9. A helical compression spring is used to absorb the shock. The initial compression of the spring is 30 mm and it is further compressed by 50 mm while absorbing the shock. The spring is to absorb 250 J of energy during the process. The spring index can be taken as 6. The spring is made of patented and cold-drawn steel wire with an ultimate tensile strength of 1500 N/mm^2 and modulus of rigidity of 81370 N/mm^2. The permissible shear stress for the spring wire should be taken as 30% of the ultimate tensile strength. Design the spring and calculate:
(i) wire diameter; (ii) mean coil diameter; (iii) number of active turns; (iv) free length; and (v) pitch of the turns.

4 +1 + 2 + 3 + 2=12

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 R20 series is:
(a) $\sqrt[10]{20}$ (b) $\sqrt{20}$ (c) $\sqrt[20]{10}$ (d) $\sqrt[3]{20}$.

(ii) Steel containing upto 0.15% carbon is known as
(a) mild steel (b) dead mild steel
(c) medium carbon steel (d) high carbon steel.

(iii) According to Indian standard specifications, a plain carbon steel designated by 40C8 means that
(a) carbon content is 0.04 per cent and manganese is 0.08 per cent
(b) carbon content is 0.4 per cent and manganese is 0.8 per cent
(c) carbon content is 0.35 to 0.45 per cent and manganese is 0.60 to 0.90 per cent
(d) carbon content is 0.60 to 0.80 per cent and manganese is 0.8 to 1.2 per cent

(iv) A plate with an elliptical hole in the centre, with semi-major axis *(a)* perpendicular to the direction of loading and semi-minor axis *(b)* along the direction of loading, is subjected to a pull P. The maximum stress induced at the edge of the hole is equal to (where σ = Stress for a plate with no hole i.e. nominal stress)
(a) σ(1+ b/2a) (b) σ(1+ 2a/b)
(c) σ(1+ b/3a) (d) σ(1+ 3a/b).

(v) If an object is subjected to stresses σ_x, σ_y *and* τ_{xy} then according to von-Misses, the generated stress will be,
(a) $\left({\sigma_x}^2 + \sigma_x\sigma_y + {\sigma_y}^2 + 3{\tau_{xy}}^2\right)^{1/2}$ (b) $\left({\sigma_x}^2 - \sigma_x\sigma_y + {\sigma_y}^2 + 3{\tau_{xy}}^2\right)^{1/2}$
(c) $\left({\sigma_x}^2 - \sigma_x\sigma_y + {\sigma_y}^2\right)^{1/2}$ (d) $\left({\sigma_x}^2 + \sigma_x\sigma_y + {\sigma_y}^2 - 3{\tau_{xy}}^2\right)^{1/2}$.

(vi) When screw threads are to be used in a situation where power is being transmitted in one direction only, then the screw threads suitable for this will be
(a) square threads (b) acme threads
(c) knuckle threads (d) buttress threads.

(vii) In leaf springs, the longest leaf is known as
(a) lower leaf (b) master leaf
(c) upper leaf (d) none of these.

(viii) When spring index increases, the value of Wahl's stress factor
(a) increases linearly (b) decreases linearly
(c) remains same (d) decreases non-linearly.

(ix) If a shaft made from ductile material is subjected to combined bending and twisting moment, calculations based on which one of the following failure theories will give the most conservative value?
(a) Maximum principal stress theory
(b) Maximum shear stress theory
(c) Maximum strain energy theory
(d) Maximum distortion energy theory.

(x) In transverse fillet welded joint, the size of weld is equal to
(a) 0.5 x throat of weld (b) throat of weld
(c) 2 x throat of weld (d) $\sqrt{2}$ x throat of weld

Group – B

2. (a) What are the Advantages and Disadvantages of Cast Iron from design point of view?

(b) An Allen key is subjected to a load of 60 N at its end B as shown in Figure 1 below. The Allen Key is made of a low carbon steel of Grade AISI 1018 having Yield Strength 370 MPa and Ultimate Strength 440 MPa. The dimensions are as shown in figure. Now find out the Factor of Safety considered in designing this Allen Key according to von-Misses theory of failure.

(b) A welded connection of steel plates, as shown in Figure 4, is subjected to an eccentric force of 10 kN. Determine the throat dimension of the welds, if the permissible shear stress is limited to 95 N/mm^2. Assume static conditions.

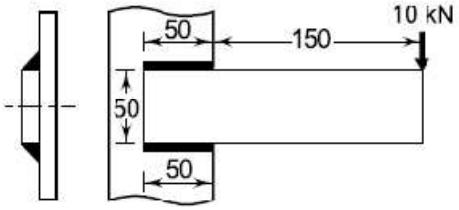

Figure 4

2+ 10 = 12

Group – E

8. The layout of an intermediate shaft of a gear box supporting two spur gears B and C is shown in Figure 5. The shaft is mounted on two bearings A and D. The pitch circle diameters of gears B and C are 900 and 600 mm respectively. The material of the shaft is steel FeE 580 (S_{ut} = 770 and S_{yt} = 580 N/mm^2). The factors k_b and k_t of ASME code are 1.5 and 2.0 respectively. Determine the shaft diameter using the ASME code. Assume that the gears are connected to the shaft by means of keys.

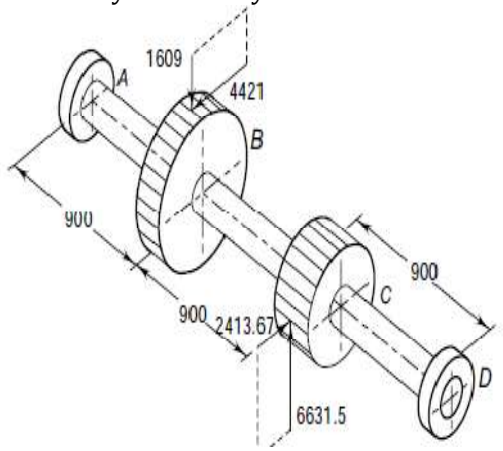

Figure 5

12

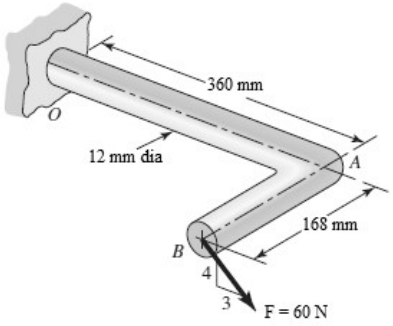

Figure 1

4 + 8 =12

3. Design a cotter joint to connect two steel rods of equal diameter. The permissible stresses for the rods, spigot end and socket end are: σt = 96 N/mm^2, σc = 134 N/mm^2, τ = 45 N/mm^2. For cotter: σt = 80 N/mm^2, τ = 40 N/mm^2. Each rod is subjected to an axial tensile force of 60 kN. The FOS for the rods, spigot end and socket end is assumed as 6, while for cotter, it is 4.

12

Group – C

4. (a) Calculate the remaining life of a round steel bar (having Sut = 750 N/mm^2 and Se = 250 N/mm^2) at the stress amplitude of 420 N/mm^2 after subjected to given alternating stresses:
(i) 350 N/mm^2 for 1.5 × 104 cycles
(ii) 300 N/mm^2 for 5 × 104 cycles
(iii) 400N/mm^2 for 104 cycles

(b) What are the various factor that reduce fatigue strength of the material? How the endurance limit for a given component is obtained from the endurance limit from standard test?

7 + (3 + 2) = 12

5. The shaft shown in the Figure 2 is machined from AISI 1040 CD steel having Yield Strength 490 MPa and Ultimate Strength 590 MPa. The shaft rotates at 1600 rpm and is supported in rolling bearings at A and B. The applied forces are F_1 = 15 kN and F_2 = 4 kN. Determine the minimum factor of safety based on achieving infinite life. If the shaft is designed with same factor of safety and for Yield Strength as design criterion then what would be the life of the shaft? Here expected reliability is 90%.

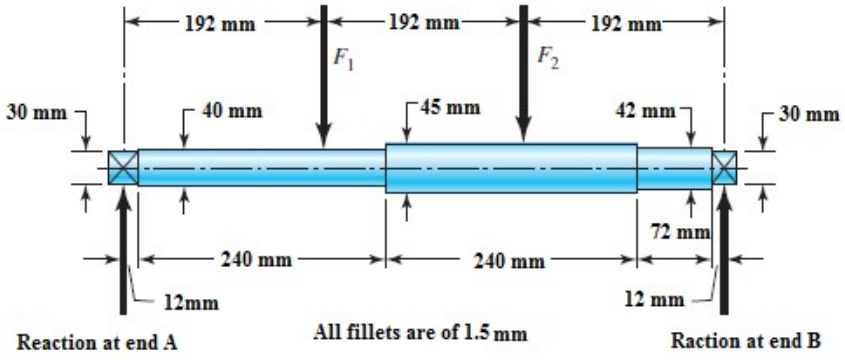

Figure 2

12

Group – D

6. A rigid bracket subjected to a vertical force of 10 kN is shown in Figure 3. It is fastened to a vertical stanchion by means of four identical bolts. Determine the size of the bolts by maximum shear stress theory. The maximum permissible shear stress in any bolt is limited to 50 N/mm^2.

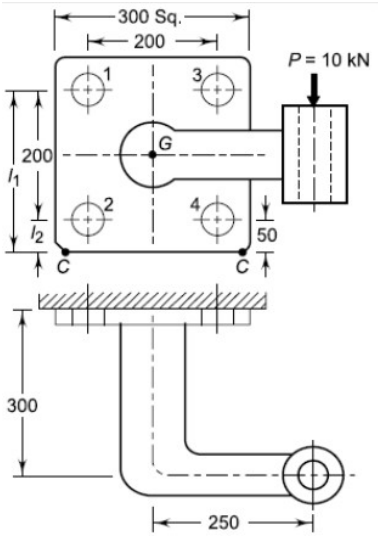

Figure 3 All Dimensions are in mm

12

7. (a) What is Caulking and Fullering?