This question paper contains 8+4 printed pages]

CODE : FS-17

MECHANICAL ENGINEERING

Time : 3 *Hours* *Maximum Marks* : 200

Note :— (1) 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 remaining, any *three* are to be attempted choosing at least *one* from each section. Unless otherwise mentioned, symbols and notations have their usual standard meanings.

(2) Parts of same questions must be attempted together and not to be attempted in between the answers to other questions.

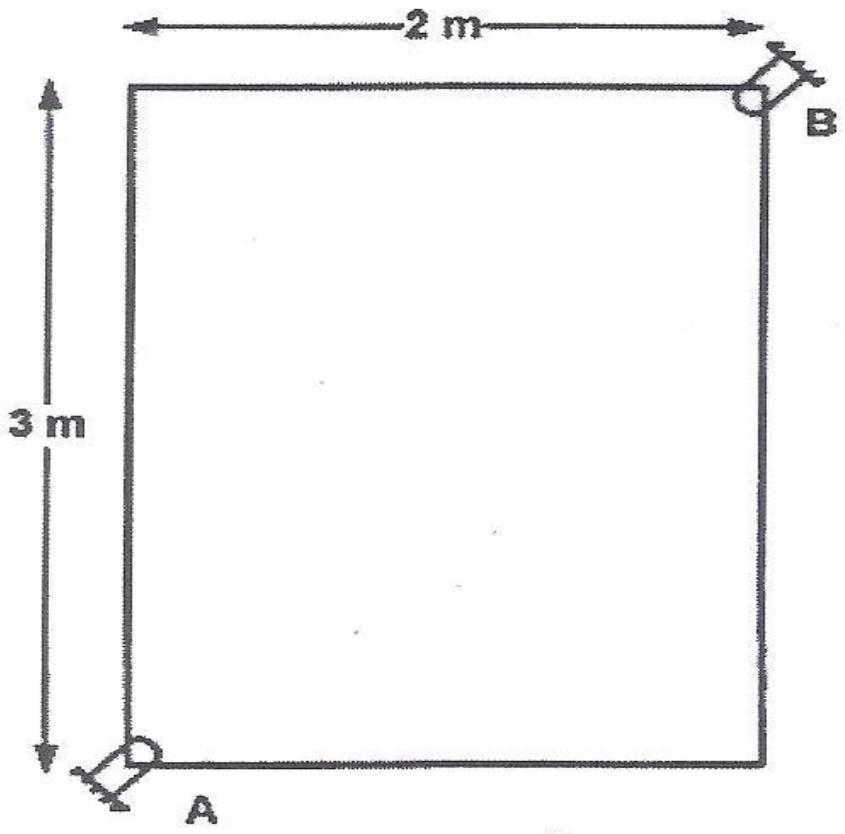
Section A

1. (*a*) Describe various modes of Tool failure. Explain up to what extent these failures can be controlled. Explain how the flank wear growth is dependent on time and machining speed. 10

P.T.O.

(*b*) Explain the working of an Electro Chemical Machining (ECM) with the help of a neat diagram. What are the basic functions served by the electrolyte in ECM process ? 15

(*c*) A rectangular plate 2 m × 3 m of mass 100 kg/m^2 is supported by hinges at A and B as shown in Figure. If the support A is removed, determine the reaction at B, the angular acceleration of the plate and acceleration of the centre of mass. 15



Figure

2. (*a*) Sketch and explain the working of two different types of quick return mechanisms. Give suitable examples explaining their applications. 10

(*b*) In an epicyclic gear train, the internal wheel A and B and compound wheels C and D rotate independently about axis O. The Wheels E and F rotates on pins fixed to the arm G. E gears with A and C, and F gears with B and D. All the wheels have same module and the number of teeth are $T_C = 28$, $T_D = 26$, $T_E = T_F = 18$. Then find : 15

(*i*) Sketch the arrangement

(*ii*) Find the number of teeth on A and B

(*iii*) If the arm G makes 100 r.p.m. clockwise and A is fixed, find the speed of B.

(*iv*) If the arm G makes 100 r.p.m. clockwise and wheel A makes 10 r.p.m. counter clockwise, then find the speed of B.

P.T.O.

(*c*) A mass of 10 kg is suspended from one end of a helical spring, the other end being fixed. The stiffness of the spring is 10 N/mm. The viscous damping causes the amplitude to decrease to one-tenth of the initial value in four complete oscillations. If a periodic force of 150 cos 50t N is applied at the mass in the vertical direction, find the amplitude of the forced vibrations. What is its value of resonance ? 15

3. (*a*) With the help of Merchant's Circle Diagram, derive and explain how various machining forces are estimated. 10

(*b*) A strip of lead with initial dimensions 24 mm × 24 mm × 120 mm is forged between two flat dies to a final size of 6 mm × 96 mm × 120 mm. If the coefficient of friction is 0.25, determine the maximum forging force. The average yield stress of lead in tension is 7 N/mm^2. 15

(*c*) Why do we need inventory ? ABC manufacturing company requires special involute gears at the rate of 300 per year. Each gear costs Rs. 36. The procurement cost and inventory carrying cost are estimated at Rs. 30 and 20% respectively. If the supplier offers a discount of Rs. 2 per gear on an order of 200 or above, will it be advisable to purchase higher quantity ? 15

4. (*a*) A simply supported beam of length 8 m carries a uniformly varying load whose intensity varies from a maximum value of 3 kN/m at both ends to zero at the centre of the beam. It is desired to replace the beam with another simply supported beam which will be subjected to the same maximum 'Bending Moment' and 'Shear Force' as in the case of the previous one. Determine the length and rate of loading for the second beam, if it is subjected to a uniformly

distributed load over its whole length. Draw the variations of shear force and bending moment in both the cases. 20

(*b*) A horizontal shaft, securely fixed at each end, has a free length of 8 m. Viewed from the one end of the shaft, axial couples of 35 kN-m clockwise and 50 kN-m counter clockwise act on the shaft at distance of 3.2 m and 5.5 m from the viewed end. Determine the end fixing couple in magnitude and direction and find the diameter of solid shaft for a maximum shearing stress of 75 N/mm^2. Also find the position where the shaft suffers no angular twist. 20

Section B

5. (*a*) Explain supercharging with its objectives and sketch the various configurations of supercharger. Which engine is more suitable for supercharging — spark ignition or compression ignition ? Why ? 10

(*b*) Discuss in detail the factors affecting the performance of vapour compression refrigeration cycle. 15

(*c*) 9 kg of pure ice at −10°C is separated from 5 kg of pure water at +12°C in an adiabatic chamber using a thin adiabatic membrane. Upon rupture of the membrane, ice and water mix uniformly at constant pressure. At this pressure, the melting temperature of ice is 0°C and the latent heat of melting is 335 kJ/kg. The mean specific heat at constant pressure for ice and water are respectively 2.1 kJ /kgK and 4.2 kJ/kgK.

(*i*) Sketch the systems before and after mixing.

(*ii*) What is the final equilibrium temperature of the system after the completion of the mixing process ?

(*iii*) Estimate the change of entropy of the universe due to the mixing.

(*iv*) What is the final phase of the system ? (Solid ice, liquid water or ice-water mixture ?) 15

6. (*a*) Air at 101.325 kPa, 20°C is taken into a gas turbine power plant at a velocity of 150 m/s through an opening of 0.15 m^2 cross-sectional area. The air is compressed heated, expanded through a turbine, and exhausted at 0.18 MPa, 150°C through an opening of 0.10 m^2 cross-sectional area. The power output is 350 kW. Calculate the net amount of heat added to the air in kJ/kg. Assume that air obeys the law $pv = 0.287\ (t + 273)$, where p is the pressure in kPa, v is the specific volume in m^3/kg, and t is the temperature in °C. Take $c_p = 1.005$ kJ/kg K. 10

(*b*) Find the surface area required for a surface condenser dealing with 25000 kg of saturated steam per hour at a pressure of 0.5 bar. Temperature of condensing water is 25°C. Cooling water is heated from 15°C to 25°C while passing through the

condenser. Assume a heat transfer coefficient of 10 kW/m^{2}K. The condenser has 2 water passes with tubes of 19 mm OD and 1.2 mm thickness. Find the length and no. of tubes per pass. Assume velocity of water is 1 m/s. Assume correction factor for 2 tube pass exchanger as 0.86. At 0.5 bar saturation temperature is 32.55°C and latent heat is 2560 kJ/kg. Sp. heat of water is 4.18 kJ/kg K and density is 1000 kg/m^3. 15

(*c*) A steel pipe of diameter 8.9 cm has eight longitudinal fins of 1.5 mm thickness which extend, 30 mm from the pipe surface. If the thermal conductivity of the fin material is 45 W/mK, find the percentage increase in the rate of heat transfer for the finned surface compared to the base surface. Assume the film heat transfer coefficient as 75 W/m^{2}K. 15

7. (*a*) Explain the separation of flow and discuss the methods used for controlling of separation in a diffuser. 10

(*b*) Find the discharge of water flowing through an inclined venturimeter of 25 cm main size and 12 cm throat size. The difference between the main and the throat pressure measured by an inverted liquid manometer with the liquid of specific gravity of 0.6 gives a reading of 30 cm. The loss of head between the main and the throat is 0.2 times the K.E. of the main. 15

(*c*) A Francis turbine with an overall efficiency of 76% is required to produce 150 kW. It is working under a head of 8 m. The peripheral velocity = $0.25\sqrt{2}\,gH$ and the radial velocity of flow at inlet is = $0.95\sqrt{2}\,gH$. The wheels runs at 200 r.p.m. and the hydraulic losses in the turbine are 20% of the available energy. Assuming radial discharge, determine :

(*i*) The guide blade angle

(*ii*) The wheel vane angle at inlet

(*iii*) Diameter of the wheel at inlet, and

(*iv*) Width of the wheel at inlet. 15

8. (*a*) A gas turbine plant operates on the Brayton cycle using an optimum pressure ratio for maximum net work output and a regenerator of 100% effectiveness. Derive expressions for net work output per kg of air and corresponding efficiency of the cycle in terms of the maximum and the minimum temperatures.

If the maximum and minimum temperatures are 600°C and 30°C respectively, compute the optimum value of pressure ratio, the maximum net work output per kg and the corresponding cycle efficiency. 20

(*b*) An ammonia ice plant operates between a condenser temperature of 35°C and an evaporator temperature of –15°C. It produces 12 tons of ice per day from water at 28°C to ice at –3°C. Assuming simple saturation cycle, determine :

(*i*) The capacity of the refrigeration plant.

(*ii*) The mass flow rate of refrigerant.

(*iii*) The compressor cylinder diameter and stroke if its volumetric efficiency is 70%, r.p.m. = 1250 and stroke to bore ratio is = 1.3.

(*iv*) The power of the compressor motor if the adiabatic efficiency of the compressor = 0.86 and mechanical efficiency = 0.94.

(*v*) The theoretical and actual COP.

Assume latent heat of ice = 335 kJ/kg

Specific heat of water = 4.1868 kJ/kgK

Specific heat of ice = 1.94 kJ/kgK.

The properties of NH_3 are given below :

T (°C)	$V_f \times 10^{-3}$ (m^3/kg)	V_g (m^3/kg)	h_f (kJ/kg)	h_g (kJ/kg)	S_f (kJ/kg-K)	S_g (kJ/kg-K)
–15	1.52	0.508	131.3	1443.9	0.7426	5.8223
35	1.7	0.096	366.1	1488.6	1.566	5.2086

Average specific heat of ammonia vapour is 2.2 kJ/kg-K. 20