

MECHANICAL ENGINEERING
(Paper I)

Time Allowed : Three Hours	Maximum Marks : 250
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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.

Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page or portion of the page left blank in the Question-cum-Answer Booklet must be clearly struck off.

SECTION 'A'

1. (a) Draw a cranked-slider quick return mechanism and explain its principle with figure. **10**
(b) Explain the fundamental law of gearing with a neat sketch. **10**
(c) A circular punch, 20 mm in diameter, is used to punch a hole through a steel plate 10 mm thick. If the force necessary to drive the punch is 250 kN, determine the maximum shearing stress developed in the plate. **10**
(d) A spherical gas container made of steel has 5.4 m outer diameter and wall thickness of 10 mm. Knowing that the internal pressure is 400 kPa, determine the hoop stress and longitudinal stress in the container. **10**
(e) What are the advantages of tempering carbon steel? Show with the help of iron-carbon equilibrium diagram, how low, medium and high temperature tempering are done. **10**
2. (a) Consider a hollow circular shaft whose outside diameter is 0.0762 m and whose inside diameter is equal to one-half the outside diameter. The shaft is subjected to twisting moment of 2259.584 N-m as well as bending moment of 3389.376 N-m. Determine the principal stresses. Also determine the maximum shear stress. **20**
(b) For the beam shown in Figure 2(b), write the equations for the shear force and bending moment at any point. Also draw the shear force and bending moment diagrams. **20**
[Figure: Figure 2(b) – Horizontal beam with x-axis pointing to the right from its right end; total length 0.6096 m + 4.2672 m + 0.6096 m. A clockwise couple of 5423 Nm (curved arrow round the left end, rising from below the beam to an arrowhead at the top pointing right) acts at the left (free, overhanging) end; a pin (hinge) support is at 0.6096 m from the left end; a downward point load of 15568 N acts 4.2672 m to the right of the pin support, i.e. 0.6096 m from the right end; a roller support is at the right end]
(c) Find the centroid of the element shown in Figure 2(c). **10**
[Figure: Figure 2(c) – Plane lamina: a rectangle 200 mm wide and 140 mm high from which a rectangular notch 40 mm wide is cut at the top-right corner, the remaining right edge being 80 mm high (i.e. the notch is 40 mm × 60 mm, shown by dashed lines); a circular hole, marked 100 mm across its diameter, has its centre 100 mm from the left edge and 70 mm above the bottom edge]
3. (a) An epicyclic gear train consists of a pinion, a wheel of 40 teeth and an annulus with 84 internal teeth concentric with the wheel. The pinion gears with the wheel and the annulus. The arm that carries the

axis of the pinion rotates at 100 rpm. (i) Find the speed of the wheel. (ii) Find the speed of the annulus, if the wheel is fixed. **20**

- (b) A machine of mass 20 kg is mounted on springs and dashpot as shown schematically in the Figure 3(b). The total stiffness of the springs is 100 N/cm and the total damping is $1.5 \text{ N} \cdot \text{sec} \cdot \text{cm}^{-1}$. If the system is initially at rest and a velocity of 10 cm/sec is imparted to the mass, determine (i) the displacement and velocity of the mass as a function of time, (ii) the displacement and velocity at the time equal to one second. **20**

[Figure: Figure 3(b) – Mass m (block) supported on a fixed ground by two springs, each of stiffness $k/2$, one on each side, and a dashpot L between them]

- (c) What is the composition of maraging steel? What are its uses? Give the composition of austenitic stainless steel and state some of its applications. **10**

4. (a) An automobile with the distance between front and rear wheels 3.0 m and height of centre of gravity 300 mm is travelling over a roadway inclined at an angle θ with horizontal. The coefficient of static and dynamic friction are 0.6 and 0.5 respectively. The automobile is a rear wheel drive and has a load of 18 kN. What is the maximum inclination θ_{max} that the automobile can climb at uniform speed? **20**

- (b) A riveting machine is driven by a constant torque 4 kW motor. Each riveting operation takes 1 second and requires 9000 N-m of energy. A flywheel of mass 130 kg and radius of gyration 0.5 m is fitted to the riveting machine. If the speed of the flywheel is 420 rpm before riveting, find (i) the fall in the speed of the flywheel after riveting, (ii) the number of rivets fitted per hour. **20**

- (c) What are the advantages of annealing steel? Explain the process of annealing with a sketch of Time – Temperature transformation and ending with spheroidizing. **10**

SECTION 'B'

5. (a) What are the different tool wear causes that are responsible for wearing of tool? Explain crater, flank and wear. **10**
- (b) There are five jobs each of which must go through machines A, B and C in the order A – B – C. Processing times are as per the following table: **10**

Job i	Processing Time A_i	Processing Time B_i	Processing Time C_i
1	8	5	4
2	10	6	9
3	6	2	8
4	7	3	6
5	11	4	5

Determine the sequence for the five jobs that will minimize the elapsed time.

- (c) Derive the relationship between tensile and shear yield stresses by applying the following: (i) Von-Mises criterion (Maximum distortion energy) (ii) Tresca criterion **10**

- (d) Discuss the advantages and limitations of 'Process Layout'. **10**

- (e) A 20 mm diameter shaft and bearing are to be assembled with a clearance fit. The tolerance and allowances are as under: Allowance = 0.002 mm Tolerance on hole = 0.005 mm Tolerance on shaft = 0.003 mm Find the limits of size for the hole and shaft, if (i) the hole basis system is used, (ii) the shaft basis system is used. The tolerances are disposed off unilaterally. **10**

6. (a) In an orthogonal cutting operation, the tool has a rake angle = 10° . The chip thickness before the cut = 0.5 mm and the cut yields a deformed chip thickness = 1.125 mm. Calculate (i) shear plane angle, (ii) shear strain for the operation. Derive the formulae that are to be used while finding out the shear plane angle and shear strain. **20**

- (b) How is plasma arc welding different from tungsten inert gas welding (TIG)? Why is plasma arc welding associated with higher temperatures? With the help of neat sketches, explain transferred and non-transferred plasma arc welding. **20**
- (c) Briefly explain the different types of jigs. What do you understand by intermediate jig concept? **10**

7. (a)(i) Derive an expression for Economic Order Quantity (EOQ) when stock replenishment is non-instantaneous (Production Model) with the following assumptions: I. Item is sold and consumed at the constant rate which is known. II. Set-up cost is constant and does not change with lot size. III. The increase in inventory is not instantaneous but gradual. **10**

- (a)(ii) A contractor undertakes to supply diesel engines to a truck manufacturer at the rate of ₹ 25 per day. Cost of holding a completed engine in stock is ₹ 16/month. Production of engines is undertaken in batches. Each time a new batch is started, a set-up cost of ₹ 10,000 is required irrespective of the number of engines produced. How frequently should the batches be started and what will be the minimum average inventory cost and production time, if the production rate is 40 engines/day? Assume 300 working days in a year. **10**

- (b) A dairy firm has three plants located in a State. The daily milk production at each plant is as follow: Plant 1: 6 million litres Plant 2: 1 million litres Plant 3: 10 million litres Each day, the firm must fulfil the needs of its four distribution centres. The minimum requirement of each centre is as follows: Distribution Centre 1: 7 million litres Distribution Centre 2: 5 million litres Distribution Centre 3: 3 million litres Distribution Centre 4: 2 million litres Cost (in hundreds of rupees) of shipping one million litres from each plant to each distribution centre is given in the following table: **20**

Plant \ Distribution Centre	D_1	D_2	D_3	D_4
P_1	2	3	11	7
P_2	1	0	6	1
P_3	5	8	15	9

Find the initial basic feasible solution for minimum total cost by (i) Least Cost Method, and (ii) Vogel's Approximation Method.

- (c) Will Just-In-Time (JIT) work in service requirement as well as it works in production environment? Enlist the applications of JIT in service industry. **10**

8. (a) Use the dual simplex method to solve the following problem:

$$\text{Maximize: } z = -2x_1 - 3x_2$$

$$\text{subject to: } x_1 + x_2 \geq 2, 2x_1 + x_2 \leq 10, x_1 + x_2 \leq 8$$

with x_1 and x_2 non-negative.

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- (b) With the help of a neat schematic sketch explain the electrochemical machining process. Also discuss its applications. **20**
- (c) Discuss the advantages and limitations of NC manufacturing process. Also enlist the advantages of CNC manufacturing over NC manufacturing process. **10**
