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) Which of the following material has the maximum ductility?
(a) Mild steel (b) Copper (c) Zinc (d) Aluminium.

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

(iii) According to Indian standard specifications, a grey cast iron designated by 'FG 200' means that the
(a) carbon content is 2%
(b) maximum compressive strength is 200 N/mm^2
(c) minimum tensile strength is 200 N/mm^2
(d) maximum shear strength is 200 N/mm^2.

(iv) Series factor for R20 series is
(a) $\sqrt[10]{20}$ (b) $\sqrt{20}$ (c) $\sqrt[20]{10}$ (d) $\sqrt[20]{20}$.

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

(vi) According to Maximum Shear Stress theory of failure, the relationship between yield strength in shear (S_{sy}) and tensile yield strength (S_{yt}) is
(a) $S_{sy} = 0.5\ S_{yt}$ (b) $S_{sy} = 0.577\ S_{yt}$ (c) $S_{sy} = 0.75\ S_{yt}$ (d) $S_{sy} = 0.4\ S_{yt}$

(vii) In static loading, the effect of stress concentration is more serious in case of
(a) components made of brittle materials
(b) components made of ductile materials
(c) components made of brittle as well as ductile materials
(d) Brittleness and Ductility has no effect on the Stress Concentration.

(viii) Stress concentration factor is defined as
(a) ratio of highest stress near the discontinuity to endurance limit
(b) ratio of highest stress near the discontinuity to yield strength
(c) ratio of highest stress near the discontinuity to nominal stress obtained by elementary equation
(d) ratio of endurance limit to highest stress near the discontinuity.

(ix) The stress which vary from a minimum value to a maximum value of the same nature (i.e. tensile or compressive) is called
(a) repeated stress (b) yield stress
(c) fluctuating stress (d) alternating stress.

(x) Relation between notch sensitivity q, fatigue stress concentration factor K_f and theoretical stress concentration factor K_t, is
(a) $k_f = 1 + q(k_t + 1)$ (b) $k_f = q + (k_t - 1)$
(c) $k_f = 1 + q(k_t - 1)$ (d) $k_f = k_t + (q - 1)$.

Group – B

2. (a) Discuss in detail the stress-strain curve of mild steel.

(b) Discuss in detail about the 'Maximum Principal Stress Theory'.

6 + 6 = 12

3. A cantilevered handle as shown in figure 3 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=800 N and F_z=0 N. Neglecting stress concentration factor, calculate factor of safety which might have been considered in designing the rod shown in Fig.1. Consider Maximum Shear Stress Theory in solving this problem.

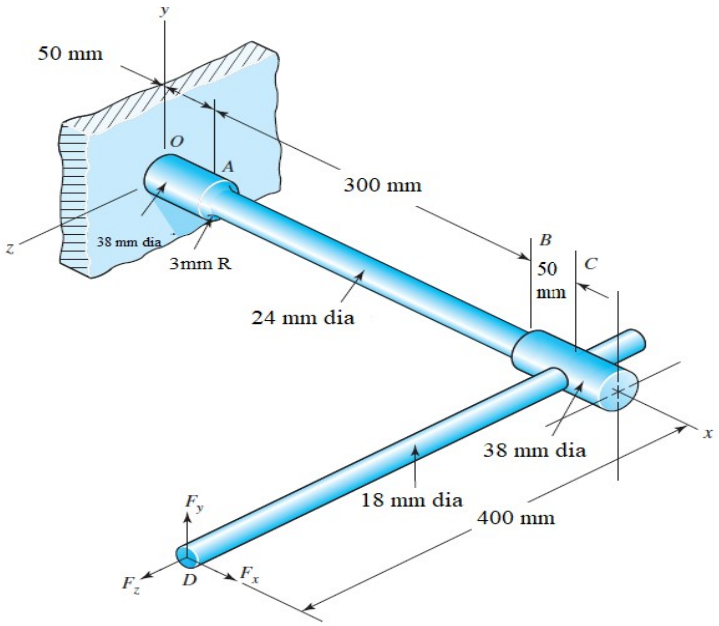

Fig: 1

12

Group – C

4. A round shaft made of a brittle material and subjected to a bending moment of 15 N-m is shown in Fig.2. The stress concentration factor at the fillet is 1.5 and 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.

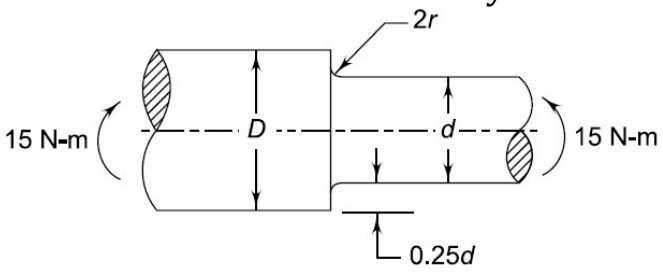

Fig.2

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

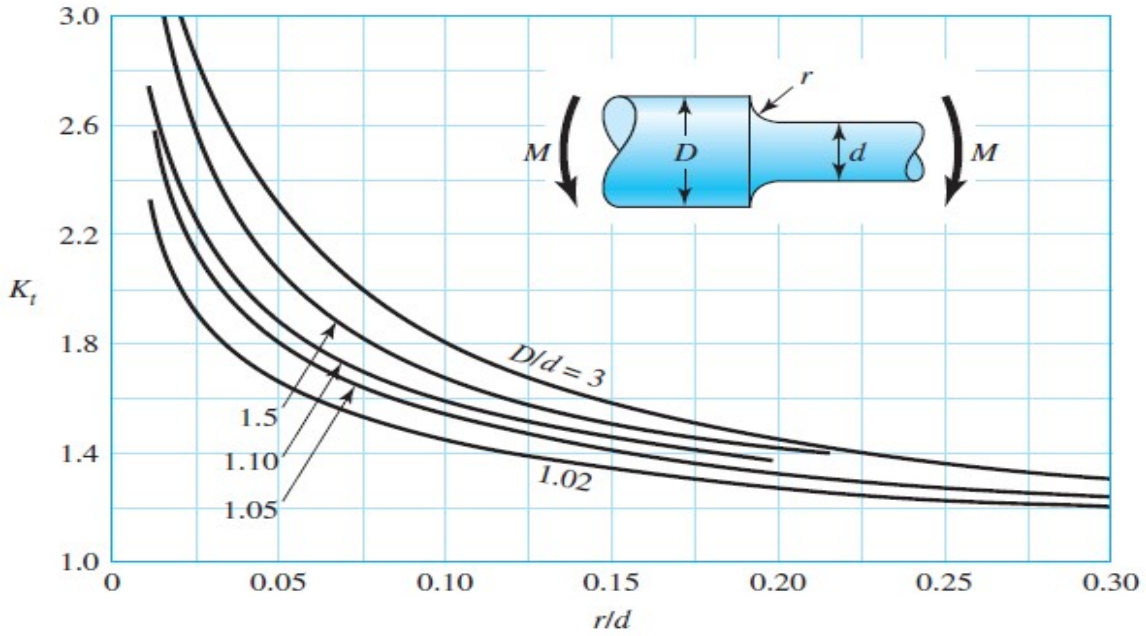

Fig.3

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5. A cantilever beam made of steel Fe 540 (S_{ut} = 540 N/mm^2 and S_{yt} = 320 N/mm^2) and subjected to an alternating load (P) of ±7 kN as shown in Fig.4. 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. To solve this problem graph shown in Fig.3 may be referred. Consider here 'Surface Finish Factor' as 0.78, 'Size Factor' as 0.85, and 'Reliability Factor' as 0.897.

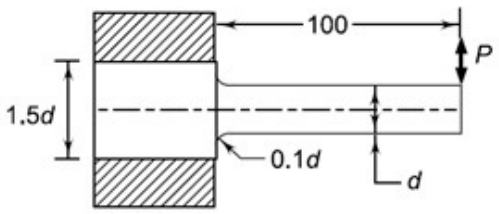

Fig.4

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Group – D

6. (a) Name the types of threads which are popularly used in power screw. Schematically represent a square thread profile.

   (b) Discuss in detail about self-locking characteristic of a power screw.

(2 + 3) + 7 = 12

7. A steel plate subjected to a force of 5 kN and fixed to a vertical channel by means of four identical bolts is shown in Fig.5. The bolts are made of plain carbon steel 40C8 (*Syt* = 420 N/mm^2) and the factor of safety is 2. Determine the diameter of the shank.

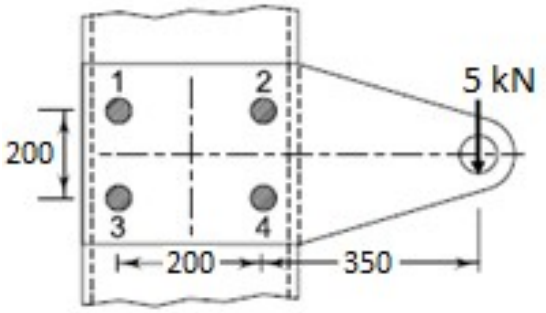

Fig.5

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Group – E

8. A protective flange coupling is used to connect two shafts and transmit 7.5 kW power at 720 rpm. The design torque is 150% of the rated torque. The shafts and bolts are made of plain carbon steel 30C8 (S_{yt} = 400 N/mm^2) and the factor of safety is 5. Assume, S_{yc} = 1.5 S_{yt} and S_{sy} = 0.5 $S_{yt.}$ The flanges are made of cast iron. Then calculate: (i) diameter of the shafts; (ii) number of bolts; and (iii) diameter of the bolts.
   Use the following relations to solve this problem
   No of bolts (N) = 3 for shafts up to 40 mm diameter.
   No of bolts (N) = 4 for shafts from 40 to 100 mm diameter.
   No of bolts (N) = 6 for shafts from 100 to 180 mm diameter.

3 + 3 + 6 = 12

9. 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 + 4 + 4) = 12

Department & Section	Submission link:
ME	https://classroom.google.com/c/Mjc0NzM5MzA4OTY0/a/Mjc0NzM5MzA5MDg2/detail