

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:

- (a) The turning moment diagram for a quadruple expansion marine engine drawn to the following scales: 1 cm = 15 ton-m and 1 cm = 15°. The areas of the loops above and below the mean turning moment line taken in order are 0.12, 0.34, 0.91, 0.81, 0.15, 0.18, 1.86 and 1.71 cm^2 . If the moment of inertia of the propeller and entrained water is 100 ton-m^2 and the mean speed of rotation is 100 r.p.m., what is the value of the coefficient of fluctuation of speed? 20

- (b) A compound tube is made by shrinking a thin steel tube on a thin brass tube. The areas of cross-section of these tubes are A_s and A_b , while the Young's moduli are E_s and E_b , respectively. Show that for any tensile load, the extension of the compound tube is equal to that of a single tube of the same length and total cross-sectional area, but having a Young's modulus of $\frac{E_s A_s + E_b A_b}{A_s + A_b}$ 20

- (c) A steel rod of square cross-section is loaded as shown in the figure. 20

[Figure: Stepped bar of three segments, each 2 m long, fixed to a wall at its left end. Segment 1 (next to the wall): solid square section 25 mm side; a force of 100 kN acts at its right end, directed to the left (towards the wall). Segment 2: solid square section 20 mm side (same outer size as segment 3); a force of 75 kN acts at its right end, directed to the left. Segment 3: hollow square section, 20 mm outside with a 10 mm square hole (cross-section sketch shows a hollow square, 20 mm wide and 20 mm high); a force of 25 kN acts at the free right end, directed to the right (away from the wall). Lengths marked 2 m, 2 m, 2 m.]

Find the section which is subjected to maximum stress, its magnitude and nature. What will be total change in its length? Take $E = 200 \text{ GPa}$.

- (d)(i) What is a slip system? What is its significance? 10

- (d)(ii) Explain the term crystallographic anisotropy. 10

2. (a) An automobile fitted with a spring loaded Hartnell governor, the flyballs of it rotate at 500 r.p.m. having radius of rotation of 7 cm with sleeve in mid-position and balls arms vertical. The length of ball and sleeve arms is same. The maximum sleeve movement is 2 cm with $\pm 5\%$ variation in speed. The mass of the sleeve is 5 kg and the friction may be assumed to be equivalent of an additional load of 30 N at the sleeve. The effort of governor is sufficient to overcome the friction of the sleeve caused by 1% change of speed at mid-position. Calculate– (i) the mass of flyballs; (ii) the spring rate; (iii) the initial compression of the spring; (iv) the governor effort for 1 % change of speed; (v) the power of governor 30

- (b) The disc of a torsional pendulum has a moment of inertia of 600 kg-cm^2 and is immersed in a viscous fluid. The brass shaft attached to it is of 10 cm diameter and 40 cm long. When the pendulum is vibrating, the observed amplitudes on the same side of the rest position for successive cycles are 9° , 6° and 4° . Find (i) logarithmic decrement, (ii) damping torque at unit velocity and (iii) the periodic time of vibration. Assume for brass shaft $C = 4.4 \times 10^{10} \text{ N/mm}^2$. What would be the frequency, if the disc is removed from viscous fluid? **30**
3. (a) A hollow column, 400 mm external diameter and 300 mm internal diameter, is hinged at both ends. If the length of column is 5m, $E = 0.75 \times 10^5 \text{ N/mm}^2$, factor of safety 5, Rankine's constant $1/1600$ and crushing stress 587 N/mm^2 , find the safe load the column can carry without buckling. Use Euler's and Rankine formulae. **30**
- (b) A solid circular shaft running at 110 r.p.m. is used to transmit a power of 30 kW and produces safe stress of 80 N/mm^2 . Find the diameter of shaft. If this shaft is replaced by a hollow shaft having ratio of external diameter to internal diameter of 2, what percentage saving of weight can be achieved, the length and material of the shafts remain same? **30**
4. (a) In a tabulated form briefly outline the procedure, general characteristics and two typical applications of carburizing, cyaniding and boronizing processes. **20**
- (b) Name any four commonly used reinforcing fibres used in plastic composites. What are their properties and applications? **20**
- (c) What elements are generally alloyed to aluminum? What are their effects? **10**
- (d) Explain the mechanism of fatigue and creep failures. **10**

SECTION 'B'

5. Answer any three of the following:
- (a) In an orthogonal cutting operation, the following data have been observed: Uncut chip thickness = 0.127 mm Width of cut = 6.35 mm Cutting speed = 2 m/s Rake angle = 10° Cutting force = 567 N Thrust force = 227 N Chip thickness = 0.228 mm Determine the shear angle, the friction angle, shear stress along the shear plane, and the power for the cutting operation. Also find the chip velocity, shear strain in chip, and the strain rate. **20**
- (b) With the help of a neat sketch, explain the electro-hydraulic forming process for making tubular parts and list the variables governing the process. What are the main applications of this process? **20**
- (c) Explain the difference between operation chart, activity chart, and flow process chart. What are their respective areas of application? **20**
- (d) Explain Johnson's procedure for determining an optimal sequence for processing n items on two machines. Determine the optimal sequence of jobs which minimizes the total elapsed time based on the following information (processing time on machines is given in hours and passing is not allowed): **20**

Machines	A	B	C	D	E
M1	5	7	6	9	5
M2	2	1	4	5	3
M3	3	7	5	6	7

6. (a) With a neat sketch, explain the working of ECM machine. How the machining rate is influenced by (i) rate of electrolytic flow, (ii) temperature of electrolyte, and (iii) applied voltage? What are the main applications of the process? **30**
- (b) Differentiate between point-to-point and continuous path control systems used in NC machines. What are their respective areas of application? **15**

(c) Illustrate the uses of the following preparatory functions: G01, G02 and G03 15

7. (a) Samples of $n = 8$ items each are taken from a manufacturing process at regular intervals. A quality characteristic is measured, and $\bar{x}$ and R values are calculated for each sample. After 50 samples, we have $\sum_{i=1}^{50} \bar{x}_i = 2000$; and $\sum_{i=1}^{50} R_i = 250$. Assume that the quality characteristic is normally distributed.

(i) Compute control limits for the $\bar{x}$ and R control charts. (ii) All points on both control charts fall between the control limits computed in part (i). What are the natural tolerance limits of the process? (iii) If the specification limits are 41 ± 5.0 , what are your conclusions regarding the ability of the process to produce items within these specifications? (iv) Assuming that if an item exceeds the upper specification limit it can be reworked, and if it is below the lower specification limit it must be scrapped, what percent scrap and rework is the process producing? (v) Make suggestions as to how the process performance can be improved. 30

[Figure: Statistical tables printed with the paper (four pages): (1) "Cumulative distribution function for the standard normal distribution (SND)" – sketch of the $N(0, 1)$ curve with the area to the left of z shaded, note "For the SND, the table

gives the cdf value at z , that is $\int_{-\infty}^z N(0, 1) dz$ ", tabulated for $z = -3.5$ to $+3.5$ in steps of 0.1 (columns 0.00 to 0.09); (2)

"Factors for constructing variables control charts" – chart for averages (factors A, A_2, A_3), chart for standard deviations (factors $C_4, 1/C_4, B_3, B_4, B_5, B_6$) and chart for ranges (factors $d_2, 1/d_2, d_3, D_1, D_2, D_3, D_4$) for $n = 2$ to 25, with the formulae for $n > 25$.]

- (b) A small electronics company produces pocket calculators and records the demand monthly. The following demand data are for a representative calculator: November 45; December 57; January 60. Using 50 as the first-order exponential smoothing forecast for November, forecast February sales with a smoothing constant of 0.2. Is 0.2 a good choice as a smoothing constant? Comment. 10

- (c) A cottage industry produces two types of toys which are sold with a profit margin of Rs. 10 for toy 1 and toy 2 respectively. The assembly cost and packing cost for one unit of type 1 are Rs. 4 and Rs. 5 respectively, and corresponding figures for type 2 are Rs. 5 and Rs. 2. The expenditure on assembly and packing is to be kept strictly within and up to Rs. 100 and Rs. 80 respectively. Using Simplex Method, calculate the number of toys of each type to be manufactured to get maximum profit. 20

8. (a) What is 'Lay'? Describe with neat sketches and symbols the types of lay produced by different machining processes. 20

- (b) What is the function of a clamp? Describe the design and operational factors to be considered for proper and adequate clamping of a workpiece. 20

- (c) Write a flow chart to solve the quadratic equation $ax^2 + bx + c = 0$. Write also the corresponding C program. 20
