B.TECH/ME/5TH SEM/MECH 3103/2018
DESIGN OF MECHANICAL SYSTEMS-I
(MECH 3103)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Series factor for R40 series is:
(a) $\sqrt[10]{40}$ (b) $\sqrt{40}$ (c) $\sqrt[40]{10}$ (d) $\sqrt[3]{40}$.

(ii) When a shaft of diameter d and length l is subjected to torsional moment M_t, then the angle of twist θ in degrees is given by,
(a) $\frac{584\ M_t l}{Gd^4}$ (b) $\frac{M_t l}{\pi d^4}$ (c) $\frac{584\ M_t l}{Gd^3}$ (d) $\frac{M_t G}{d^4 l}$.

(iii) If Yield strength under shear is S_{sy} and Yield strength under tension is S_{yt} then according to Distortion Energy theory
(a) $S_{sy} = 0.568\ S_{yt}$ (b) $S_{sy} = 0.755\ S_{yt}$
(c) $S_{sy} = 0.577\ S_{yt}$ (d) $S_{sy} = S_{yt}$.

(iv) For a power screw to be self-locking, tangent of helix angle should be
(a) Less than coefficient of friction
(b)Greater than coefficient of friction
(c) Equal to coefficient of friction
(d) Equal to twice of coefficient of friction.

(v) Which of the following provides most safe zone for design under fluctuating load?
(a) Soderberg Line (b) Goodman Line
(c) Gerber Line (d) ASME-Elliptic line.

(vi) A test specimen is stressed slightly beyond the yield point and then unloaded. Its yield strength will
(a) decrease (b) increase
(c) remain same (d) become equal to ultimate tensile strength.

(vii) A solid circular shaft is subjected to a maximum shear stress of 140 MPa. The magnitude of the maximum normal stress developed in the shaft is
(a) 140 MPa (b) 80 MPa (c) 70 MPa (d) 60 MPa.

(viii) Palmgren-Miner rule is based on
(a) linear cumulative damage
(b) summation rule
(c) both the above
(d) order of stress application and linear cumulative damage.

(ix) The type of stresses developed in key is/are
(a) shear stress alone
(b) bearing stress alone
(c) both shear and bearing stresses
(d) shearing, bearing and bending stresses.

(x) If the tearing efficiency of a riveted joint is 50%, the ratio of diameter of rivet hole to the pitch of rivets is
(a) 0.20 (b) 0.30 (c) 0.50 (d) 0.60

Group – B

2. (a) It is required to design the piston rod of a steam engine on the basis of buckling strength. The internal diameter of the cylinder is 200 mm, while the operating steam pressure is limited to 1 N/mm^2. The length of the piston rod is 1 m. One end of the piston rod is fixed in the piston, while the other can be considered as hinged. The piston rod is made of steel 40C8 (S_{yt} = 380 N/mm^2 and E = 207000 N/mm^2). The factor of safety is 5. Neglecting inertia forces, determine the diameter of the piston rod.

(b) A cylindrical shaft made of steel of yield strength 700 MPa is subjected to static loads consisting of bending moment 10 kN-m and a torsional moment 30 kN-m. Determine the diameter of the shaft using two different theories of failure, and assuming a factor of safety of 2. Take E = 210 GPa and Poisson's ratio 0.25.

6 + 6 = 12

3. It is required to design a cotter to connect two circular rods subjected to an axial tensile force of 50kN. Design the joint and specify the dimensions of its components as shown in Figure 1. Consider plain carbon steel of Grade 30C8 having yield strength of 400MPa. Take factor of safety for different components as per convenience.

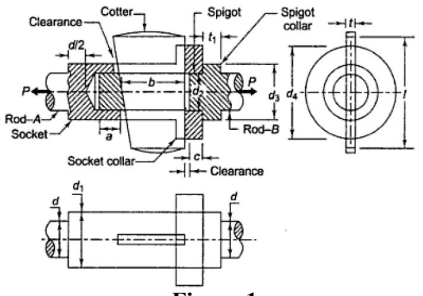

Figure 1

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Group – C

4. The rotating shaft shown in the Figure 2 below is machined from AISI 1020 Cold Drawn steel (S_{yt} = 420 N/mm² and S_{ut} = 770 N/mm²). It is subjected to a force of F = 9kN. Find the minimum factor of safety for fatigue based on infinite life as well as for 456789 cycles. All dimensions in the figure are in millimetre.

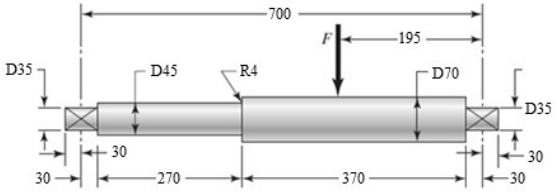

Figure 2

7 + 5 = 12

5. A solid circular shaft, 15 mm in diameter is subjected to torsional shear stress, which varies from 0 to 35 N/mm² and at the same time, is subjected to an axial stress that varies from -15 to +30 N/mm². The frequency of variation of these stresses is equal to the shaft speed. The shaft is made of steel FeE400 (S_{ut} = 540 N/mm² and S_{yt} = 400 N/mm²) and the corrected endurance limit of the shaft is 200 N/mm². Determine factor safety of the object for infinite life as well as for 340567 cycles.

5 + 7 = 12

Group – D

6. For supporting the travelling crane in a workshop, the brackets are fixed on steel columns as shown in Figure 3. The maximum load that comes on the bracket is 12 kN acting vertically at a distance of 400 mm from the face of the column. The vertical face of the bracket is secured to a column by four bolts, in two rows (two in each row) at a distance of 50 mm from the lower edge of the bracket. Determine the size of the bolts if the permissible value of the tensile stress for the bolt material is 84 MPa. Also find the cross-section of the arm of the bracket which is rectangular.

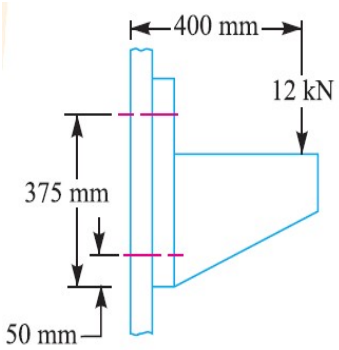

Figure 3

12

7.(a) A rectangular steel plate is welded as a cantilever to a vertical column and supports a single concentrated load P, as shown in Figure 4. Determine the weld size if shear stress in the same is not to exceed 140 MPa.

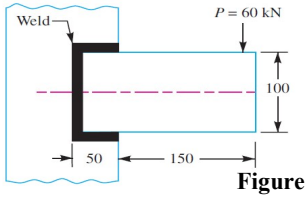

Figure 4

(b) Calculate the diameter of the rivets required in the following bracket. The rivet arrangements are shown in Figure 5. The tensile strength of the bracket is 90 MPa and shear strength of the rivet is 65 MPa. Take E = 170 MPa. The bracket thickness is 10 mm.

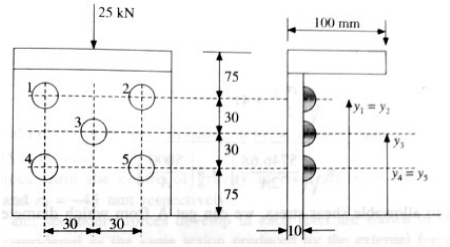

Figure 5

6 + 6 = 12

Group – E

8. Design a cast iron protective type flange coupling to transmit 15 kW at 900 r.p.m. from an electric motor to a compressor. The service factor may be assumed as 1.35. The following permissible stresses may be used:

- Shear stress for shaft, bolt and key material = 40 MPa
- Crushing stress for bolt and key = 80 MPa
- Shear stress for cast iron = 8 MPa

Draw a neat sketch of the coupling. Designing of the flange coupling should include designing of Shaft, Key, Flange and Bolt.

3+ 3+ 3 + 3 = 12

9. (a) In an open flat belt drive, a leather belt transmits 20 HP at a belt speed of 18 m/sec. The smaller pulley, the driver, rotates at 1000 rpm and the speed ratio is 2.5 : 1. The density of the belt material is 0.95 gm/cc and the coefficient of friction between the pulley and belt is 0.35. The design should be such that the stress in the belt should not exceed 2.5 N/mm². If the belt thickness is 6 mm and the centre distance is 2.5 times the diameter of the larger pulley, calculate pulley diameters, the belt tensions, the width and the total length of the belt required for installation.

(b) A helical tension spring is used in the spring balance to measure the weights. One end of the spring is attached to the rigid support while the other end, which is free, carries the weights to be measured. The maximum weight that can be attached to the spring balance is 1500 N and the length of the scale should be approximately 100 mm. The spring index can be taken as 6. The spring is made of oil-hardened and tempered steel wire of SW grade (G= 81370 N/mm²). The allowable shear stress for the spring material is 645 N/mm². Design the spring and calculate:
(i) Wire diameter, (ii) Mean coil diameter, (iii) Number of active coils &
(iv) Actual spring rate

7 + 5 = 12