

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) A 15 mm diameter shaft rotates in long fixed bearings 60 cm apart. A rotor of mass 20 kg is mounted at the mid span. The mass centre of the rotor is 0.5 mm from the shaft axis. If the bending stress in the shaft is not to exceed 120 MPa, find the range of speed over which the shaft must not run. Take modulus of elasticity for the shaft material as 200 G N/m^2 . **20**
- (b) A round member is subjected to a direct tensile load of 20 kN and a shear load of 12 kN. The yield stress in tension is 25 k N/c m^2 and Poisson's ratio is 0.3. Determine the diameter of the member, using a factor of safety 2, according to (i) Maximum principal stress theory (ii) Maximum shear stress theory (iii) Maximum distortion energy theory. **20**
- (c) A flat belt drive is to transmit 110 kW at a belt speed of 25 m/s between two pulleys of diameter 250 mm and 400 mm. The centre distance between the pulleys is 1 m. The permissible stress in the belt is 8.5 M N/m^2 . Thickness to width ratio of the belt is 0.1 and the density of the belt material is 1100 k g/m^3 . The coefficient of friction between the belt and pulleys is 0.3. Determine the minimum required belt width. What would be the necessary installation force between the pulley bearings and the force when full power is being transmitted? **20**
- (d) Give composition and application of following: (i) Stellite (ii) Phosphor Bronze (iii) Muntz Metal (iv) Alnico. **20**

2. (a) A press has to punch 30 holes per minute and the motor delivers 1.5 kW to the press uniformly. If the actual punching of each hole is accomplished during 30° of crank rotation of the punching machine and the fluctuation of speed is not to exceed $\pm 10\%$, determine the minimum moment of inertia of the flywheel which is directly mounted on the crankshaft. Neglect the inertia of the rest of the system. **30**

- (b) Fig. 1 shows a planetary gear train that has two inputs ω_2 and ω_6 ; Sun gear 2 rotates at 500 r.p.m. and the arm 6 rotates at 750 r.p.m. both clockwise as viewed from left. Determine the speed and direction of rotation of the output gear 5. **30**

[Figure: Fig. 1 – Planetary gear train. Input shaft entering from the left carries the sun gear 2 (18 T) and is driven at ω_2 ; the arm 6 is mounted on a hollow shaft around the input shaft (supported in the left frame bearing 1) and is driven at ω_6 . The arm carries a compound planet consisting of gear 3 (22 T), meshing with sun gear 2, and gear 4 (25 T), meshing with gear 5 (15 T). Gear 5 is fixed on the output shaft, coaxial with the input shaft, supported in the right frame bearing 1.]

3. (a) At a point in a material under stress, the intensity of the resultant stress on a certain plane is 50 MN/m^2 (tensile) inclined at 30° to the normal of that plane. (Refer fig. 2) The stress on a plane at right angles to this plane has a normal tensile component of intensity of 30 MN/m^2 . Find (i) The resultant stress on the second plane (ii) The principal planes and stresses (iii) Maximum shear stress and the plane on which it occurs. **30**
- [Figure: Fig. 2 – Two mutually perpendicular planes through the point, shown as hatched lines: a vertical plane and a horizontal plane meeting at a corner. On the vertical plane the resultant stress of 50 MN/m^2 acts outward at 30° to the horizontal normal of that plane. On the horizontal plane a normal (tensile) stress of 30 MN/m^2 acts vertically upwards.]
- (b) A simply supported beam of length 'L' carries a concentrated load 'W' at a distance 'a' from one end and 'b' from the other ($a > b$). Find the position and magnitude of the maximum deflection and show that the position is always within $L/13$ approximately from the centre of the beam. **30**
4. (a) State: (i) Gibbs phase rule and lever rule (ii) Isomorphous system (iii) Peritectic reaction in steel **15**
- (b) Explain: (i) Strain Aging (ii) Eutectoid steel (iii) Dead Mild steel. **15**
- (c) What is TTT diagram for steel? How is it used in designing heat treatment cycle for steels? **15**
- (d) Differentiate among pearlite, ferrite, martensite and austenite. **15**

SECTION 'B'

5. Answer any THREE of the following:-

- (a) List the criterion for tool life evaluation for HSS or ceramic tool and sintered carbide tool. Show the variables used in figures. **20**
- (b) A turning tool with sharp corner and a major cutting edge angle of 60° is to be used at a feed of 0.05 mm. What minor cutting edge angle should be provided to obtain an arithmetical mean surface roughness of $3 \mu\text{m}$ under ideal condition? **20**
- (c) What is value analysis and in what way it is different from conventional cost reduction techniques? How can the value be increased? Discuss a value analysis programme, step by step, for improving a product viz. "BALL POINT PEN". Can this technique be applied to service activities? **20**
- (d) Differentiate between method study and motion analysis. How are they used in job design? The elemental times (in minutes) for 4 cycles of an operation using a time measuring device are presented below. **20**

ELEMENTS	C1	C2	C3	C4
1	3.0	3.0	2.6	2.8
2	5.2	5.4	4.8	5.2
3	6.6	6.4	6.8	6.8
4	2.4	2.4	2.2	2.4
5	1.02	1.02	1.04	0.96

Calculate standard time for the operation, if (i) Elements 2 and 4 are machine dependent. (ii) For other elements, the operator is rated at 110%. (iii) Total allowances are 15% of the normal time.

6. (a) (i) For small feeds, the apparent shear strength of a material increases with decreases in undeformed chip thickness. Why? (ii) The relation between shear angle, friction angle and rake angle derived using Merchant's theory are not in quantities agreement with experimental relationship. State the reasons. **30**
- (b) During turning process with $7-\alpha-6-6-8-30-1 \text{ mm}$ (ASA) tool the undeformed chip thickness of 0.2 mm and width of cut of 2.5 mm were used. The side rake angle of the tool was a chosen that the machining operation could be approximated to be orthogonal cutting. The tangential cutting force

and thrust force were 1177 N and 560 N respectively. Calculate (i) The side rake angle (ii) Coefficient of friction at the rake face. (iii) The dynamic shear strength of the work material. **30**

7. (a) A hole and shaft have a basic size of 30 mm and are to have a clearance fit with maximum clearance of 0.04 mm and a minimum clearance of 0.02 mm. The hole tolerance is to be 1.5 times the shaft clearance. Determine limits for both hole and shaft using (i) a hole basis system (ii) a shaft basis system. **30**

- (b) Sun Ray Transport Corporation (SRTC) ships truck loads of grain from 3 godowns to 4 mills. The supply (in truck loads) and the demand (also in truck loads) together with the unit transportation cost per truck load on different routes are given in the adjoining table. Cost of transportation is given in the north-eastern corner in 100's of rupees **30**

GODOWNS / MILLS	A	B	C	D	SUPPLY
P	10	2	20	11	15
Q	12	7	9	20	25
R	4	14	16	18	10
DEMAND	5	15	15	15	

(i) What is north-west corner rule? (ii) How do you check for degeneracy? (iii) Design the quantity to be transported from each godowns to different mills, with the objective of cost minimization of transporting. Develop this using Vogel's approximation (or penalty rating) method (VAM). (iv) How do you check for optimality of the solution?

8. (a) What do you understand by inspection of attributes and inspection of variables? In which case the sample size (for the same confidence level) is more and why? Weight of pineapple cans with fruit and juice is measured in kg from a continuous production run. Every day a sample of 4 cans are picked up at random and weighed. The data so collected are given in the following table. Plot the $\bar{X}$ and R charts with their control limits. What is your observation of behavior? What suggestions you wish to make for a proper control of the process? **30**

DAY	1	2	3	4
Day-1	1.20	1.24	1.25	1.25
Day-2	1.24	1.28	1.28	1.14
Day-3	1.10	1.20	1.26	1.26
Day-4	1.18	0.98	1.18	1.16

Constant A for control limits of $\bar{X}$ = 0.729 B for control limits of R = 2.282

- (b) A plant manufactures two products A and B, using three inputs, labour, material R and material S. To make one unit of product A, it requires 6 kg of R and 7.5 kg of S, and 9 person-hours of labour. To make one unit of B it requires 12 kg of R and 4.5 kg of S and 6 person-hours of labour. The demands for the products are such that the plant can sell as much of each of the product as it can produce. It earns a profit of Rs. 30 per unit of A and Rs. 40 per unit of B. However only 900 kg of R and 675 kg of S and 1200 person-hours of labour are available each day. (i) Formulate the plant's strategy as a linear program to maximize the profit. (ii) Indicate the feasible region in a graphical representation of the problem. (iii) Solve the problem graphically by finding the optimum operating point. What is the maximum profit? **30**
