

CSM – 54/17

Mechanical Engineering

Paper – I

Time : 3 hours

Full Marks : 300

The figures in the right-hand margin indicate marks.

*Candidates should attempt Q. No. 1 from Section – A and Q. No. 5 from Section – B which are compulsory and any **three** of the remaining questions selecting at least **one** from each Section.*

No Data Books/Tables are allowed, assume the data if required anywhere.

SECTION – A

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1. Answer any **three** of the following : $20 \times 3 = 60$
- (a) Draw the line diagram of mini drafter and determine the following :
- (i) No. of links
 - (ii) No. of kinematic pairs
 - (iii) Degree of freedom

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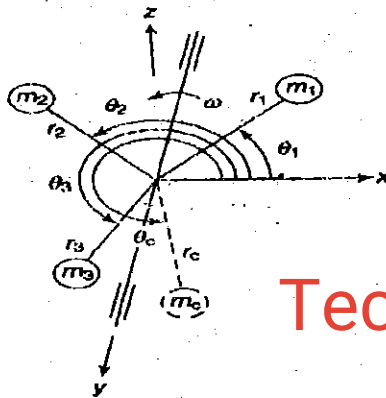
- (b) A Vibrometer having the amplitude of vibration of the machine part as 4 mm and $\epsilon = 0.2$, performs harmonic motion. If the difference between the maximum and minimum recorded value is 10 mm, determine the natural frequency of Vibrometer if the frequency of the vibration part is 12 rad/sec.
- (c) A beam of length ℓ is hinged at one end and is supported at a distance of $2\ell/3$ from the hinged end. It carries a load W distributed over a length $\ell/3$ starting of $\ell/3$ from the hinged end. If EI is flexural rigidity show that the deflection under the point load W at the free end is $\frac{13}{432} \frac{W\ell^3}{EI}$.
- (d) Carbon is allowed to diffuse through a steel plate 10 mm thick. The concentrations of carbon at the two faces are 0.85 and 0.40 kg C/cm³ Fe, which are maintained constant. If the pre-exponential and activation energy are 6.2×10^{-7} m²/s and 80000 J/mol, respectively, compute the temperature at which the diffusion flux is 6.2×10^{-10} kg/m²-s.

2. (a) The rotor shown in the Figure-1 has the following properties: 30

$$m_1 = 3 \text{ kg}, \quad r_1 = 30 \text{ mm} \quad \theta_1 = 30^\circ$$

$$m_2 = 4 \text{ kg}, \quad r_2 = 20 \text{ mm} \quad \theta_2 = 120^\circ$$

$$m_3 = 2 \text{ kg}, \quad r_3 = 25 \text{ mm} \quad \theta_3 = 270^\circ$$



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Figure-1

Find the amount of counter mass of a radial distance of 35 mm for the static balance.

- (b) Draw the profile of a cam operating a knife-edge follower having a lift of 30 mm. The cam raises the follower with SHM for 1500 of the rotation followed by a period of dwell for 600. The follower descends for the next 1000 rotation of the cam with uniform velocity,

again followed by a dwell period. The cam rotates at a uniform velocity of 120 rpm and has a least radius of 20 mm. What will be the maximum velocity and acceleration of the follower during the lift and the return? 30

3. (a) The stress tensor at a point in a body is given as follows :

$$\sigma_{ij} = \begin{bmatrix} 10 & 20 & 0 \\ 20 & 50 & -20 \\ 0 & -20 & 0 \end{bmatrix} \text{ MPa}$$

What are the strains at the point for a Poisson's ratio of 0.2 and modulus of elasticity 2×10^5 MPa. 30

- (b) A beam of angle section shown in Figure-2 is simply supported over a span of 1.6 meters with 15 cm leg vertical. A uniformly distributed vertical load of 10 kN/m is applied through the span.

Determine : (A) Maximum bending stress, (B) Direction of neutral axis and (C) Deflection at the centre. Take $E = 210 \text{ kN/mm}^2$. 30

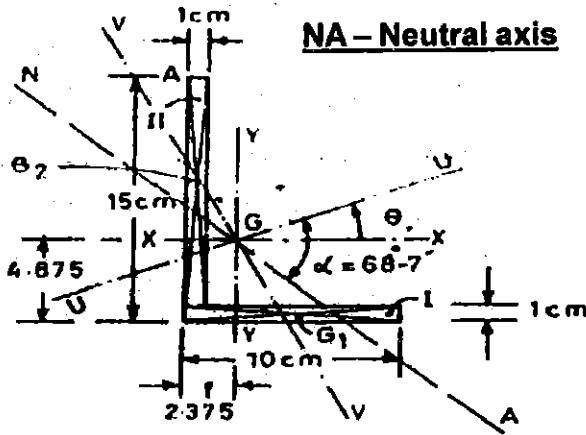


Figure-2

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4. (a) The diffusion coefficients for copper in aluminium at 500°C and 600°C are 4.8×10^{-14} and $5.3 \times 10^{-13} \text{ m}^2/\text{s}$ respectively. Determine the approximate time at 500°C that will produce the same diffusion result (in terms of concentration of Cu at some specific point in Al) as a 10-h heat treatment at 600°C . 30
- (b) Using the isothermal transformation diagram for an iron-carbon alloy of eutectoid composition, specify the nature of the final microstructure of a small specimen that has

been subjected to the following time-temperature treatments. In each case assume that the specimen begins at 760°C and that it has been held at this temperature long enough to have achieved a complete and homogenous austenitic structure. 30

- (i) Cool rapidly to 700°C , hold for 10^4 s, then quench to room temperature.
- (ii) Rapidly cool to 600°C , hold for 4 s, rapidly cool to 450°C , hold for 10 s, then quench to room temperature.
- (iii) Rapidly cool to 250°C , hold for 100 s, then quench to room temperature in water. Reheat to 315°C for 1 h and slowly cool to room temperature.

SECTION - B

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5. Answer any **three** of the following: $20 \times 3 = 60$
- (a) Design the downsprue, avoiding aspiration, show in Figure-3 to deliver liquid cast iron ($\rho_m = 7800 \text{ kg/m}^3$) at a rate of 10 kg/sec against no head at the base of the sprue. Neglect the friction and orifice effects.

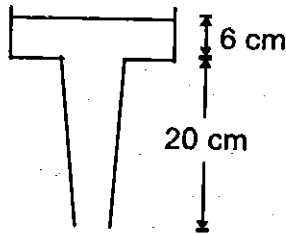


Figure-3

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- (b) Estimate the three components of the machining force during shaping of a mild steel block, using the following data : depth of cut = 2.5 mm, feed = 0.125 mm/stroke, normal rake angle of tool = 7° , side cutting edge angle = 20° , coefficient of friction between chip and tool = 0.8, and ultimate shear stress of work material = 450 N/mm^2 .
- (c) Explain the clamping force for a die casting machine in which the casting is rectangular with projected dimensions of 100 mm \times 200 mm (4 in. \times 8 in.). Would your answer depend on whether or not it is a hot-chamber or cold-chamber process ? Explain.
- (d) In a butt welding process using arc welding, the arc power is found to be 2.5 kVA. The process is used to weld two steel plates, each of 3 mm thickness, as shown in Figure-4.

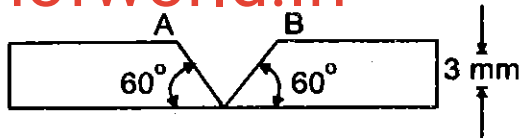


Figure-4

Determine the maximum possible welding speed. It is assumed that the metal transfer is short circuit type and arc is on for 85% of the total time. Given :

$$\alpha_{\text{steel}} = 1.2 \times 10^{-5} \text{ m}^2/\text{sec}$$

$$k_{\text{steel}} = 43.6 \text{ W/m-}^\circ\text{C}$$

The melting point of steel = 1530°C and ambient temperature = 30°C .

6. (a) The worktable of a positioning system is driven by a lead screw whose pitch = 6.0 mm. The lead screw is connected to the output of a shaft of a stepping motor through a gearbox whose ratio is 5 : 1. The stepping motor has 48 step angles. The table must move a distance of 250 mm from its present position at a linear velocity = 500 mm/min. Determine :
- 15
- (i) How many pulses are required to move the table for the specified distance ?
- (ii) The required motor speed and the pulse rate to achieve the desired table velocity.

- (b) Estimate the cutting component of the machining force during the orthogonal machining of an aluminium alloy with an uncut thickness of 0.15 mm, the width of cut being 2.5 mm. 15
- (c) A 10 mm diameter hole has to be drilled in a 5 mm HSS sheet by EDM using a relaxation circuit. The required surface finish is 20μ . Determine the capacitance to be used when the supply and discharge voltages are 220 V and 150 V respectively, the resistance being 50Ω , also, estimate the time required to complete the job. 15
- (d) Write the Part Programme of the given component shown in Figure-5., assume the suitable datum, speed, feed, depth of cut and any other machining data required. 15

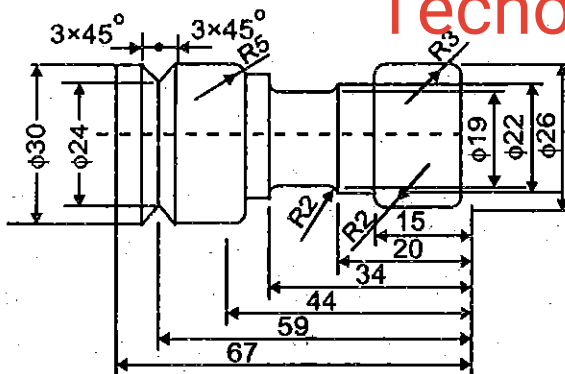


Figure-5

7. (a) Construct the network for the manufacture of a storage cabinet, given the following specification : A simple storage cabinet is to be manufactured by fabrication and assembly of frame and panels. The cabinet is to be painted. Panels and paints are variable in from the store. The activities involved with their duration are as follows : 15

Order material for framework	2 days
Await delivery of material	7 days
Obtain panels and paint from store	1 day
Set up tools	2 days
Fabricate frame	8 days
Fix panels	2 days
Paint cabinet	2 days

(i) Find total project duration.

(ii) Mark the critical path on the network diagram.

- (b) A light engineering company uses 60,000 numbers of special type of stud at an approximately constant rate of 5,000 numbers per year. Each stud costs the company Rs. 6. The cost to place an order

and process the delivery is estimated as Rs. 36 per order and the cost of holding stock is computed as 18% of the average inventory investment. 15

- (i) Calculate the quantity to be purchased at a time to optimize the cost involved.
- (ii) What will be the stock turnover rate if item is replenished by EOQ ?
- (iii) What will be the effect on total cost if the stock turnover rate is reduced to 1/3 by infrequent ordering ?

(c) The following are the available data of sales in lakhs of rupees :

Year	Sales
1980	50
1981	70
1982	60
1983	80
1985	90

Assuming the same relationship holds true for future ; forecast the sales for the year 1990 by applying least square method. 15

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- (d) A company has three plants with capacities of 60, 70 and 80 units respectively to meet the demands of three warehouses with respective requirements of 50, 80 and 80 units. Given the following per unit cost of transportation, find the optimum plan. 15

Warehouses

Plant	A	B	C
x	8	7	3
y	3	8	9
z	11	3	5

8. (a) Explain the internal architecture of a digital computer. What is 'Cache' memory? 15
- (b) What are the latest developments in the field of computing machines? Mention some of the characteristics of a Super Computer. 15
- (c) Explain the terms 'Primary memory' and 'Secondary memory'. What type of memory devices are used in each of these memories? 15
- (d) Draw a flow chart for finding the largest number among A, B, C, the three numbers. 15

