ/kg. Determine .

(i) The compression ratio

(ii) Temperature at the end of compression

P.T.O.

(iii) Temperature at the end of combustion

(iv) The air-standard efficiency of the cycle.

Assume adiabatic index, $\gamma = 1.4$, and specific heat at constant pressure = 1 kJ/kg k for air. **15**

(c) An ice plant operates with ammonia as a refrigerant between the temperature limits of –20°C and 30°C. It produces ten tons of ice per day from water at 25°C to ice at 0°C. Assuming simple vapor compression cycle and using properties of ammonia given below find :

(i) Refrigerating effect in kW

(ii) Mass flow rate of refrigerant

(iii) Compressor power in kW

(iv) COP.

Data : C_p for water = 4.18 kJ/kg k

C_p for gaseous ammonia = 2.8 kJ/kg k

Latent heat of ice = 335 kJ/kg.

Temperature at the end of compression = 106°C. **15**

Saturation Temperature	Specific volume, Vg m^3/kg	Specific enthalpy, (kJ / kg)			Specific entropy (kJ / kg k)	
°C		h_f	h_{fg}	h_g	S_f	S_g
– 20	0.6243	89.81	1330.2	1420.0	0.3684	5.6244
30	0.1107	323.2	1145.8	1469.0	1.2037	4.9840

Answer the following sub-questions :

7. (a) Sketch and explain the construction and working of a simple carburettor. **10**

(b) (i) List the objectives of suspension system. Explain with a neat sketch a typical independent front suspension arrangement. **7**

(ii) List out methods of brake power measurement. Illustrate the working prony brake with a neat sketch. **8**

(c) (i) On a particular day, the atmospheric air found to have a dry-bulb temperature of 30°C and wet-bulb temperature of 18°C. The barometric pressure was observed to be 756 mm of Hg. Obtain the following properties without using psychrometric chart. Assume partial pressure of water vapour to be 0.01274 bar. The saturation pressure of water at 30°C to be 0.04241 bar. Determine :
Relative humidity and specific humidity. **5**

(ii) 28.5 cubic meter per minute of room air at 25.5°C DBT and 50% RH is mixed with 28.5 cubic meter per minute outside air at 38°C DBT and 27°C WBT. Find the ventilation load and the condition of air after mixing.
The above mixture of air is passed through an air conditioning equipment. If the WBT of air after the equipment is 14.5°C and its corresponding specific enthalpy is 40.6 kJ/kg of dry air, determine heat removed by the equipment.

You can use the following data. 10

Condition	DBT (°C)	WBT (°C)	RH %	w	h	v
				kg w.v./kg d.a	kJ/kg d.a.	m^3/kg d.a.
Room Air	25.5	–	50	0.0102	52	0.86
Outside Air	38	27	–	0.018	85	0.906

(One can get the enthalpy of mixed air by interpolation using the above table).

SECTION – D

8. (a) (i) Describe Taylor's principle for design of limit gauges. What is the guideline to identify surface of a gauge ? 5

(ii) Explain the various types of controllers on the basis of their slide control capabilities. 10

(b) For the three data points shown in Fig. 8(b) find the straight-line curve fit. Also find the values of r^2 (coefficient of determination) for the linear curve fit and for the quadratic curve fit. 15

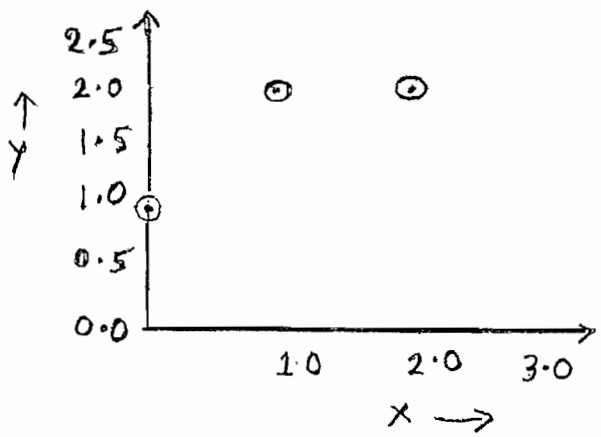

Fig. 8 (b)

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(c) In the Fig. 8(c) determine 'k' and 'a' for the closed-loop system shown below such that the transient response to a step input satisfies % overshoot $\leq 5\%$ and setting time $t_S \leq 4$ sec. **10**

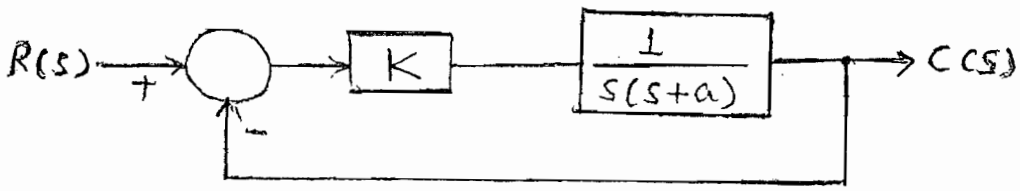

Fig. 8 (c)

9. (a) (i) Explain how the effective diameter or pitch diameter of screw thread is measured using three wire method. **5**

(ii) What is the significance of adaptive control ? Distinguish between ACC and ACO types of adaptive control for CNC systems. What are the advantages of AC systems ? **10**

(b) For the spring-mass system shown in Fig 9(b), the masses are pulled downward by the force of gravity. Draw free body diagrams for the three masses and write the force-balance equations for the system. Find the displacements x_1, x_2 and x_3 for the set of differential equations, when the system reaches steady state. Assume $m_1 = 2$kg, $m_2 = 3$kg, $m_3 = 2.5$ kg and $k = 10$ kg/s^2. **15**

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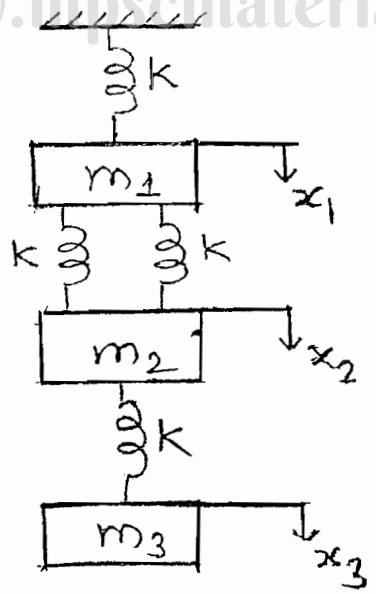

Fig. 9 (b)

(c) If a system has $G(S)H(S) = \dfrac{k}{s(s+2)(s+4)}$, what value of k makes the system unstable ? Find the intersection of root-loci with the imaginary axis. Plot the root loci for the system. **10**