

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 (each answer should not exceed 200 words): **20×3=60**
- (a) What is coriolis acceleration? Find the magnitude and direction of this acceleration in the following cases
[Figure: Fig-1, two sketches, (i) and (ii), each with x and y axes. (i) A rod through the origin inclined at about 45° to the x-axis, rotating about the origin with angular velocity ω (marked by a curved arrow at the origin); a slider on the rod moves along the rod away from the origin with velocity V (arrow pointing up the rod). (ii) The same arrangement with ω marked by a curved arrow at the origin; the slider moves along the rod towards the origin with velocity V (arrow pointing down the rod). The sense of ω in each sketch cannot be read with certainty from the copy [?]]
- (b) Deduce the condition under which a centrifugal governor becomes unstable.
- (c) What is a failure theory? Discuss its importance. Enumerate various failure theories and mention their fields of application
- (d) Draw Mohr's circle for a 2-dimensional stress field subjected to (i) pure shear (ii) pure bi-axial tension (iii) pure uni-axial compression (iv) pure uni-axial tension
2. (a) What is the effect of centrifugal force of the Transmission of power in a belt drive? A prime mover running at 300 r.p.m., drives a d.c. generator at 500 r.p.m. by a belt drive. Diameter of the pulley at the output shaft of the prime mover is 600 mm. Assuming a slip of 3%, determine the diameter of the generator pulley if the belt running over it is 6 mm thick. **30**
- (b) A spur gear pinion is driven by an electric motor of power 15 kW running at 740 r.p.m. pitch diameter of the pinion is 108 mm and speed reduction is 3:1. Module is 6 mm and the pressure angle is 20°. The pinion is mounted on a shaft located in symmetrical bearings over a span of 300 mm. The gear is overhanging by 50 mm on the left of two bearings 200 mm apart. Calculate the bearing reactions for the gear when the pinion rotates clockwise. **30**
3. (a) A compressor rotor having a mass of 55 kg is mounted on a shaft of stiffness $1.4 \times 10^7 \text{ N/m}$. determine the critical speed of the rotor assuming the bearings to be rigid. If the rotor has an eccentricity of 1000 micron and its operating speed is 6000 r.p.m., determine the dynamic response. The damping ratio in the system can be assumed to be 0.05. If the compressor is started from rest, what will be the maximum whirl amplitude of the rotor before it reaches its full operational speed? **30**
- (b) What is transmissibility? Discuss it with reference to a single degree of freedom (SDF) system having viscous damping. **30**

4. (a) The reciprocating mass per cylinder in a 60° V-twin engine is 1.2 kg. The stroke and the connecting rod length are 10 cm and 25 cm respectively. If the engine runs at 2000 r.p.m determine the maximum and minimum value of the primary and secondary forces. Also, find out the crank positions correspondence to these values. **30**
- (b) Develop an equation for the relationship between the angular velocities of the input and output cranks of a four-bar linkage **30**

SECTION 'B'

5. Answer any three of the following (each answer should not exceed 200 words) **20×3=60**

- (a) (i) Mention the crystal structures for the following elements: Iron; Chromium; tungsten; Nickel and Zinc. (ii) Sketch the following for an FCC structure: (iii) and $\langle 110 \rangle$ [?]
- (b) Write a FORTRAN programme for the amount payable (A) after n years on a principle amount (P) at a rate of interest (i%) compounded annually. The formula for calculating the amount is given below:

$$A = P \left(1 + \frac{i}{100} \right)^n$$

- (c) How do you define tool life? Describe the mechanisms of tool failure.
- (d) A machine shop manager has two machines that can do the same operations. The set up costs and the variable costs are given below.

Machine	Set-up cost (Rs.)	Variable cost/unit (Rs.)
A	80	2.40
B	800	0.90

A decision has to be taken to select the machine A or B to minimize the total cost of production when an order comes. (i) Determine the total cost equation for the two machines. (ii) At what volume of production do machines A or B breakeven? (iii) What is the decision rule?

6. (a) Two products X_1 or X_2 are to be produced which require machining on machines M_1 and M_2 and as per the following table: **30**

Machine	Machine hours required for X_1	Machine hours required for X_2	Total machine hours available
M_1	1	2	40
M_2	3	2	60

Profit contribution rates for X_1 and X_2 are Rs. 60 and Rs. 50 respectively. Obtain a solution for the manufacture of products X_1 and X_2 so as to maximize the profit.

- (b) A network is shown below (Fig2) in which A, B, C, D, E, F, and G are the activities having the durations 5, 4, 8, 5, 5, 4, and 9 respectively (i) Calculate the earliest start time, earliest finish time, latest start time, latest finish time and total slack for each activity using a deadline of 20 days for project completion. (ii) Indicate the critical path and its completion time. **30**

[Figure: Fig-2, activity-on-arrow network; only the start node O is labelled. From O three activities leave: E,5 (upper), F,4 (middle) and G,9 (lower). A,5 follows E; B,4 follows F; A and B end at the same node, from which D,5 runs to the final node; C,8 follows G and also ends at the final node]

7. (a) (i) Show with a neat sketch the forces acting on a chip in orthogonal machining. Derive an expression to calculate the coefficient of friction between tool chip interfaces. (ii) During an orthogonal machining operation on mild steel, the results obtained are: Uncut chip thickness = 0.25 mm; Chip thickness = 0.75 mm; Width of the cut = 2.5 mm; Rake angle = 0°; Horizontal cutting

force = 900 N; Thrust force = 400 N. Compute the coefficient of friction between the tool and chip interface. Determine also the ultimate shear stress of the work material **40**

(b) Differentiate between roughness and waviness. How do you measure the roughness of a ground surface using talysurf instrument? **20**

8. (a) Describe with a neat sketch the principle of explosive forming of sheet metal. Give examples of two components that are manufactured by high energy rate forming. **30**

(b) State basic principle of operation of CNC machine tools. Describe the essentials of control system used in position (point to point) and path control of the tool with respect to the work piece. **30**

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