

MECHANICAL ENGINEERING**Paper—I**

Time : Three Hours

Full Marks : 300

*Candidates should attempt Question No. 1 from Section-A and Question No. 5 from Section-B which are compulsory, and any **THREE** of the remaining questions, selecting at least **ONE** from each Section.*

All questions carry equal marks.

SECTION—A

1. Answer any **THREE** of the following :—

- (a) A punching press is required to punch 30 mm diameter holes in a plate of 20 mm thickness at the rate of 20 holes per minute. It requires 6 Nm of energy per mm^2 of sheared area. If punching takes place in $1/10$ of a second and the rpm of the flywheel varies from 160 to 140, determine the mass of the flywheel having radius of gyration of 1 meter. 20

- (b) A steel tube 24 mm external diameter and 18 mm internal diameter encloses a copper rod 15 mm diameter to which it is rigidly joined at each end. If at a temperature of 10°C there is no longitudinal stress, calculate the stresses in the rod and tube when the temperature is raised to 200°C .

Take $E_{\text{steel}} = 210,000 \text{ N/mm}^2$

$E_{\text{copper}} = 100,000 \text{ N/mm}^2$

Coefficient of linear expansion,

$L_{\text{steel}} = 11 \times 10^{-6}/^{\circ}\text{C}$

$L_{\text{copper}} = 18 \times 10^{-6}/^{\circ}\text{C}$. 20

- (c) A cylindrical shell made of mild steel plate at 1.2 m in diameter is to be subjected to an internal pressure of 1.5 MN/m^2 . If the material yields at 200 MN/m^2 , calculate the thickness of the plate on the basis of the following three theories, assuming a factor of safety 3 in each case :

- (i) Maximum principal stress theory
- (ii) Maximum shear stress theory and
- (iii) Maximum shear strain energy theory. 20

- (d) (i) What is creep curve ? How are various stages in creep identified ? 6

In which stage a part of structure will generally be during service ? 2

At what temperature creep becomes an important design problem ? 2

- (ii) What is 'fatigue' and why the study of fatigue has become so important ? 5

What are the variables that affect fatigue ? 5

2. (a) A V-twin engine has the cylinder axes at right angles and the connecting rods operate a common crank. The reciprocating mass per cylinder is 10 kg and the crank radius is 80 mm. The length of connecting rod is 0.4 m. Show that the engine may be balanced for primary forces by means of a revolving balance mass. If the engine speed is 600 rpm, what is the value of maximum resultant secondary force ? 30

- (b) A rotating machine of mass 650 kg, operating at a constant speed of 1500 rpm, has an unbalance of 0.12 kgm. If the damping in the isolators is given by damping ratio of $\xi = 0.08$, determine stiffness of the isolators so that the transmissibility

at the operating speed is less than or equal to 0.15. Also determine the magnitude of the force transmitted. 30

3. (a) A composite spring has two close-coiled helical springs connected in series; each spring has twelve coils at a mean diameter of 25 mm. Find the wire diameter in one if the other is 2.5 mm and the stiffness of the composite spring is 700 N/m.

Estimate the greatest load that can be carried by the composite spring and the corresponding extension for a maximum shearing stress of 180 N/mm^2 . Take the value of $G = 80,000 \text{ N/mm}^2$. 30

- (b) Three beams have the same length, the same allowable stress and the same bending moment. The cross-sections of the beam are a square, a rectangle with depth twice the width and a circle. Determine the ratios of the weights of the circular and the rectangular beams with respect to the square beam. 30

4. (a) Define the following terms associated with crystallography :

(i) Crystal

(ii) Space lattice

(iii) Unit cell

(iv) Atomic planes

(v) Miller Indices

(vi) Atomic packing factor. 9

- (b) Indicate the structures of the following metallic crystals :

Copper (Cu), Lead (Pb), Chromium (Cr)

Nickel (Ni), Zinc (Zn), Magnesium (Mg). 6

- (c) Show that the atomic packing factors for BCC and FCC structures are 0.68 and 0.74 respectively. 10

- (d) Give classification of imperfections in metal crystals and their effect on metal properties. 10

- (e) List the four classifications of steels. For each, briefly describe the properties and typical applications. 15

- (f) A continuous and aligned glass fiber-reinforced composite consists of 40 vol % of glass fibers having a modulus of elasticity of 69 GPa and

60 vol % of a polyester resin that, when hardened, displays a modulus of 3.4 GP_a . Compute the modulus of elasticity of this composite in the longitudinal direction. 10

SECTION—B

5. Answer any **THREE** of the following :—

- (a) Describe different pattern allowances and their necessities in a sand casting process. 20
- (b) A cutting tool could be used to machine 30 parts while machining at a spindle speed of 800 RPM. The tool could be used to machine 40 parts at a spindle speed of 400 RPM. How many parts can be produced at a spindle speed of 630 RPM ? 20
- (c) In a work study analysis, determine the number of observations required to obtain an accuracy of $\pm 5\%$ and confidence level of 95%, if the worker is found idle for half of the number of observation times. 20
- (d) Determine the control limits in SQC method for use in a car manufacturing company if the number defects observed in each of the consecutively

produced car (before inspection) are 20, 10, 12, 10, 8, 9, 11, 8, 6, 10, 12, 8, 9, 7, 6. 20

6. (a) Draw Merchant's force diagram and derive the relation between three angles in metal cutting. State clearly any assumptions made in the derivation. 30
- (b) Describe the process of thermit welding, its applications, and advantages over other three welding processes. 30
7. (a) The annual sale of bicycles in a town for the last five years is given as 600, 800, 700, 900 and 950. Determine the forecast of the expected sales for the next period using three period moving average method. 15
- (b) The demand for cars in a town for five consecutive years is given as 600, 800, 700, 900 and 950. If single exponential smoothing method is used with a value of 0.2, determine the forecast value for the sixth year. Use a seed value of 700 for the first period. 15
- (c) Derive an equation to determine economic order quantity for placing a purchase order in an

inventory model where the consumption rate is constant. 15

- (d) Determine the critical path in a project consisting of activities A to G with their durations in hours are marked in the precedence diagram as shown in Fig. 1. 15

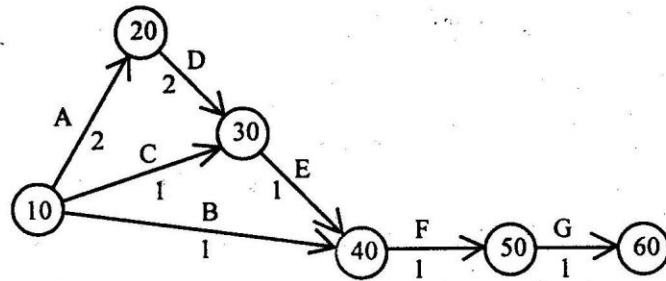


Fig. 1
Precedence diagram of seven
activities in a project.

8. (a) A goods train consists of one engine, 48 wagons and one guard compartment. While the train moves slowly over a weigh bridge, the weight of each load moving over the bridge is recorded and transmitted to a computer. After the material is unloaded from the wagons, the train travels again over the weigh bridge which records and transmits

the weights to the computer. Write a computer program in C or Fortran to compute the total weight of the unloaded material from the stored information. 30

- (b) Describe the principle of electro-discharge machining process (EDM) and explain its applications. 30