MACHINE DESIGN – I
(MECH 3101)

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) Which of the following materials has maximum strength?
(a) grey cast iron (b) plain carbon steel
(c) alloy steel (d) aluminium alloy.

(ii) Hooke's law holds good upto
(a) yield point (b) proportional limit
(c) plastic limit (d) breaking point.

(iii) The process which improves the machinability of steels, but lower the hardness and tensile strength is
(a) Normalizing (b) Full annealing
(c) Process annealing (d) Spheroidising.

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

(v) Maximum Shear Stress (MSS) theory is used for
(a) brittle materials (b) ductile materials
(c) elastic materials (d) plastic materials.

(vi) A screw is said to be self-locking if its efficiency is
(a) equal to 50% (b) more than 50%
(c) less than 50% (d) equal to 75%.

(vii) If an object is subjected to stresses $\sigma_x, \sigma_y \; and \; \tau_{xy}$ 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) $\left({\sigma_x}^2 + \sigma_x\sigma_y + {\sigma_y}^2 - 3{\tau_{xy}}^2\right)^{1/2}$

(viii) In fillet welded joint, the throat of weld as compared to the size of weld is
(a) about 0.5 times (b) about 0.707 times
(c) about same size (d) about $\sqrt{2}$ times.

(ix) Which of the following coupling is used to connect two shafts which have angular misalignment?
(a) Bush pin type coupling (b) Universal coupling
(c) Oldham coupling (d) Flange coupling.

(x) The notch sensitivity q is expressed in terms of fatigue stress concentration factor K_f and theoretical stress concentration factor K_t, as
(a) $\frac{K_f+1}{K_t+1}$ (b) $\frac{K_f-1}{K_t-1}$ (c) $\frac{K_t+1}{K_f+1}$ (d) $\frac{K_t-1}{K_f-1}$

Group – B

2. (a) Discuss in detail about Stress-Strain curve of a brittle material and explain proof stress.

(b) How many theories of failure are there? Discuss in detail about the 'Maximum Shear Stress Theory'.

4 + (3 + 5) = 12

3. (a) Differentiate 'True Stress-Strain' and 'Engineering Stress-Strain'.

(b) A cantilevered handle as shown in Fig. 1 is made of plain carbon steel 50C4 having Yield stress 460 MPa, Ultimate tensile stress 660 MPa and percentage elongation 17%. The handle is subjected to a loading of F_x=0 N, F_y=500 N and F_z=0 N. Neglecting stress concentration factor and adopting 'Distortion Energy Theory' calculate diameter 'd' of the rod which is welded with the fixed support as shown in the figure. Consider here factor of safety as 1.7.

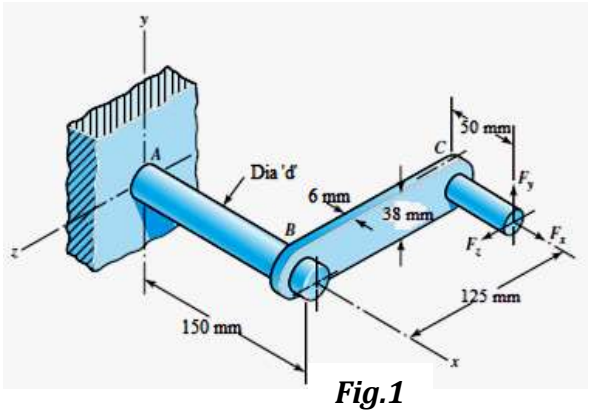

Fig.1

3 + 9 = 12

Group – C

4. (a) A round shaft made of a brittle material and subjected to a bending moment of 15 N-m is shown in Fig.2. The ultimate tensile strength of the shaft material is 200 N/mm^2. Determine the diameter d, the magnitude of stress at the fillet and the factor of safety.

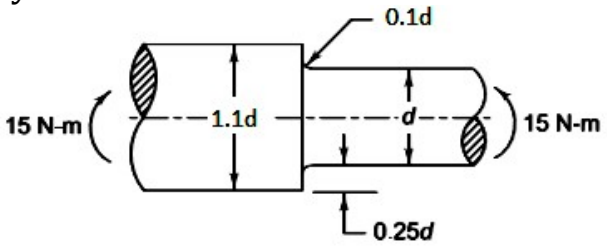

Fig.2

To solve this problem refer the graph shown in Fig.3.

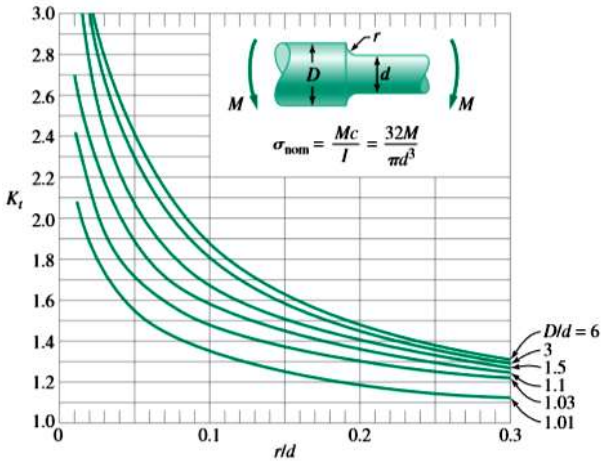

Fig.3

(b) Create an estimated S-N diagram for a steel rod and define its equation. How many cycles of life can be expected if the alternating stress is 110 MPa?
Given data: S_{ut} = 600 MPa, k_a = 0.584, k_b = 0.747, k_c = 0.753
The loading will be fully reversed bending.

(2 + 2 + 2) + 6 = 12

5. (a) The shaft shown in the Fig.4 is supported in rolling bearings at A and B. The applied forces are F_1= 10kN and F_2 = 4 kN. Determine the maximum bending stress induced in the shaft. To solve this problem refer the graph shown in Fig.3.

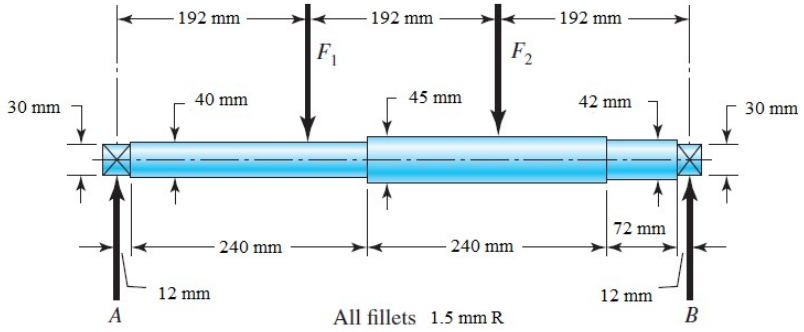

Fig.4

(b) A cantilever beam made of steel Fe 540 (S_{ut} = 540 N/mm^2 and S_{yt} = 320 N/mm^2) and subjected to a completely reversed load (P) of +7 kN as shown in Fig.5. The beam is machined, and the reliability is 90%. The factor of safety is 2 and the notch sensitivity factor is 0.9. Calculate
(i) endurance limit at the fillet section; and
(ii) diameter d of the beam for infinite life.

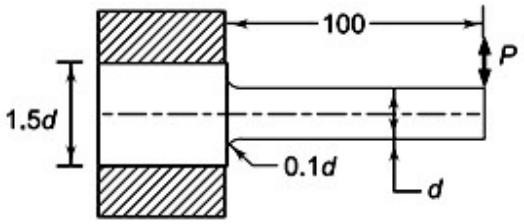

Fig.5

To solve this problem graph shown in figure 3 may be referred. Consider here 'Surface Finish Factor' as 0.78, 'Size Factor' as 0.85, and 'Reliability Factor' as 0.897.

7 + (3 + 2) = 12

Group – D

6. The square-threaded jack is used to raise and lower the 100-kg block as shown in Fig.6.

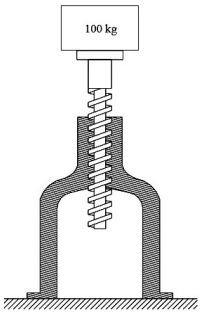

Fig.6

Determine (i) the torque M_u required to begin moving the block up, and (ii) the torque M_d required to begin moving the block down. Also determine if the block will remain stationary when the torque is removed.
The screw has lead L = 10 mm, mean radius r = 8 mm, and is single-threaded. The coefficient of static friction between the screw and the supporting threads of the base is μ=0.25.
What is 'self-locking' of power screw? What is the condition for self-locking?

(3 + 3 + 1) + (3 + 2) = 12

7. A steel plate subjected to a force of 3 kN and fixed to a vertical channel by means of four identical bolts is shown in Fig.7. The bolts are made of plain carbon steel 45C8 (S_{yt} = 380 N/mm^2) and the factor of safety is 2. Determine the diameter of the shank.

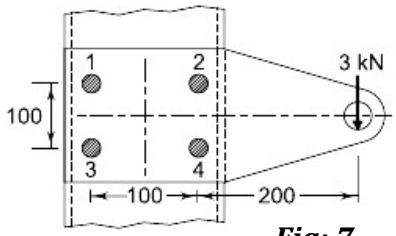

Fig: 7

12

Group – E

8. An intermediate shaft of a gearbox, supporting two spur gears A and B and mounted between two bearings C1 and C2, is shown in Fig.8. The pitch circle diameters of gears A and B are 500 mm and 250 mm respectively. The shaft is made of alloy steel 20MnCr5. (S_{ut} = 620 N/mm^2 and S_{yt} = 480 N/mm^2). The factors k_b and k_t of the ASME code are 2 and 1.5 respectively. The gears are keyed to the shaft.
Determine the shaft diameter using the ASME code.
Assume that the gears are connected to the shaft by means of keys.

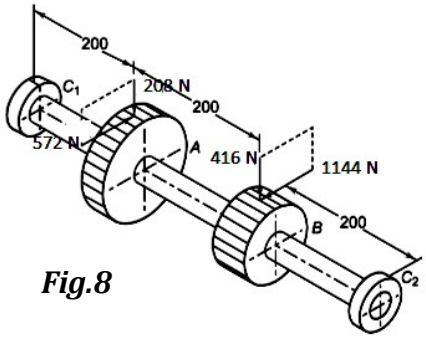

Fig.8

All Dimensions are in mm

(4 + 4 + 4) = 12

9. (a) Write a short note on Nipping of Leaf Spring with a neat sketch.

(b) A semi-elliptic leaf spring used for automobile suspension consists of three extra full-length leaves and 15 graduated-length leaves, including the master leaf. The centre-to-centre distance between two eyes of the spring is 1 m. The maximum force that can act on the spring is 82 kN. For each leaf, the ratio of width to thickness is 8:1. The modulus of elasticity of the leaf material is 210 000 N/mm^2. The leaves are pre-stressed in such a way that when the force is maximum, the stresses induced in all leaves are same and equal to 510 N/mm^2. Determine (i) the width and thickness of the leaves; (ii) the initial nip; and (iii) the initial pre-load required to close the gap C between extra full-length leaves and graduated-length leaves.

4 + (3 + 3 + 2) = 12

Department & Section	Submission link:
ME A	https://classroom.google.com/c/MTIyNDIyOTkwMTA1/a/Mjc0NzMwODQ3Mjc0/details
ME B	https://forms.gle/AQH83Tzpa9cgWqTy9