TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
Model Question

Exam	**Regular (New course)**		
Level	BE	**Full Marks**	60
Programme	BAM	**Pass Marks**	24
Year/Part	III/II	**Time**	3 hr.

Subject: Automobile Component Design I (ENAM 352)

- ✓ *Candidates are required to give answers in their own words as far as practicable.*
- ✓ *Attempt **all** questions.*
- ✓ *The figure in the margin indicates the **full marks**.*
- ✓ *Use suitable data if necessary.*
- ✓ *Unless stated, all the dimensions in the drawing are in millimeters.*

1. Explain the concepts of design factor and factor of safety, and illustrate their application in the design process with a suitable relevant numerical example. **[4]**

2. Explain how Ashby charts can be used for material selection in the design of an automobile system, with a suitable relevant example. **[4]**

3. For an ASTM 30 cast iron component (ultimate tensile strength S_{ut}=30 kpsi and an ultimate compressive strength S_{uc}=110 kpsi), determine the following for the state of stress given below: **[6]**

   $\sigma_x = 15$ kpsi, $\sigma_y = 8$ kpsi, $\tau_{xy} = -8$ kpsi

   a) Calculate the factors of safety using the Brittle Coulomb–Mohr (BCM) and Modified Mohr (MM) failure theories.

   b) Plot the BCM and MM failure diagrams to scale in the σ_A- σ_B plane and locate the given stress state to estimate the factor of safety.

4. Explain the Maximum Shear Stress (MSS) theory (Tresca theory) for predicting the yielding of ductile materials, including its basic principle and yielding criterion. **[2+6]**

   A cantilever rod OA, 0.5 m in length, is made from AISI 1010 hot-rolled steel and subjected to a constant force and torque as illustrated in **Figure 1**. Determine the minimum rod diameter d required to achieve a static factor of safety of 2 using the Distortion-Energy failure theory.

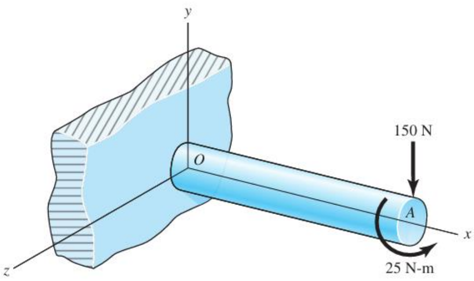


Figure 1: *A cantilever rod subjected to combined loading mode.*

5. Given a 1050 HR steel, estimate **[2+2+2]**

   a) The rotating-beam endurance limit at 10^6 cycles.

   b) The endurance strength of a polished rotating-beam specimen corresponding to 10^4 cycles to failure.

   c) The expected life of a polished rotating-beam specimen under a completely reversed stress of 379 MPa.

6. A rotating steel shaft with an end-mill key seat is subjected to combined bending and torsional loading. At the critical section, the alternating bending moment is 300 N·m, the mean bending moment is zero, the alternating torque is zero, and the mean torque is 125 N·m. The key seat has r/d=0.02, with fatigue stress concentration factors of 2.14 for bending and 3.0 for torsion. Using a factor of safety of 2, determine the required shaft diameter at the critical section using an appropriate fatigue failure criterion. **[8]**

Students are encouraged to use the value of $\sqrt{a}$ and f as provided herewith.

$$\sqrt{\mathrm{a}}_{Bending} = 1.24 - 2.25(10^{-3})\mathrm{S_{ut}} + 1.60(10^{-6})\mathrm{S_{ut}}^2 - 4.11(10^{-10})\mathrm{S_{ut}}^3$$

$$\sqrt{\mathrm{a}}_{Torsion} = 0.958 - 1.83(10^{-3})\mathrm{S_{ut}} + 1.43(10^{-6})\mathrm{S_{ut}}^2 - 4.11(10^{-10})\mathrm{S_{ut}}^3$$

$$f = 1.06 - 4.1(10^{-4})\mathrm{S_{ut}} + 1.5(10^{-7})\mathrm{S_{ut}}^2$$

Where $\mathrm{S_{ut}}$ is in MegaPascals.

7. An outer hub rotates around a stationary shaft, supported by two tapered roller bearings as shown in **Figure 2**. The device is to operate at 250 rev/min, 8 hours per day, 5 days per week, for 5 years, before bearing replacement is necessary. A reliability of 90 percent on each bearing is acceptable. A free-body analysis determines the radial force carried by the upper bearing to be 12 kN and the radial force at the lower bearing to be 25 kN. In addition, the outer hub applies a downward force of 5 kN. Assuming bearings are available from Timken with K = 1.5, find the required radial rating for each bearing. Assume an application factor of 1.2. **[5]**

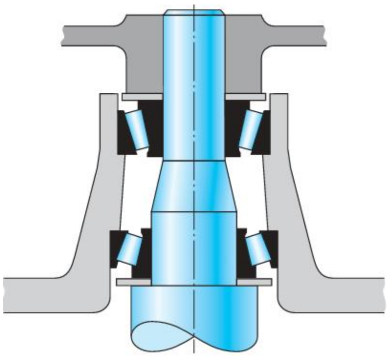


Figure 2: *Mounting for a washing machine spindle.*

8. The nominal diameter of a triple-threaded square screw is 50 mm, while the pitch is 8 mm. It is used with a collar having an outer diameter of 100 mm and an inner diameter of 65 mm. The coefficient of friction at the thread surface as well as at the collar surface can be taken as 0.15. The screw is used to raise a load of 15 kN. Using the uniform wear theory for collar friction, calculate: **[2+2+1]**
   a) torque required to raise the load;
   b) torque required to lower the load; and
   c) the force required to raise the load, if applied at a radius of 500 mm.

9. A vertical channel 152 × 76 (Thickness 6.4 mm) has a cantilever beam bolted to it as shown in **Figure 3**. The channel is hot-rolled AISI 1006 steel. The bar is of hot-rolled AISI 1015 steel. The shoulder bolts are M10 × 1.5 ISO 5.8. Assume the bolt threads do not extend into the joint. For a design factor of 2.0, find the safe force F that can be applied to the cantilever. **[5]**

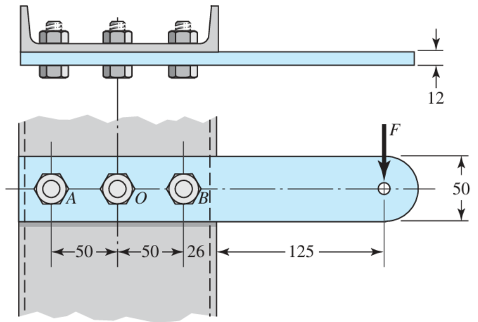


Figure 3: *Bolted joint in certain application.*

Note:- *For Bolts, S_y = 420 MPa , For Channel, S_y = 170 MPa and For Cantilever, S_y = 190 MPa*

Use $S_{sy} = 0.577S_y$ wherever necessary.

10. **Figure 4** shows a horizontal steel bar of thickness h, loaded and welded to a vertical support. Find the safe bending force F if the allowable shear stress in the welds is τ_{allow}=180 MPa. Use b = 50mm, d = 30mm, c = 150 mm, and h = 5 mm. **[5]**

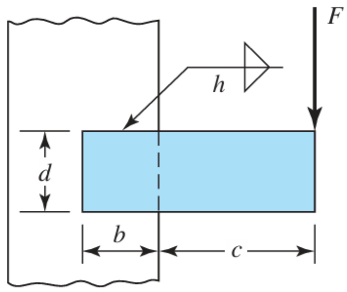
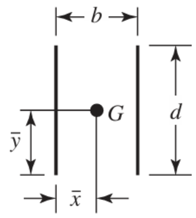


Figure 4: *A horizontal bar added to a vertical support.*

Torsional properties of fillet welds are attached herewith.



$$A = 1.414hd, \bar{x} = \frac{b}{2}, \bar{y} = \frac{d}{2}, J_u = \frac{d(3b^2 + d^2)}{6}, and\ J = 0.707hJ_u$$

11. Explain steering geometry for Ackerman's steering in brief. **[4]**