

MECHANICAL ENGINEERING (Paper I)

Time Allowed : Three Hours	Maximum Marks : 300
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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.

SECTION 'A'

1. Answer any three of the following (each answer should not exceed 200 words): **20×3=60**
- (a) Explain clearly the difference in the nature of unbalance caused by primary and secondary disturbing force in case of a reciprocating mass. What is the essential difference between unbalance caused by a reciprocating mass and that caused by a revolving mass? How will you achieve the complete balance in the case of a multi-cylinder in line engine?
 - (b) Differentiate between kinematic analysis and synthesis. What is the significance of Chebyshev spacing points and how can you obtain them? Draw and explain the working of any one mechanism generating exact straight line.
 - (c) Define Effort and Power in relation to Governors. Obtain the expressions for these in the case of a Porter Governor.
 - (d) What is the classical Reynold's Equation for one dimensional fluid flow based on Hydrodynamic lubrication theory? What are the assumptions made in arriving at this equation? Explain the significance of Sommerfeld Number, Temperature Rise and Minimum Film Thickness for assessing a bearing performance.
2. (a) A solid circular uniformly tapered shaft of length l , with a small angle of taper is subjected to a torque T . The diameter at the two ends of the shaft are d and $1.2 d$. Determine the error introduced if the angular twist for a given length is determined on the basis of the uniform mean diameter of the shaft. **20**
- (b) A close coiled helical spring is of 80 mm mean coil diameter. The spring extends by 37.75 mm when loaded axially by a weight of 500 N. There is an angular rotation of 45° when this spring is subjected to an axial couple of magnitude 20.0 Nm. Determine the poisson's ratio for the material of the spring. **20**
- (c) A circular bar of diameter d is bent at right angle. It is fixed at one end and a load W is applied at the other end as shown in the figure. Determine the deflection under the load W if E & G are Young's and shear Moduli of the material.
- [Figure: Fig. 1. A circular bar of diameter d (marked "dia. d ") built in (fixed) at a wall at A. Portion AB of length a runs horizontally from the wall to the bend at B; portion BC of length b is bent through 90° from AB in the horizontal plane (the angle between AB and BC marked 90° ; BC drawn in perspective). A vertical load W acts downward at the free end C]
3. (a) A steel bracket is bolted to a column by three similar bolts as shown in the figure. It is subjected to an eccentric load of 30 kN as indicated. Determine a suitable minimum diameter for the bolts using

a factor of safety of 5.0. Assume the bracket and the attached plate to be rigid. Take the allowable stresses for the bolt material in tension as 600 MN/m^2 and in shear as 350 MN/m^2 . **30**

[Figure: (a) Front view of the bracket plate bolted to the column: two upper bolts, both marked D, on a horizontal line, at 154 [?] mm to the left and 160 [?] mm to the right of the vertical centre line; a third bolt E below them on the centre line. The 30 kN vertical load acts at 150 [?] mm from the centre line, in line with the right-hand bolt. (b) Side view: bracket bolted to the vertical column, the 30 kN downward load applied at 500 mm from the face of the column; the bracket tilts about its lower edge A at the column face; upper bolt force F_D at 400 mm above A and lower bolt force F_E at 100 mm above A]

- (b) A simply-supported beam is subject to the loading as shown in the figure. Calculate the deflection at a section 2.0 m from the end A. Assume $E = 70 \text{ GN/m}^2$ and $I = 830 \text{ cm}^4$. **30**

[Figure: Simply supported beam AB, hinged at A and on a roller at B, span 3.0 m (1.5 m + 0.9 m + 0.6 m). At 1.5 m from A a rigid vertical bracket attached to the beam carries two horizontal 10 kN forces 0.3 m apart (the upper one, at the top of the bracket above the beam, acting towards A; the lower one, below the beam, acting towards B), forming a couple. A uniformly distributed load of 20 kN/m acts over the 0.9 m length starting at 1.5 m from A; a concentrated load of 15 kN acts at the end of the distributed load, i.e. 0.6 m from B]

4. (a) The figure shows a schematic of an indicator mechanism. The arm pivoted at point O has a mass moment of inertia I and is constrained to move about O by two-spring-mass systems K_1 - m_1 and K_2 - m_2 and by another spring K_3 , as shown. Obtain an expression for natural frequency of small oscillations of the mechanism.

[Figure: Fig. 4. An L-shaped (bell-crank) arm pivoted at O at its corner. The vertical arm extends upward from O; at its top (height b above O) a horizontal link connects it to mass m_2 , which rests on rollers on a horizontal surface and is attached by spring K_2 to a fixed wall on the left. Spring K_3 is attached horizontally to the vertical arm at height a above O and to a fixed wall on the right. The horizontal arm extends to the right of O; at distance c from O mass m_1 hangs on it, supported below by spring K_1 to the ground]

- (b) A shaft and a disc system consists of a rotating shaft of length 0.5 m supported at its ends by self-aligning bearings and a disc of mass 10 kg mounted midway between the bearings. The diameter of the shaft is 20 mm and the disc has an eccentricity of 0.05 mm. Assume mass density of shaft as 7840 kg/m^3 and modulus of elasticity of shaft material as 210 GPa. Considering the shaft to be simply supported and the deflection shape function to be sinusoidal, determine the critical speed of the system taking into account the distributed mass of the shaft. Also, determine the dynamic bearing reactions at resonance when a 2 percent damping is assumed to be present. **40**

SECTION 'B'

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

- Sketch and discuss the defects in a lattice structure of a crystalline material.
- Draw a sketch of the rolling operation for a strip and indicate the forces and stresses during rolling. Discuss the aspects of friction and velocity during the process.
- Discuss the possible modes of failure of a cutting tool. For a lathe tool, show the flank and crater wears.
- Distinguish between Quality Control and Quality Assurance with particular reference manufacturing. Which is done first and why?

6. (a) Explain the mechanism of electric discharge machining. What is wire cut EDM? Indicate its special application. What are the basic requirements of a dielectric fluid? **30**

- (b) Distinguish between form error and surface roughness for an engineering component. How are these caused? How is surface finish measured and explain any one of its measure and the units used. **30**

7. (a) A company has to manufacture 1,50,000 brackets in a year. It orders raw material for the brackets in lots of 40,000 units from a supplier. It costs Rs. 40 to place an order and estimated inventory carrying costs are 20% of the item cost, which is Rs. 0.15. Calculate the variation (in %) in their order quantity from optimal, and what this variation cost. **20**
- (b) Justify the use of jigs and fixtures in large batch production. Briefly discuss the design of a jig required for drilling a hole of 5 mm in the centre of a 10 mm thick M.S. plate of size 100 x 100 mm. **20**
- (c) There are 'NSTUD' students in a class whose roll numbers are given in an array 'NROLL' and the marks obtained in the final examination are given in array 'TOTAL'. Write a program, in FORTRAN, to read roll numbers and corresponding marks of all the students and arrange them in order of merit. Assume the value of 'NSTUD' as 40. **20**
8. (a) The final product of firm has a requirement that it must weigh exactly 150kg. The two raw materials used in the manufacture of this product are A, costing Rs. 2 per unit, and B costing Rs 8 per unit. Each unit of A and B weighs 5kg and 10kg respectively. At least 14 units of B and no more than 20 units of A must be used. How much of each type of raw material should be used for each unit of the final product if cost is to be minimised? **20**
- (b) Consider a project with following precedence requirements and estimated times: **20**

Activity	Time in weeks	Immediate Predecessor
A	3	-
B	5	-
C	7	-
D	3	C
E	7	A, B
F	3	E, D
G	2	D
H	2	F, G

Draw the CPM network and find the critical path.

- (c) Define Value Engineering and explain its role in a manufacturing enterprise. List down the questions which need to be answered when carrying out value analysis for a product. Take a suitable example to illustrate your reply. **20**
