Fifth Semester B.E. Degree Examination, July/August 2021
Design of Machine Elements – I

Time: 3 hrs.   Max. Marks:100

Note: 1. *Answer FIVE full questions.*
        2. *Use of design data hand books is permitted.*
        3. *Assume missing data suitably.*

1 a. Explain : (i) Mechanical Engineering design.   **(04 Marks)**
                 (ii) Stress tensor   **(02 Marks)**
                 (iii) Toughness   **(02 Marks)**
                 (iv) Resilience.   **(02 Marks)**

   b. A point in a structural member is subjected to plane stress shown in Fig. Q1 (b). Determine the following:
        (i)   Normal and tangential stress intensities at an angle of $\theta = 45°$
        (ii)   Principal stresses σ_1 and σ_2 and their directions.
        (iii)   Maximum shear stress and its plane.   **(10 Marks)**

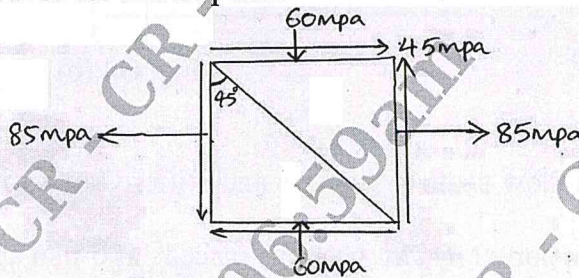Fig. Q1 (b)

2 a. State and explain the following theories of failure:
        (i)   Maximum shear stress theory.
        (ii)   Distortion energy theory.   **(06 Marks)**

   b. A bar of rectangular cross section is subjected to a tensile load of 90kN as shown in Fig.Q2 (b). Calculate its thickness if the allowable tensile stress in the bar is 120 MPa.   **(08 Marks)**

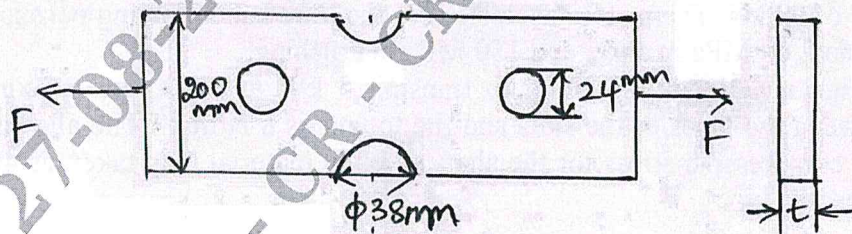Fig. Q2 (b)

   c. An elevator car carrying a load of 5000 N is descending by means of a steel rope at a speed of 60 m/min. The cross sectional area of rope is 400 mm². The rope is suddenly brought to rest by braking after 30 seconds of descent. Calculate the stress induced in the rope due to sudden stoppage, if the Young's modulus for the rope is 60 GPa.   **(06 Marks)**

3 a. Define endurance limit. State and explain factors affecting endurance limit. **(05 Marks)**

   b. A hot rolled steel rod circular in cross section is subjected to a turning moment fluctuating between 800 kN-m and 600 kN-m and also subjected to bending moment fluctuating between +500 kN-m and −300 kN-m. Determine the required rod diameter taking factor of safety 2.5. The material selected for the rod has a shear stress value of 120 MPa at yield point and 100 MPa at endurance limit respectively. Surface factor, size factor and load factor can be taken as 0.9, 0.85 and 1 respectively. Shear stress concentration factor is 1.8 and notch sensitivity is 0.95. **(15 Marks)**

4 a. Explain various types of stresses in threaded fasteners. **(06 Marks)**

   b. A bracket is bolted as shown in Fig. Q4 (b). All the bolts are identical. Calculate the size of the bolts if the load is 10 kN and allowable shear stress in material is 40 MPa. **(14 Marks)**
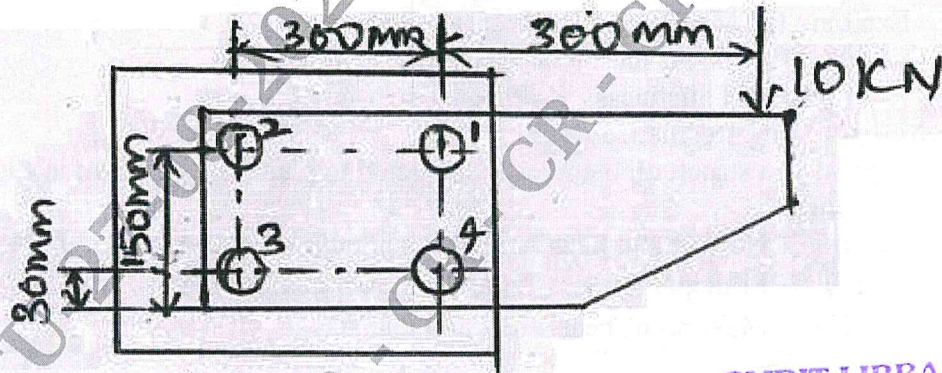

Fig. Q4 (b)

5 a. Prove that hollow shaft is stronger and stiffer than a solid shaft of same length, weight and material. **(05 Marks)**

   b. A shaft is supported by two bearings placed 1100 mm apart. A pulley of diameter 620 mm is keyed at 400 mm to the right from the left hand bearing and this drives a pulley directly below it with a maximum tension of 2.75 kN. Another pulley of diameter 400 mm is placed 200 mm to the left of right hand bearing and is driven with a motor horizontally to the right. The angle of contact of pulleys is 180°, $\mu = 0.3$. Assume $K_b = 3.0$, $K_t = 2.5$, $\sigma_y = 190$ MPa and $\sigma_{ut} = 300$ MPa. **(15 Marks)**

6 a. Design and sketch the assembly of a knuckle joint to connect two rods subjected to an axial pull of 90 kN. The material selected for the joint has following permissible stresses: 90 MPa in tension, 60 MPa in shear and 150 MPa in crushing. **(10 Marks)**

   b. Design an Oldham coupling to transmit 5 kW at 1000 rpm. Maximum allowable pressure between the faces of the slots and the tongue is 8 N/mm^2. The allowable value of shear stress and compressive stress for the shaft and key material may taken as 40 N/mm^2 and 80 N/mm^2 respectively. **(10 Marks)**

7 a. Explain the possible failures of riveted joints by means of simple sketches. **(08 Marks)**

   b. Determine the safe load that can be applied to the bracket as shown in Fig. Q7 (b). The size of the weld is 8 mm. Take allowable shear stress for weld 70 MPa. **(12 Marks)**
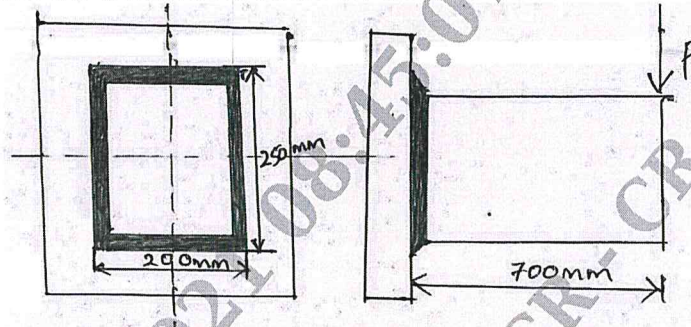

Fig. Q7 (b)

8 a. Show that efficiency of self locking screw is less than 50%. **(05 Marks)**

   b. A machine slide weighing 3 kN is elevated by a double start acme threaded screw at a rate of 0.84 m/s. The coefficient of thread friction is 0.15 and collar friction 0.2. The end of the screw is carried on a thrust collar of 32 mm inside diameter and 58 mm outside diameter. The screw has a diameter of 44 mm and pitch of 7 mm. If the screw is made of 45C8 steel ($\sigma_y = 353$ MPa), is it strong enough to sustain load. Also, find the efficiency and check for self locking. What is the power of motor required to drive the screw? **(15 Marks)**

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