

CSM – 54/19
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.*

SECTION – A

1. Attempt any three of the following : $20 \times 3 = 60$

(a) The state of stress at a point is given by the
following stress tensor :

$$\sigma_{ij} = \begin{vmatrix} 1 & 3 & 1 \\ 3 & -3 & -2 \\ 1 & -2 & 2 \end{vmatrix}$$

All in units of 10 kN/mm^2 . Find the directions
of the principal axes, the values of the

corresponding principal stresses and maximum shear stress.

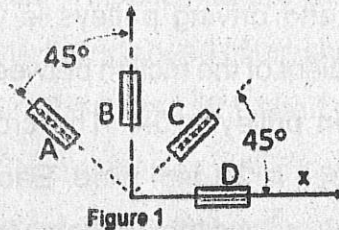
- (b) A single cylinder reciprocating engine has a reciprocating mass of 50 kg. The crank rotates at 50 rpm and the stroke is 250 mm. Mass of the revolving parts at 150 mm radius is 50 kg. If two-third of the reciprocating parts and the whole of the revolving parts are to be balanced, find :

- (i) The balance mass required at a radius of 400 mm
- (ii) The unbalanced force when the crank has turned 50° from the top dead center.

- (c) A square cantilever of 15 mm × 15 mm cross section and 120 mm length is made of steel having uniaxial yield stress of 400 N/cm². Calculate the maximum force or maximum moment the cantilever can carry at the free end according to Tresca's and Von-Mises yield criterions.

- (d) The rosette shown in Figure 1 has been used to determine the following strains at a point on the surface of a crane hook :
- $$\epsilon_A = +190 \times 10^{-6}, \epsilon_C = -50 \times 10^{-6}, \epsilon_D = +400 \times 10^{-6}$$

- (i) What is reading on gage B ?
- (ii) Determine the principal strains and the maximum in-plane shearing strain.



2. (a) The following data are given for a system with viscous damping : $m = 15 \text{ kg}$, $k = 6500 \text{ N/m}$ and $c = 50 \text{ N/m/s}$. Determine (i) the damping factor, (ii) the natural frequency of damped oscillation, (iii) the logarithmic decrement, and (iv) the ratio of any two consecutive amplitudes. Determine the number of

complete cycles required for 80% reduction in amplitude from the beginning for the given case. 25

(b) An open type flat-belt drive is to transmit 22 kW from a 250 mm diameter pulley operating at 1,600 rpm. The diameter of the big pulley is 900 mm. The center distance between the input and output shafts is 1000 mm. The coefficient of friction for the belt and driving pulleys is 0.25, and the coefficient of the friction between the belt and driven pulley is 0.4. The cross section of the belt is 30 mm wide. Each belt weighs 1.1 g/cm^3 and the allowable tension per belt is 850 N. Find (i) How many belts are required ? (ii) Calculate the belt velocity for the maximum power transmission of the belt drive. 25

(c) Differentiate among annealing, tempering and normalizing. What is the influence of recrystallization temperature in those processes ? 10

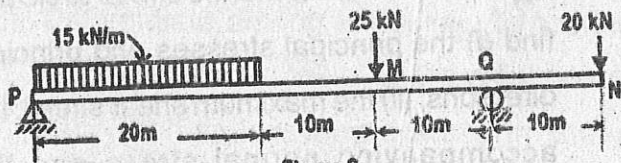
3. (a) A shaft 1.4 m long supported in flexible bearing at the end carries two wheels each of 60 kg mass. One wheel is situated at the center of the shaft and the other at a distance of 0.35 m from the center towards left. The shaft is hollow of external diameter 80 mm and internal diameter 40mm, the density of the shaft material is $7,800 \text{ kg/m}^3$ and its modulus of elasticity is 210 GN/m^2 . Find the lowest whirling speed of the shaft, taking into account the mass of the shaft. 25
- (b) What is cutting tool ? Discuss on different advanced cutting tool materials. 10
- (c) An element in a structure is subjected to a plane stress system that has the stress values, $\sigma_x = 140 \text{ MPa}$, $\sigma_y = 150 \text{ MPa}$ and $\sigma_{xy} = 50 \text{ MPa}$. Draw Mohr's stress circle and find (i) the principal stresses and principal directions, (ii) the maximum shear stress, the accompanying normal stress and the direction of the planes. 25

4. (a) A plain carbon steel containing 0.1 wt. % C is slowly cooled from austenizing temperature to room temperature. Find the % of proeutectoid ferrite slightly above eutectoid temperature and % of eutectoid ferrite, cementite (Fe_3C) at eutectoid temperature. Also show schematically development of microstructures at different temperatures during cooling using Fe-C equilibrium diagram.

15

- (b) A beam 50 m long is supported at P and Q and loaded as shown in Figure 2. Sketch the SF and BM diagrams and find (i) the position and magnitude of maximum BM and (ii) the position of the point of contra flexure.

25



- (c) The following data is given for a 3600 hydrodynamic bearing : radial load = 1.4 kN, journal diameter = 60 mm, journal speed = 4500 rpm, bearing length = 60 mm, viscosity of oil = 25 cP, minimum film thickness = 50 microns, Sommerfeld number = 1.25, CFV = 6.12, FV = 4.41, specific gravity of lubricant = 0.91, specific heat of lubricant = 1.85 kJ/kg°C; inlet temperature of oil = 35°C; evaluate :
- (i) the corresponding coefficient of friction,
 - (ii) power lost in friction, (iii) temperature rise,
 - (iv) flow requirement and (v) average temperature of oil in the bearing.
- 20

SECTION – B

5. Answer any three of the following : $20 \times 3 = 60$
- (a) Find the diameter of a cylindrical riser to be used for a casting of $300 \times 250 \times 50$ cm rectangular plate. Assume height of the riser is equal to that of diameter. Riser takes 25% longer time to solidify.

(b) Arc voltage-arc length characteristics is $V = 40 + 20L$, where V is the arc voltage and L is the arc length in cm. Open Circuit Voltage(OCV) is 90V and short circuit current (ISC) is 900 amp. Power-source characteristic is a straight line. Find optimum arc length.

(c) Find the tangential cutting force, feed force and radial force during turning operation.

The tool signature of the cutting tool is $4^\circ - 7^\circ - 6^\circ - 7^\circ - 8^\circ - 75^\circ - 1.0 \text{ mm(ORS)}$.

The feed and depth of cut are 0.25 mm/revolution and 2.0 mm respectively.

Dynamic shear strength of work material is 400 N/mm^2 . Chip thickness is 0.150 mm. Use Lee and Shaffer theory.

(d) Check if the following transportation problem is balanced. Find its initial solution using North-West corner rule. Check if this

solution is (i) feasible, (ii) basic, (iii) degenerate and (iv) optimal.

		To			Available
		1	2	3	
From	1	7	3	4	2
	2	2	1	3	3
	3	3	4	6	4
Demand		4	1	5	

6. (a) A person requires 10, 12 and 12 units of chemicals A, B respectively for his garden. A liquid product contains 5, 2 and 1 units of A, B and C respectively per jar. A dry product contains 1, 2 and 4 units of A, B, C per carton. If the liquid product sells for Rs. 3 per jar and the dry product sells for Rs. 2 per carton. Formulate and solve the given problem in LPP in order to minimize the cost and meet the requirements. 15

- (b) A cylindrical impression with a diameter of 10 mm and depth of 1 mm has to be made on a tungsten carbide surface by USM. The feed force is constant and equal to 5 N. The average diameter of the abrasive slurry is 0.01 mm. The tool oscillates with amplitude of 30 μm at 20 kHz. The slurry contains 1 part of abrasive with 1 part of water. The fracture hardness of tungsten carbide is 7000 N/mm^2 . Estimate the machining time. 15

- (c) There are four jobs to be assigned to the machines. Only one job could be assigned to one machine. The amount of time in hours required for the jobs in a machine are given in the following matrix. Find an optimum assignment of jobs to the machines to minimize the total processing time and also, find for which machine no job is assigned. What is the total processing time to complete all the jobs ? 15

Jobs	Machine				
	A	B	C	D	E
1	4	3	6	2	7
2	10	12	11	14	16
3	4	3	2	1	5
4	8	7	6	9	6

- (d) Write a FORTRAN program to add the integer numbers from 1 to 100. 15
7. (a) A job $100 \times 50 \times 30$ mm is to be made from cast iron by casting process. Determine the dimensions of the wooden pattern assuming machining allowance of 2 mm on each side, shaking allowance of 1 mm on length and width, shrinkage allowance is 2%. 10
- (b) Give the differences between a nested query and correlated query with suitable examples in database management systems. 10

- (c) Annual demand for an item is 225 units. Ordering cost is Rs. 100 per order. Inventory carrying cost is 2.0% of the purchase price per unit per year. The price breaks are as shown below :

Quantity	Price (Rs.)
$Q_1 < 550$	10.00
$550 \leq Q_2 < 700$	9.20
$700 \leq Q_3$	8.70

Find the optimal order size. 20

- (d) The following table represents production data in units of T. V. set (in thousands) by a manufacturer : 20

Month	Sale
1	96
2	106
3	92
4	114
5	108

Month	Sale
6	98
7	99
8	115
9	106
10	91
11	102
12	99

Analyze the data from the standpoint of applicability of moving average technique.

Forecast the demand on 13th month by :

- (i) Moving average technique
- (ii) Exponential smoothing technique, with $\alpha = 0.2$
- (iii) Fit a simple regression for the above data

8. (a) A small post office has two open windows. Customers arrive according to a Poisson distribution at the rate of 1 every 3 minutes.

However, only 75% of them seek service at the windows. The service time per customer is exponential, with a mean of 5 minutes. All the arriving customers form one line and access available windows on a 'First come First serve' basis. (i) What is the probability that an arriving customer will wait in line ? (ii) What is the probability that both windows are idle ? (iii) What is the average length of the waiting line ? (iv) Would it be possible to offer reasonable service with only one window ? 20

(b) Determine the temperature rise at the shear plane in orthogonal cutting of brass of yield strength in shear of 200 N/mm^2 with a tool rake angle of 5° . The friction angle is 30° and 75% of heat is retained by the chip. Depth of cut is 1.5mm. Density of brass is 8.26 gm/cm^3 and specific heat 0.69 J/gm . 10

(c) Write a C program to find the highest number among J, K, L and M. 10

(d) Using the following information plot a network.

Determine the critical path. 20

Activity	Description	Immediate Predecessor(s)	Duration (Days)
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A	Forecasts Sales Volume	—	10
B	Study competitive market	—	7
C	Design item & facilities	A	5
D	Prepare production plan	C	3
E	Estimate cost of production	D	2
F	Set sales price	B, E	1
G	Prepare budget	E, F	14

