

MECHANICAL ENGINEERING (Paper I)

Time Allowed : Three Hours

Maximum Marks : 300

QUESTION PAPER SPECIFIC INSTRUCTIONS

(Please read each of the following instructions carefully before attempting questions)

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 the remaining, any THREE are to be attempted choosing at least ONE question from each Section.

The number of marks carried by a question/part is indicated against it.

Wherever any assumptions are made for answering a question, they must be clearly indicated.

Word limit in questions, wherever specified, should be adhered to.

SECTION 'A'

1. Answer any three of the following:

- (a) The link AB of a mechanism is 40 cm long and weights 30 N. It is undergoing plane motion in X-Y plane and the accelerations of its ends are: $a_A = 12 \text{ m/sec}^2$ at 10° from X-axis in counter clockwise direction, $a_B = 20 \text{ m/sec}^2$ at 60° in counter clockwise direction from AB (Refer the above figure). The centre of gravity of the link is at G where $AG = 20 \text{ cm}$. The radius of gyration of the link about Z-axis through G is 12 cm. Determine the forces F_A and F_B applied at A and B respectively to give above-mentioned accelerations, if F_A has a horizontal component of 60 N towards right. **20**

[Figure (printed above the text): X-Y axes with origin at A. Link AB rises from A at 45° to the X-axis; G is a point on AB between A and B. At A the acceleration a_A is drawn as an arrow at 10° above the X-axis. At B the acceleration a_B is drawn as an arrow pointing vertically downwards, with the angle between BA and a_B marked 60° .]

- (b) A circle of 100 mm diameter is inscribed on a steel plate before it is stressed. Then the plate is loaded so as to produce stresses as shown in the above figure and the circle is deformed into an ellipse. Determine the lengths of major and minor axes of the ellipse and their directions. Take modulus of elasticity of steel as 2.1 MN/cm^2 and Poisson's ratio 0.28. **20**

[Figure (printed above the text): Rectangular plate with a circle drawn at its centre (centre lines shown). Normal stress 12 kN/cm^2 tensile on the top and bottom faces (arrow up on the top face, arrow down on the bottom face). Normal stress 6 kN/cm^2 compressive on the left and right faces (arrows pointing into the plate). Shear stress 4 kN/cm^2 : on the top face directed to the left, on the bottom face directed to the right, on the left face directed upwards and on the right face directed downwards.]

- (c) A machine of mass 100 kg is supported on springs which deflect 8 mm under the static load. With negligible damping the machine vibrates with an amplitude of 5 mm when subjected to a vertical harmonic force at 80 per cent of the resonant frequency. When a damper is fitted it is found that the resonant amplitude is 2 mm. Determine: (i) the damping coefficient (ii) the critical damping coefficient (iii) damping ratio (iv) logarithmic decrement (v) the damping force **20**
- (d) What is 'heat treatment'? Differentiate clearly between 'Annealing' and 'Normalising'. **20**

2. (a) A shaft carries four masses in parallel planes A, B, C and D in order. The masses at B and C are 18 kg and 12.5 kg respectively and each has an eccentricity of 6 cm. The masses at A and D have an eccentricity of 8 cm. The angle between the masses at B and C is 100° and that between the masses at B and A is 190° (both angles measured in the same sense). The axial distance between the planes

A and B is 10 cm and between B and C 20 cm. If the shaft is in complete dynamic balance, determine (i) the masses at A and D (ii) the distance between the planes C and D. (iii) the angular position of the mass at D. **30**

- (b) Explain the term 'interference' as applied to involute gears. How could it be eliminated? Two standard full depth $14\frac{1}{2}^\circ$ involute gears have module of 5 mm. The pinion has 15 teeth while the gear has 60 teeth. Addendum is equal to the module. (i) Show that the gear will interfere with the pinion (ii) To what value should the pressure angle be increased in order to eliminate the interference? **30**

3. (a) A beam ABCD, 10 m long is supported at B, 1 m from end A and at C, x m from end D. The beam carries a point load of 10 kN at end A and a uniformly distributed load of 4 kN per metre run throughout its length. Determine the value of x if the centre of the beam is the point of contraflexure. Draw the bending moment diagram. **30**

[Figure (printed above the text): Overhanging beam ABCD. Point load 10 kN acting downwards at the left end A; uniformly distributed load 4 kN/m over the whole length A to D. Supports (upward reactions) at B, 1 m from A, and at C, distance x from the right end D.]

- (b) A hollow circular steel shaft is subjected to a torque of 800 N-m and a bending moment of 1200 N-m. The internal diameter of the shaft is 60% of the external diameter. Determine the external diameter of the shaft according to: (i) maximum principal stress theory (ii) maximum shear stress theory (iii) shear strain energy theory Take factor of safety as 2 and the yield strength of steel as 27 kN/cm^2 . **30**

4. (a) Differentiate between ceramics, polymers and composites. **15**
 (b) What is a 'hybrid composites'? State the principal applications of hybrid composites. **15**
 (c) Explain the following: (i) Process annealing (ii) Normalising (iii) Spheroidizing **15**
 (d) Explain the terms 'Natural aging' and 'Artificial aging'. **15**

SECTION 'B'

5. Answer any three of the following:

- (a) (i) Define tool life. What are the various ways of expressing tool life? Illustrate how wear land of a cutting tool grows with respect to machining time. (ii) A generalized Taylor's tool life equation was obtained for H.S.S. tool,

$$V = \frac{C}{T^{0.13} f^{0.6} d^{0.3}}$$

A 60 min tool life was obtained using the following cutting parameters, $V = 40 \text{ m/min}$, $f = 0.25 \text{ mm}$, $d = 2.0 \text{ mm}$ Compute the effect on tool life if cutting speed, feed and depth of cut are increased by 25% and also if they are increased individually by 25%. Where, V = cutting speed; f = feed; d = depth of cut. **10+10**

- (b) Define automation. What are the features of flexible automation? Illustrate with neat sketches two configurations of automated flow lines of production. **20**
- (c) (i) What is the objectives of break-even analysis? The cost of producing between 1500 units and 2500 units of a product consists of Rs. 25,000 fixed cost and Rs. 10 per unit variable cost. With the selling price at Rs. 20 per unit, what is the break-even point? Suppose the price per unit was increased to Rs. 25. Illustrate with a neat sketch how does this affect the break-even point. (ii) What are the various purposes of inventory control? According to the economic lot size formula, if the annual requirement for an item is 8,000 units, set up cost are Rs. 20, and the cost of holding the item

in inventory is Re. 0.20 per year, what is the economic lot size to order? Supposing the holding cost doubled to Re. 0.40 per year, what is the percentage effect on the order size? **20**

- (d) National Bank is considering opening a teller window for customer service. Management estimates that customers will arrive for service at the rate of 15 per hour. The teller whom it is considering to staff the window can service customers at the rate of one every three minutes. Because of limited space availability and a desire to provide an acceptable level of service, the bank manager would like to assure, with 95 per cent confidence, that not more than three customers will be in the system at any one time. Assume Poisson arrivals and exponential service, compute (i) utilization of the teller, (ii) average number in the waiting line, (iii) average number in the system, (iv) average waiting time in line, (v) average waiting time in the system. What is the present level of service for the three-person limit? What level of utilization of the teller must be attained and what must be the service rate of the teller to assure the 95 per cent level of service? **20**

6. (a)(i) What are the three basic components of NC system? Explain the principle of operation of NC system with the help of a neat sketch. Why it is essential to provide co-ordinate system in NC? What is the difference between fixed zero and floating zero co-ordinate system? **20**

- (a)(ii) A part program is to be written to drill the holes in the work part shown below. The part is 25 mm thick. The diameter of drill is ϕ 20 mm. **10**

[Figure: Rectangular plate 10.00 wide $\times$ 5.00 high (dimensions in cm) with five hole centres marked "+". Horizontal dimension chain from the left edge: 1.5, 2.5, 2.0, 1.0 (i.e. $x = 1.5, 4.0, 6.0, 7.0$). Vertical dimension chain from the bottom edge: 1.5, 1.5, 1.0 (i.e. $y = 1.5, 3.0, 4.0$). Holes at $(x, y) = (1.5, 4.0), (4.0, 4.0), (7.0, 4.0), (6.0, 3.0)$ and $(1.5, 1.5)$. Note under the figure: "Dimensions are in cm."]

(1) Define the x and y axes for the job. (2) Write manual part programming using word address format and an absolute position system. The speed and feed are manually set by the operator.

- (b) Illustrated by the simplified diagram explain the principle of electrical-discharge-machining process. What are the dielectric fluids commonly used in EDM? How metal removal rate can be controlled? Discuss briefly about the application of EDM. **30**

7. (a)(i) What do you understand by quality control by attributes and quality control by variables? **5**

- (a)(ii) Where do you need a larger sample size in the above and why? **5**

- (a)(iii) Four batches of products are inspected at 90 minute intervals and their percentage difference in weights from the nominal are given below: Percentage difference on weights in sample **20**

Batch-1	Batch-2	Batch-3	Batch-4
1.2	0.6	0.6	2.1
1.8	0.3	1.5	0.6
1.5	0.3	1.0	0.6
0.9	0.0	0.0	2.7
0.3	0.6	1.9	2.7

Assume that normal process average variation is 0.9% and process standard deviation is 0.5%, range U.C.L. is 5 times S.D. Plot $\bar{X}$, R chart indicating the various control limits. Is the process under control?

- (b) A company is producing a batch of five components A, O, E, N and L using three machines X, W, M. All these parts are to be produced in the technological order X, M, W machines. The sum of the processing and set-up times, in minutes for these parts in each of these machines are given below:

Component	X	W	M
N	8	5	3
A	4	6	4
O	7	7	3
L	5	8	4
E	6	4	4

- (b)(i) Find the sequence in which parts are to be produced to minimize total make span. **10**

- (b)(ii)** Are there alternative sequences? **4**
- (b)(iii)** Represent your schedule in the form of a Gantt chart with starting and ending timings. Neglect machine to machine shifting time. **10**
- (b)(iv)** What are the machine utilisation percentages for each machine if no other job is taken till the completion of this batch. **6**

- 8. (a)** Solve the following linear programming problem graphically:

$$x_1, x_2 \geq 0; x_1 + 4x_2 \leq 4; 2x_1 + 3x_2 \leq 6; \text{Max } Z = x_1 + 1.5x_2$$

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- (b)** Write a flow chart for choosing the largest of three distinct numbers X, Y and Z.

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