

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 : $10 \times 4 = 40$

(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.

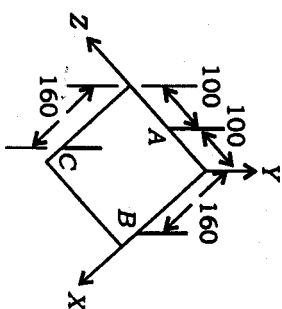
12Y—100/45

(Turn Over)

(2)

- (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

12Y—100/45

(Continued)

(9)

- 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 :
- (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?

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- (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 :
(i) Chip thickness
(ii) Friction angle
(iii) Resultant cutting force

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12Y—100/45

- (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

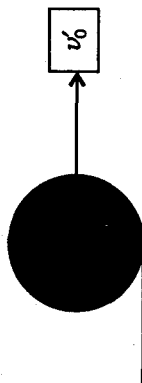
Inventory ordered per annum
= 4000 components

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.

(4)

- (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)

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 $V=28 \text{ m/min}$; $f=0.3 \text{ mm/rev}$ and $d=2.6 \text{ mm}$. 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

$$\text{Maximize } Z = 10X_1 + 20X_2$$

subject to the constraints

$$3X_1 + 2X_2 \leq 1200$$

$$2X_1 + 6X_2 \leq 1500$$

$$X_1 \leq 350$$

$$X_2 \leq 200$$

$$X_1 \text{ and } X_2 > 0$$

(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? $E = 207 \text{ GN/m}^2$, $\nu = 0.29$. 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 0.20×10^{-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 $EI = 65 \text{ MN/m}^2$. 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