MECHANICAL ENGINEERING

## PAPER—I

Time : 3 Hours

Full Marks : 250

The figures in the right-hand margin indicate marks.

*Candidates should attempt **any** 10 **(ten)** questions of* **GROUP—A** *with word limit of 250 words and should attempt **any** 5 **(five)** questions from* **GROUP—B** *with word limit of 300 words.*

GROUP—A

1. Two shafts are connected by a universal joint. The driving shaft rotates at a uniform speed of 1200 r.p.m. Determine the greatest permissible angle between the shaft axes so that the total fluctuation of speed does not exceed 100 r.p.m. Also, calculate the maximum and minimum speeds of the driven shaft. 15

2. An axial thrust on a flat bearing is 7500 N. The coefficient of friction between the contacting surfaces is 0·10. If the diameter of the shaft is 150 mm and it rotates at 180 r.p.m., what frictional power is lost at the bearing when *(a)* the pressure is assumed to be uniform and *(b)* rate of wear is assumed to be uniform? 8+7=15

3. Stresses at a point are as shown in Fig. 1. On plane *BC*, σ_1 = 100 MPa, τ = 30 MPa and on plane *AC*, σ_2 = –60 MPa, τ = 30 MPa. Determine the normal and shear stresses on the inclined plane *AB*, θ = 30°. At what angle of plane *AB*, the shear stress will become zero? 15

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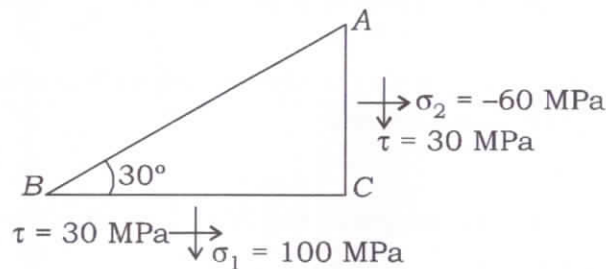
4. A 1 m long hollow circular shaft of an outer diameter of 60 mm and an inner diameter of 20 mm is subjected to a twisting moment of 4 kN-m. Determine the strain energy absorbed by the shaft, if $G = 80$ kN/mm^2. 15

5. What is Shape Memory Alloy (SMA)? Write typical applications, advantages and drawbacks of SMA. 15

6. Explain point defects and surface defects in materials. 15

7. Explain the investment casting process. Write the type of casting defects. 15

8. An aluminium rod of 6·25 mm diameter is drawn into wire of 5·6 mm diameter. Semi die angle is 10·1°. Find the drawing stress, considering the friction to be 0·04 and nominal stress 35 MPa. Also, calculate the maximum reduction that can be given to the material. 15

9. A manufacturer purchases items in lots of 800 units which is a four-month requirement. The cost per unit is ₹100 and the ordering cost is ₹120 per batch order. The inventory carrying cost is estimated as 20% of the average inventory investment.

   (a) Determine the annual variable cost managing the inventory.

   (b) How much savings can be obtained from the EOQ purchase? 15

10. A sub-group of 5 items each are taken from a manufacturing process at a regular interval. A certain quality characteristic is measured and $\bar{X}$ and R values are computed. After 25 subgroups it is found that $\sum \bar{X} = 357 \cdot 50$ and $\sum R = 8 \cdot 80$. If the specification limits are $14 \cdot 40 \pm 0 \cdot 40$ and if the process is in statistical control, what conclusion can you draw about the ability of the process to produce items within specification? (For subgroup of 5 items $d_2 = 2 \cdot 326$) 15

11. Write a program using C program to determine whether a number is prime or not using break statement. 15

12. Write a FORTRAN program to integrate the function $f(x) = 1 - e^{-x/2}$ by using the trapezoidal rule. 15

13. The turning moment curve for an engine is represented by the equation, $T = (20000 + 9500 \sin 2\theta - 5700 \cos 2\theta) N\text{-}m$, where θ is the angle moved by the crank from inner dead center. If the resisting torque is constant, then find —

(a) power developed by the engine;

(b) moment of inertia of flywheel in kg-m^2, if the total fluctuation of speed is not to exceed 1% of mean speed which is 180 r.p.m.;

(c) angular acceleration of the flywheel when the crank has turned through 45° from the inner dead center. 8+6+6=20

14. A thin aluminium alloy tube bar has a mean diameter of 200 mm and a wall thickness of 2 mm. The tube is subjected to an internal pressure of 2 N/mm^2 and a torque of 5 kN-m. If the yield strength of the material is 240 N/mm^2 and the Poisson's ratio is 0·33, determine the factor of safety according to

(a) maximum shear stress theory;

(b) maximum principal stress theory;

(c) strain energy theory. 7+6+7=20

15. (a) What are solid solutions? Explain different types of solid solution with examples.

(b) What is a phase diagram? 16+4=20

16. 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

17. (a) State the assumptions made while plotting the Break-Even Chart. 10

(b) The fixed costs for the years 2020-2023 are ₹8,00,000, variable cost per unit is ₹30. The estimated sales for the period are valued at ₹24,00,000. Each unit sells at ₹180.

   (i) Determine B.E.P.

   (ii) ₹18,00,000 will be the likely sales turnover for the next budget period. Calculate the estimated contribution and profit.

   (iii) If a profit target of ₹9,50,000 has been budgeted, compute the turn-over required. 2+4+4=10

18. (a) While purchasing certain items, a discount of 10% is offered, if the quantity purchased is more than 1000. If quantity and price per item are input through the keyboard, write a C program to calculate the total expenses.

(b) Draw a flow chart for the above problem. 10+10=20

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