

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) Obtain the expressions for primary and secondary forces for a V-twin engine having two identical cylinders lying in a plane. The included angle between the cylinder centre lines is 2α .
 - (b) What is Arnold-Kennedy theorem of three centres? State its importance in kinematic analysis of mechanisms.
 - (c) What should be the ratio of thickness of a thin cylindrical shell to the thickness of its hemispherical end for a pressure vessel subjected to internal fluid pressure so that the junction section remains free from unequal deformation?
 - (d) Explain the use of controlling force curves in the determination of stability of a centrifugal governor.
2. (a) Obtain the angle of twist of one end relative to the other of a tapered shaft having radii r_1 and r_2 at its ends and of length l . The shaft is subjected to equal and opposite torque T at its ends. Modulus of rigidity of the shaft material is G .
- (b) A steel rotor disc of uniform thickness 50mm has an outside diameter 800mm and a central hole of diameter 150mm. There are 200 blades each of weight 2 N at an effective radius of 420mm pitched evenly around the outer periphery of the disc. Determine the maximum rotational speed such that maximum shearing stress in the disc does not exceed 375 MN/m^2 . Take density (ρ) of the steel as 7470 kg/m^3 . Following basic relation for radial stress (σ_r) and hoop stress (σ_θ) at radius of rotating disc at ω rad/sec can be used with usual

$$\sigma_r = A - \frac{B}{r^2} - (3 + \gamma) \frac{\rho \omega^2 r^2}{8}$$

$$\sigma_\theta = A + \frac{B}{r^2} - (1 + 3\gamma) \frac{\rho \omega^2 r^2}{8}$$

3. (a) Figure given below shows a rotating cantilever leaf spring with flexural rigidity EI and carrying a mass m at its free end. Neglecting the mass of the spring. Determine the natural frequency of vibration of the system. The angular speed of the shaft is Ω .

[Figure: A vertical shaft rotating at angular speed Ω (curved arrow at the top of the shaft) carries a circular hub (disc). A flexible leaf spring of length l is clamped to the rim of the hub and projects radially outward; the radius of the hub (from the shaft axis to the root of the spring) is marked r . A mass m is attached at the free end of the spring; a curved double-headed arrow at the mass shows its vibration in the plane of rotation]

- (b) The Shear Force diagram for rectangular cross-section beam AB is shown in the figure given below. Width of the beam is 100 mm and depth is 250 mm. determine the maximum bending stress in the beam.

[Figure: SF diagram for beam AB divided into three segments of 1m, 1m and 1 [?] m. At A the shear force jumps to 15 kN (drawn below the base line) and stays constant over the first 1 m; at 1 m from A it steps up (reduces in magnitude) by an amount marked with a small dimension arrow whose value is illegible [?] and stays constant over the second 1 m; at 2 m from A it steps up again by a second illegible amount [?]; over the last 1 m it varies linearly to zero at B]

4. (a) A tank having liquid capacitance C_1 is supplying liquid through a pipe of resistance R_1 to another tank of liquid capacitance C_2 which delivers this liquid through another pipe of resistance R_2 . The steady-state outflow rates of tank 1 and that of tank 2 are Q_1 and Q_2 and heads are H_1 and H_2 respectively. The flow balance equation for tank 1 is

$$\Delta Q = \Delta Q_1 + C_1 \frac{d}{dt} (\Delta H_1)$$

Similarly for tank 2 is

$$\Delta Q_1 = \Delta Q_2 + C_2 \frac{d}{dt} (\Delta H_2)$$

where $\Delta Q_1 = (\Delta H_1 - \Delta H_2)/R_1$; $\Delta Q_2 = \Delta H_2/R_2$ and Δ 's show small variations of quantities. Draw the overall feedback block diagram of the system and obtain the transfer function

[Figure: Two open tanks side by side, "Tank 1" (capacitance C_1) on the left and "Tank 2" (capacitance C_2) on the right, both containing liquid. Inflow Q enters Tank 1 from the top through a valve. A pipe at the bottom of Tank 1 carries flow Q_1 (labelled below the pipe) to Tank 2; a pipe at the bottom of Tank 2 discharges to the right (arrow; its label is not legible in the copy)]

- (b) The steel bolt shown in figure given below has a thread pitch of 1.6 mm. If the nut is initially tightened up by hand so as to cause no stress in the copper spacing tube calculate the stress induced in the tube and in the bolt if a spanner is then used to turn the nut through 90° . Take E_c and E_s as 100 GPa and 209 GPa respectively.

[Figure: A "10 mm dia steel bolt" passes through a copper spacer tube ("Copper space[r] 12 mm inside dia") held between two end washers/plates by the bolt head and the nut; overall outside dimension of the assembly marked 18 mm; length of the tube between the plates marked "0 m" [?]]

SECTION 'B'

5. Answer any three of the following (each answer should not exceed 200 words): 20×3=60
- (a) How does grain size in a poly crystalline solid affect the strength of the solid? What happens to grain size in (i) forging (ii) rolling
- (b) What is form stability of a cutting tool? Discuss the properties required for an ideal cutting tool material.
- (c) Write complete program in C-language to obtain the output: Civil Services Examination.
- (d) Explain with the help of a suitable sketch the working principle of a typical pulsed ruby laser machining system.
6. A factory has a tool crib where mechanic come to check out special tools needed for the completion of a particular task assigned to them. A study is made of the time between arrivals and of the time required for service. Both distributions are found to be adequately described by the negative exponential. The average

time between arrivals was found to be 50 seconds. Determine the waiting line length, waiting time and the percent of the idle time of the attendant. If the attendant is paid Rs. 2/- per hour and the mechanics are paid Rs. 4/- per hour, what policy or service should be established? What cost function should be minimized? When will a multi-channel single phase situation arise? **60**

7. (a) Determine the workload and frictional power loss for simple forward extrusion with a flat face die. **30**

- (b) Figure given below illustrates various types of common deep drawing defects. Name the defects and the probable reasons for their development. **30**

[Figure: Six unlabelled sketches of defective deep-drawn parts in two rows. Top row: (1) a square box-shaped part with a torn/folded corner and streaked walls; (2) a small cylindrical cup with a wavy (eared) rim and vertical streaks on the wall; (3) a cup with a wide flange. Bottom row: (4) a shallow flanged cup; (5) a cylindrical cup with vertical marks on the wall; (6) a flanged cup with a wavy flange and marked walls]

8. (a) The frictional force $f(x)$ acting on a body is expressed by the following:

$$f(x) = 0 \quad |x| \leq 0.5$$

$$2x^2 \quad \text{for } x > 0.5$$

This function is required to be used in the following equation:

$$g = \left(\frac{mv}{t} \right) - f(v^2) + at$$

Write a FORTRAN programme for the stated problem. **30**

- (b) Explain the meaning of cutting tool failure and discuss its modes and causes. **30**
