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Total No. of Printed Pages—9

4CCSME

MECHANICAL ENGINEERING

PAPER—I

Full Marks : 200 *Time* : 3 hours

The figures in the margin indicate full marks

Candidates should attempt **five** questions out of the **ten** questions. Question No. **1** is compulsory

1. Answer any *four* of the following : 10×4=40

(a) What is an automobile steering gear? Which steering gear is preferred and why?

(b) What is cam? What type of motion can be transmitted with a cam and follower combination?

(c) Derive a relation for minimum number of teeth on the gear wheel and the pinion to avoid interference.

(d) Find the shortest length L for a steel column with pinned ends having a cross-sectional area of 70 mm by 90 mm, for which the elastic Euler formula applies. Let $E = 200$ GPa and assume the proportional limit to be 250 MPa.

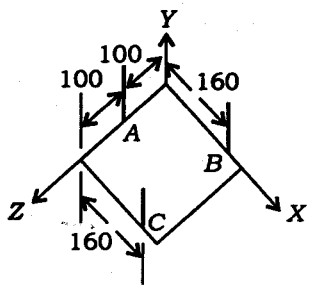
(e) Explain the term 'machinability'. What does it involve? Why does titanium have poor machinability?

(f) What are jigs and fixtures? Explain briefly the principle of jig and fixture design.

(g) What is a master production schedule? Explain its relationship with material planning and capacity planning.

(h) Explain with a neat sketch the salient features of EDM operation.

2. (a) The 200 mm × 200 mm square plate as shown in the figure below has a mass of 25 kg and is supported by three vertical wires. Determine the tension in each wire. 20



(b) A uniform sphere of mass m and radius r is projected along a rough horizontal surface with a linear velocity v_0' and no

requirements of a toolroom is 10 min and this follows the Poisson's distribution. Average service time of the storekeeper is 9 min. Determine the following : 20

(i) Average queue length

(ii) Average length of non-empty queue

(iii) Average number of mechanics in the system

(iv) Mean waiting time of a mechanic

(v) Average waiting time of a mechanic who waits

10. (a) Describe briefly with a neat diagram the working principle of laser beam machining. What are its advantages and disadvantages? 20

(b) Following data relate to an orthogonal cutting process :

Chip length obtained = 96 mm, uncut chip length = 240 mm, rake angle = 20 degree, depth of cut = 0·6 mm, horizontal and vertical components of cutting force are 2400 N and 240 N respectively.

Determine the following : 20

(i) Chip thickness

(ii) Friction angle

(iii) Resultant cutting force

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(b) Find the feasible solution of the following transportation problem : 20

		Warehouse				Supply
		W_1	W_2	W_3	W_4	
Factory	F_1	14	25	45	5	6
	F_2	65	25	35	55	8
	F_3	35	3	65	15	16
Demand		4	7	6	13	30

9. (a) *XYZ* Ltd., manufacturer of a special product, follows the policy of EOQ for one of its components. The component details are as follows :

Purchase price per component = ₹ 200·00

Cost of an order = ₹ 100·00

Annual carrying cost = 10% of purchase cost

Inventory ordered per annum = 4000 components

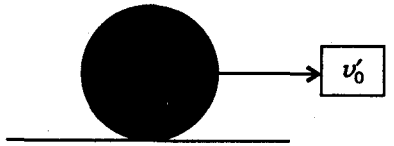
The company has been offered a discount of 2% on the price of the components provided the lot size is 2000 components at a time. Should the company accept the offer? 20

(b) A factory manufacturing tanks for military use has a separate toolroom where special maintenance tools are stored. The average time between

angular velocity as shown in the figure below. Denoting by μ_k, the coefficient of kinetic friction between the sphere and the floor, determine—

(i) the time t_1 at which the sphere will start rolling without sliding ;

(ii) the linear velocity and angular velocity of the sphere at t_1. 20



3. (a) A Hooke's joint connects two shafts whose axes intersect at 18°. The driving shaft rotates at a uniform speed of 210 r.p.m. The driven shaft with attached masses has a mass of 60 kg and radius of gyration of 120 mm. Determine the following : 20

(i) The torque required at the driving shaft if a steady torque of 180 N m resists rotation of the driven shaft and the angle of rotation is 45°

(ii) The angle between the shafts at which the total fluctuation of speed of the driven shaft is limited to 18 r.p.m.

(b) A shaft supported in bearings 1·6 m apart projects 400 mm beyond bearings at each end. It carries three pulleys one at each end and one at the center of its length. The masses of the end pulleys are 40 kg and 22 kg, and their centers of mass are at 12 mm and 18 mm respectively from the shaft axis. The mass of the center pulley is 38 kg and its center of mass is 15 mm from the shaft axis. The pulleys are arranged in a manner that they give static balance. Determine the following : 20

(i) The relative angular position of the pulleys

(ii) The dynamic forces developed on the bearings when the shafts rotate at 210 r.p.m.

4. (a) A belt drive is required to transmit 10 kW from a motor running at 600 r.p.m. The belt is 12 mm thick and has a mass density of 0·001 gm/mm^3. Safe stress in the belt is not to exceed 2·5 N/mm^2. Diameter of the driving pulley is 250 mm whereas the speed of the driven pulley is 220 r.p.m. The two shafts are 1·25 m apart. The coefficient of friction is 0·25. Determine the width of the belt. 20

7. (a) What is plasma? Explain briefly with a neat sketch the working of Plasma Arc Machining (PAM). Give its application. 20

(b) The following equation for tool life is given for a turning operation :

$$VT^{0.14} \times f^{0.78} \times d^{0.38} = C$$

One hour tool life was obtained while cutting at V=28 m/min; f=0·3 mm/rev and d=2·6 mm. Calculate the tool life if the cutting speed, feed and depth of cut are increased by 25% individually and also taken together. 20

8. (a) Solve the following linear programming problem by simplex method : 20

Maximize $Z = 10X_1 + 20X_2$

subject to the constraints

$$3X_1 + 2X_2 \leq 1200$$
$$2X_1 + 6X_2 \leq 1500$$
$$X_1 \leq 350$$
$$X_2 \leq 200$$

X_1 and $X_2 > 0$

(b) A machine mounted on springs and fitted with a dashpot has a mass of 60 kg. There are three springs, each of stiffness of 12 N/mm. The amplitude of vibrations reduces from 45 mm to 8 mm in two complete oscillations. Assuming that the damping force varies as the velocity, determine—

(i) the damping coefficient ;

(ii) the ratio of frequencies of damped and undamped vibrations ;

(iii) the periodic time of damped vibrations. 20

5. *(a)* An external pressure of 10 MN/m^2 is applied to a thick cylinder of internal diameter 160 mm and external diameter 380 mm. If the maximum hoop stress permitted on the inside wall of the cylinder is limited to 35 MN/m^2, what maximum internal pressure can be applied assuming the cylinder has closed ends? What will be the change in outside diameter when the pressure is applied? $E = 207\ GN/m^2$, $\nu = 0{\cdot}29$. 20

(b) A 30 mm diameter bar is subjected to an axial tensile load of 150 kN. Under the action of this load, a 210 mm gauge length is found to extend $0{\cdot}20 \times 10^{-3}$ mm. Determine the modulus

of elasticity for the bar material. If, in order to reduce weight whilst keeping the external diameter constant, the bar is bored axially to produce a cylinder of uniform thickness, then what is the maximum diameter of bore possible that the maximum allowable stress is 250 MN/mm^2? The load can be assumed to remain constant at 150 kN. 20

6. *(a)* A uniform cantilever is 5 m long and carries a concentrated load of 50 kN at a point 4 m away from the support. Determine the vertical deflection of the free end of the cantilever if $EI = 65\ MN/m^2$. How would this value change if the same total load were applied but uniformly distributed over the portion of the cantilever 4 m from the support? 20

(b) A steel transmission shaft is 520 mm long and of 60 mm external diameter. For part of its length, it is bored to a diameter of 30 mm and for the rest to 40 mm. Find the maximum power that may be transmitted at a speed of 210 rev/min, if the shear stress is not to exceed 70 MN/m^2. If the angle of twist in the length of 30 mm bore is equal to that in the length of 40 mm bore, find the length bored to the latter diameter. 20

Total No. of Printed Pages—7

4CCSME

MECHANICAL ENGINEERING

PAPER—II

Full Marks : 200 *Time* : 3 hours

The figures in the margin indicate full marks

Candidates should answer **five** questions out of **ten** questions. Question No. **1** is compulsory

1. Answer any *four* questions of the following *eight* : 10×4=40

(a) Define internal energy. Show that internal energy is a property of a system.

(b) A fluid contained in a cylinder receives 150 kJ of mechanical energy by means of paddle wheel, together with 50 kJ in the form of heat. At the same time, a piston in the cylinder moves in a way that the pressure remains constant at 200 kN/m^2 during the fluid expansion from $2m^3$ to $5m^3$. What is the change in internal energy and in enthalpy?

(c) The barometric pressure at sea level is 760 mm of Hg while that on a mountain top is 735 mm. If the density of air is assumed constant at 1·2 kg/m^3, what is the elevation of the mountain top?

(d) A two-dimensional flow field is given by $\phi = 3xy$, determine the velocity at $L(2, 6)$ and $M(6, 6)$ and the discharge between the streamlines passing through the points L and M.

(e) State the conditions for a process to be reversible.

(f) State the conditions necessary for a substance to be defined as perfect gas. How does it differ from ideal gas?

(g) Write the steady flow energy equation and point out the significance of various terms involved.

(h) How would you distinguish between hydrodynamically smooth and rough boundaries?

2. (a) When the system is at equilibrium, why would any conceivable change in entropy be zero? Show that the transfer of heat through a finite temperature difference is irreversible. 10

(b) A Carnot engine with a fuel burning device as source and a heat sink cannot be treated as a reversible plant. Explain. 10

(c) A heat engine receives half of its heat supply at 1000K and half at 500K while rejecting heat to a sink at 300K. What is the maximum thermal efficiency of the heat engine? 20

10. (a) In a hydroelectric station, water is available at the rate of 175 m^3/s under a head of 18 m. The turbines run at a speed of 150 r.p.m. with overall efficiency of 82%. Find the number of turbines required if they have the maximum specific speed of 460. 10

(b) With suitable sketch, explain the working principle of nuclear power plant. What are their advantages of limitations? 10

(c) A classroom of 60-seating capacity is air-conditioned. The outdoor conditions are 32 °C DBT and 22 °C WBT and required comfort conditions are 22 °C DBT and 55% RH. The quantity of outdoor air supplied is 0·5 m^3/min/student. The comfort conditions are achieved first by chemical dehumidifying the air and then cooling by the cooling coil. Find —

(i) DBT of the air leaving the dehumidifier ;

(ii) capacity of the humidifier and cooling coil. 20

★★★

The pump feedsback the water into the boiler. If the turbine and pump have each 80% efficiency, find the net work per kg of steam and the cycle efficiency. 20

9. *(a)* State elements of refrigeration system. What is a standard rating of a refrigeration system? Show the simple vapour compression refrigeration cycle on *p–h* chert. 10

(b) An air-water vapour mixture at 25 °C and 1 bar has a relative humidity of 75%. Determine the specific humidity and dew point temperature. Also find the amount of water vapour condensed, if the mixture is cooled to 10 °C at constant pressure. 10

(c) A refrigerator operating on standard vapour compression cycle has a COP of 6·5 and is driven by a 50 kW compressor. The enthalpies of saturated liquid and saturated vapour refrigerant at the condensing temperature of 35 °C are 62·55 kJ/kg and 201·45 kJ/kg respectively. The saturated refrigerant vapour leaving evaporator has an enthalpy of 187·53 kJ/kg. Find the refrigerant temperature at compressor discharge. Take C_p of refrigerant vapour as 0·6155 kJ/kg-°C. 20

3. *(a)* For a steady laminar flow through a circular pipe, prove that the velocity distribution across the section is parabolic and the average velocity is half of the maximum local velocity. 20

(b) A plate 450 mm × 150 mm has been placed longitudinally in an oil of specific gravity 0·925 and kinematic viscosity $0{\cdot}9\times10^{-4}$ m^2/s which flows with velocity of 6 m/s. Calculate —

(i) the friction drag on the plate ;

(ii) boundary layer thickness at the trailing edge ;

(iii) shear stress at the trailing edge. 20

4. *(a)* How is sonic velocity defined in terms of pressure and density of the fluid? Show that for an ideal gas in an isentropic flow, the sonic velocity depends on the temperature and nature of the gas. 20

(b) In aircraft flying at an altitude where the pressure was 35 kPa and temperature –38 °C, stagnation pressure measured was 65·4 kPa. Calculate the speed of the aircraft. Take molecular weight of air as 28. 20

5. *(a)* A long steel rod, 22 mm in diameter, is to be heated from 420 °C to 540 °C. It is placed concentrically in a long cylindrical furnace which has an inside diameter of 180 mm. The inner surface of the furnace is at a temperature of 1100 °C and has an emissivity of 0·82. If the surface of the rod has an emissivity of 0·62, find the time required for the heating operation. Take C_p for steel=0·67 kJ/kgK and ρ =7845 kg/m^3. 20

(b) A current of 200 amperes is passed through a stainless-steel wire of 3 mm diameter having thermal conductivity (K) = 19 W/m. °C. The resistivity of the steel may be taken as 70 $\mu\Omega$.cm, and the length of the wire is 1 m. The wire is submerged in a liquid at 110 °C and experiences a convective heat transfer coefficient of 4 kW/m^2. °C. Calculate the centre temperature of the wire. 20

6. *(a)* Calculate the critical radius of insulation for asbestos [K=0·17W/m–°C] surrounding a pipe and exposed to room air at 20 °C with h=3 W/m^2. °C. Calculate the heat loss from a 200 °C, 5 cm diameter pipe when covered with critical radius of insulation and without insulation. 20

(Continued)

(b) An oil cooler for a lubrication system has to cool 1000 kg/hr of oil (C_p=2·09 kJ/kg-K) from 80 °C to 40 °C by using a cooling water flow of 1000 kg/hr at 30 °C. Give your choice for a parallel flow or counter flow heat exchanger, with reasons. Estimate the surface area of the heat exchanger, if the overall heat transfer coefficient is 24 W/m^2-K. 20

7. *(a)* Briefly explain the stages of combustion in SI engines elaborating the flame front propagation. Discuss also the various factors that influence the flame speed. 20

(b) A six-cylinder, four-stroke diesel engine develops 125 kW at 3000 r.p.m. Its brake specific fuel consumption is 200 gm/kWh. Calculate the quantity of fuel to be injected per cycle per cylinder. Specific gravity of the fuel may be taken as 0·85. 20

8. *(a)* Define the volumetric efficiency of a compressor. On what factors does it depend? Explain the advantages of multistage compression. 20

(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.

(Turn Over)