Fifth Semester B.E. Degree Examination, Dec.2015/Jan.2016
Design of Machine Elements – I

Time: 3 hrs.   Max. Marks:100

Note: 1. *Answer FIVE full questions, selecting*
          at least TWO questions from each part.
       2. *Use of design data handbook is permitted.*
       3. *Assume missing data if any suitably.*

PART – A

1   a. Explain briefly the selection of factor of safety in engineering design. **(03 Marks)**

     b. Explain briefly the selection of materials in the process of machine design. **(03 Marks)**

     c. A wall bracket with a rectangular cross-section is shown in Fig.Q1(c). The force P acting on the bracket at 60° to the vertical is 5 kN. The material of the bracket is gray cast iron (ordinary) and factor of safety is 2. Determine the cross section of the bracket for maximum normal stress. All dimensions shown are in mm. **(07 Marks)**
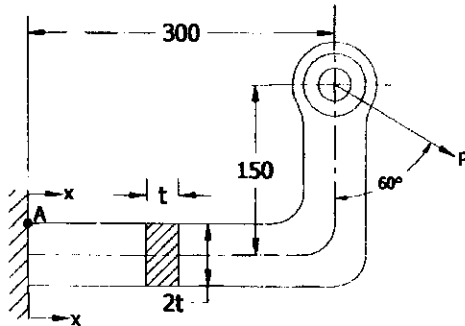

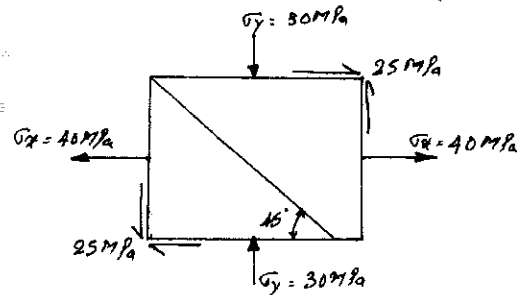Fig.Q1(c)   Fig.Q1(d)

     d. A point in a structural member subjected to plane stress as shown in Fig.Q1(d). Determine the following:

       i) Normal and tangential stress on a plane inclined at 45°.

       ii) Principal stresses and directions.

       iii) Maximum shear stress. **(07 Marks)**

2   a. Explain theories of elastic failures. Mention five types of theories of elastic failures. **(05 Marks)**

     b. An overhang crank with pin and shaft is as shown in Fig.Q2(b). A tangential load of 15 kN acts on the crank Pin. Determine the diameter at section 'XX' using maximum shear stress theory. The crank is made of C60 carbon steel. Take factor of safety as 2. All dimensions are in mm. **(05 Marks)**
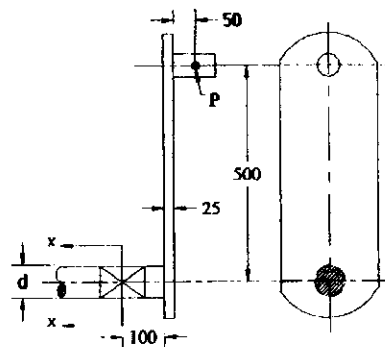

Fig.Q2(b)

c. A flat plate subjected to a tensile force of 5 kN is an shown in Fig.Q2(c). The plate material is gray cast iron (good) and the factor of safety is 2.5. Determine the thickness of the plate. All dimensions are in mm. **(07 Marks)**
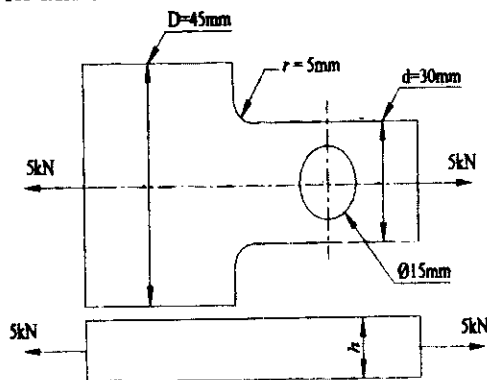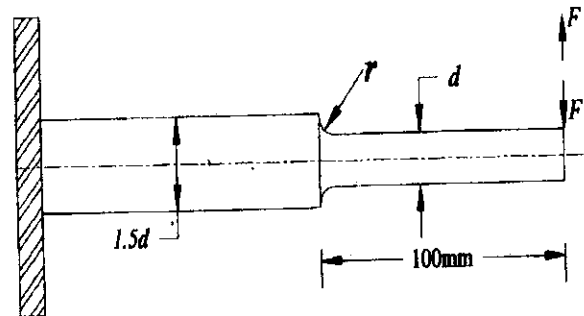

Fig.Q2(c)

Fig.Q3(c)

d. Design a rod of solid circular cross section of length 200 mm (placed vertical) to sustain an axial compressive load of 1000 N, that falls on it from a height of 10 mm. The material selected has a design stress of 80 N/mm^2 and E = 2.1 × 10^5 N/mm^2. **(03 Marks)**

3 a. Explain stress versus number of cycles (S-N) curve for ferrous and non-ferrous metals with the aid of experimental sketch and characteristic curves. **(06 Marks)**

b. Derive Soderberg equation. **(06 Marks)**

c. A stepped shaft of circular cross section shown in Fig.Q3(c) is made of SAE 1045 annealed steel. The load is repeated and completely reversed with a value of 100,000 N. Taking $\dfrac{r}{d} = \dfrac{1}{8}$, determine the diameter 'd' and the fillet radius 'r' so that the maximum stress will be limited to a value corresponding to a factor of safety 2. Consider the load factor = 1, surface finish factor = 0.85 and size factor = 0.9. **(08 Marks)**

4 a. A flat circular plate is used to close the flanged end of a pressure vessel of internal diameter 300 mm. The vessel carries a fluid pressure of 0.7 N/mm^2. A soft copper gasket is used to make the joint leak proof. Twelve bolts are used to fasten the cover plate on the pressure vessel. Find the size of the bolt, so that the stress in the bolt not to exceed 100 N/mm^2. **(10 Marks)**

b. The structural joint shown in Fig.Q4(b) is subjected to an eccentric load P of 10 kN with an eccentricity of 500 mm from the center of gravity of the bolts arrangement. Distance between the bolts is 200 mm and 150 mm perpendicular and parallel to the direction of the load acting. Bolts are identical and made of plain carbon steel having yield strength of 400 N/mm^2. Determine the size of the bolts taking factor of safety as 2.5.
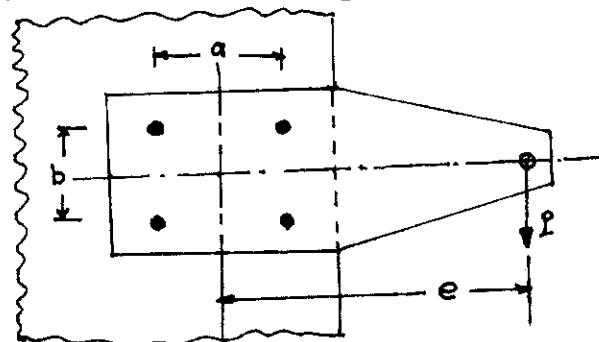

Fig.Q4(b) **(10 Marks)**

PART – B

5 A uniform circular carbon steel shaft made of SAE 1025 annealed is mounted on two bearings 850 mm apart as shown in the Fig.Q5. The shaft carries a gear 'A' at 200 mm to the right of the left bearing and a pulley 'B' at 250 mm to the left of the right bearing. The gear is subjected to horizontal pressure of 3500 N and a vertical upward pressure of 9600 N. The pulley is driven by a belt with a tension on tight side to be 6000 N and on the slack side to be 2000 N. The shock and fatigue factors for bending and torsion as $K_m = 2$ and $K_t = 1.5$ respectively and weight of the pulley to be 1500 N. Design the diameter of the shaft for yield stress taking factor of safety as 3. Draw neatly the sketch with loading and bending moment diagrams.
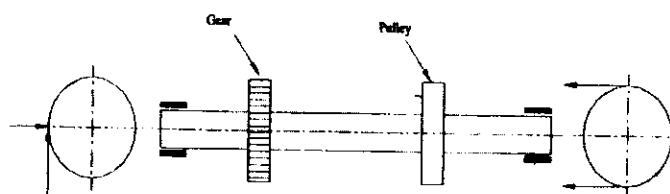

Fig.Q5   **(20 Marks)**

6 a. Design a Cotter joint for an axial load of 50 kN which alternately changes from tensile to compressive, assuming allowable stresses in the components under tension and compression as 52.5 N/mm², bearing stress as 63 N/mm² and shearing stress as 35 N/mm². Sketch neatly the joint and show dimensions.   **(15 Marks)**

b. A square key is used to key a gear and a shaft of diameter 35 mm. The hub length of the gear is 60 mm, Both key and shaft is made of same material having allowable shear stress of 55 MPa. What are the dimensions of the key according to maximum stress theory if 395 N-m of torque is to be transmitted?   **(05 Marks)**

7 a. Two mild steel tie bars, for a bridge structure are to be joined by means of butt joint with double cover plates. The thickness of the tie bar is 15 mm and caries a tensile load of 300 kN. Design an economical joint completely taking the allowable stresses as $\sigma_t = 80$ MN/m², $\sigma_c = 160$ MN/m² and $\tau = 64$ MN/m². Draw neatly a proportional top and front views of the arrangement of rivets with dimensions.   **(14 Marks)**

b. A 125 × 100 × 10 mm unequal leg angle section is to be welded to a steel plate by fillet welds along the edges of the 125 mm leg as shown in Fig.Q7(b). The angle is subjected to a tensile load of 100 kN passing through the center of gravity of angle. Determine the weld lengths if the size of the weld is 8 mm and allowable shear stress in the weld is 102 MN/m². All dimensions in the figure are in mm.
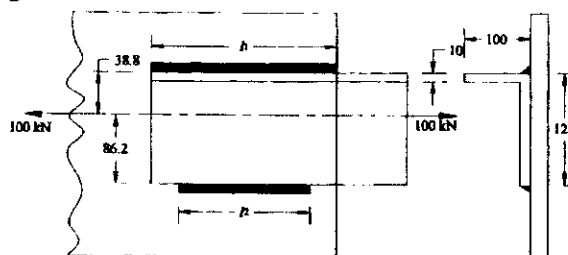

Fig.Q7(b)   **(06 Marks)**

8 a. Derive the equation for torque required to lift the load on square thread screws.   **(08 Marks)**

b. Define self locking and overhauling of power screw.   **(04 Marks)**

c. A machine slide weighing 20 kN is raised by a double start square threaded screw at the rate of 0.84 m/min. take $\mu = 0.12$ and $\mu_c = 0.14$. The outside diameter of the screw is 44 mm and the pitch is 7 mm. The outside and inside diameter of the collar at the end of the screw are 58 mm and 32 mm respectively. Calculate the power required to drive slide. If the allowable shear stress in the screw is 30 MPa, is the screw strong enough to sustain load.   **(08 Marks)**

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