UNIVERSITY OF GHANA


SECOND SEMESTER EXAMINATIONS: 2012/ 2013

LEVEL 300/400: BACHELOR OF SCIENCE IN ENGINEERING

**BMEN 308/BIEN 406: Introduction to Mechanical Systems (3 CREDITS)**

TIME ALLOWED: 3 HOURS

**SECTION A (40 MARKS)**

ANSWER **ANY FOUR** QUESTIONS FROM THIS SECTION

1

a. What are lathes? **[1 Mark]**

b. Mention four lathe operations. **[4 Marks]**

c. Draw a typical lathe and label at least five basic parts. **[5 Marks]**

2

a. What is a spindle? **[2 Marks]**

b. A shaft running at 90 *r.p.m* is to drive a parallel shaft at 150 *r.p.m*. The pulley on the driving shaft is 50 cm in diameter. Find the diameter of the pulley on the driven shaft by

(i) Neglecting belt thickness. **[2 Marks]**

(ii) Taking account belt thickness of 5 mm. **[3 Marks]**

(ii) Assuming a total slip of 5 percent. **[3 Marks]**

3

a Explain briefly the following mechanical properties of metals

(i) Malleability (ii) Brittleness (iii) Creep (iv) Fatigue **[4 Marks]**

b. Give two advantages of each of the following engineering materials

(i) Ferrous metallic (Ii) Non Ferrous metallic (iii) Non metallic **[6 Marks]**

4

a State three advantages of the V-belt over the flat belt drives. **[3 Marks]**

b. Compare the V and the Square threads under the following **[2 Marks]**

(i) Strength (ii) Manufacturing



EXAMINER: Kutor & Tetteh

(iii) Friction (iv) Application

c. Besides being used as a fastener, mention two other use of a screw. **[2 Marks]**

d. What is a stud? Sketch it to explain its use **[3 Marks]**

5

a. A bolt is subjected to a direct tensile load of 20 kN and a shear load of 15 kN. Suggest the suitable size of the bolt according to the maximum shear stress theory, if the yield stress in simple tension is 360 MPa. Take the factor of safety to be 3 and the Poison ratio as 0.25. **[6 Marks]**

b. By means of diagrams or otherwise explain the pitch and the lead of a thread **[4 Marks]**



EXAMINER: Kutor & Tetteh

## SECTION B

Instructions: ANSWER ALL QUESTIONS.

1. You are the design engineer of a company that manufactures hip implants. If the hip implant is subjected to axial compressive force of F = - 15000 N it experiences a bending moment of -300 Nm. Given that the hip bone shaft diameter is 3.0 cm and 3.7 cm for inner and outer diameters respectively and longitudinal modulus of the cortical bone is 17 GPa. Using material choices of Co-Cr alloy E = 160 GPa,

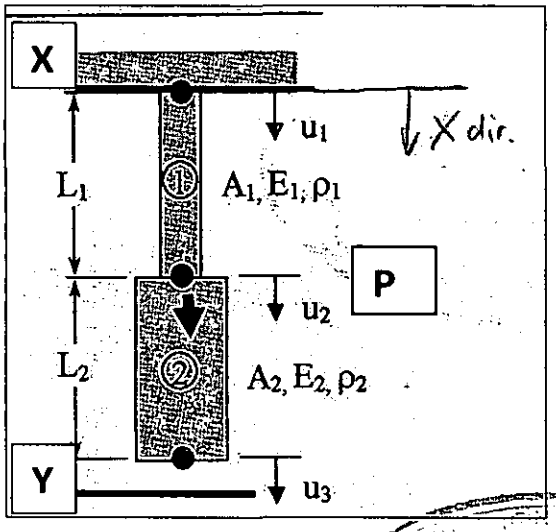
   a) Name 3 mechanical design criteria you will be looking out for and explain why?
   **[4.5 Marks]**

   b) Calculate the combined stresses experienced on the hip when the Co-Cr alloy is used?
   **[6.5 Marks]**

   c) The hip joint moves in both adduction-abduction, flexion-extension; how would you make the implant more flexible or rigid under both axial loading and pure bending cases
   **[2 Marks]**

2. You are designing a collapsible leg for a wheel chair; you want to determine the reaction forces at the two ends of the bar which has been shown in the compression device below. Please note the bar elements are represented by the numbers circled and then the nodal points by the darkened dot in the diagram. The distance between node 3 and wall Y is 2.5 mm, $L_1$ =1.5 m, $L_2$ = 1.75 m, $A_1$= 0.0173 $m^2$, $A_2$ = 0.164 $m^2$, $E_1$ =70x $10^4$ Pa, $E_2$= 95x$10^4$ Pa, P = 5x $10^2$ N

   a) Will the bar make contact with wall of the machine **[2 Marks]**
   b) Solve for the two elemental stiffness matrix for the bar element **[3 Marks]**
   c) Compute the global stiffness matrix for the whole system **[4 Marks ]**
   d) Calculate the nodal displacements **[4.5 Marks]**
   e) Solve for the reaction forces at the restraints **[ 4.5 Marks]**
   f) Solve for the bar element strains **[4 Marks]**
   g) Solve for the bar element stresses **[4 Marks]**






EXAMINER: Kutor & Tetteh

**Figure 1**: Collapsible walking stick represented by bar elements

3. In designing a metal prosthetic lower arm you are given a sample metal by your manager. In addition he gives you some data on the metal from the manufacturer. The metal has a width of 60 mm, thickness of 8.5 mm, a crack length of 23 mm, a critical stress factor of 55.5 MPa$\sqrt{m}$, and a yield strength of 2400 MPa, an applied stress of 530 MPa, mean stress of 170 MPa and an amplitude stress of 2310 MPa.

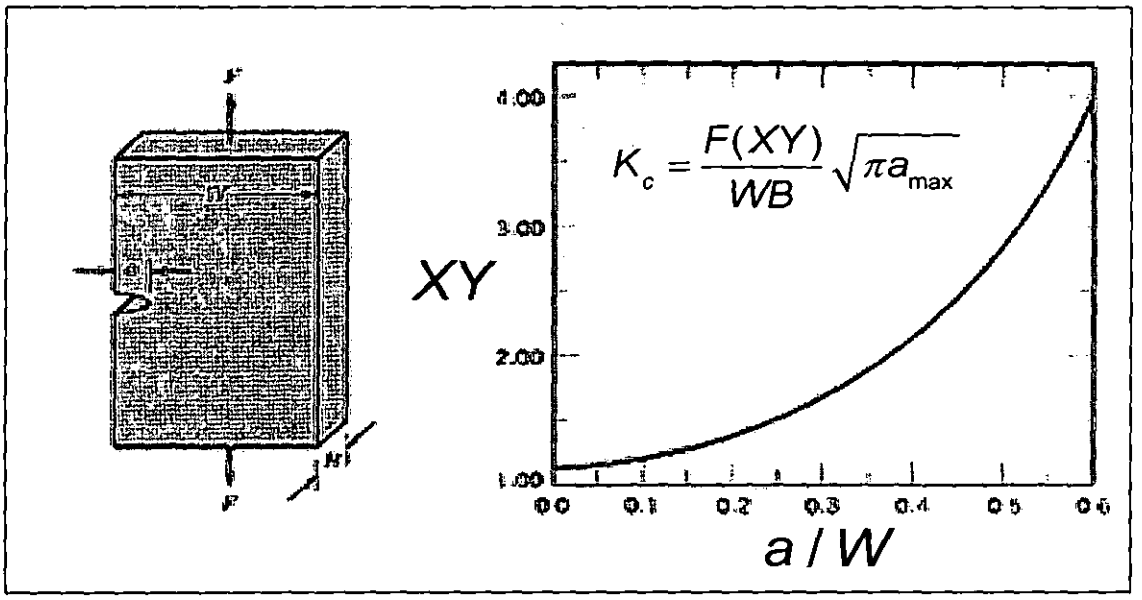



**Figure 2**: Graph of Geometric versus crack length – width ratio

a) Would you expect metal to fail with its crack length **[9 Marks ]**
b) Compute the maximum and minimum stress of metal **[5 Marks]**
c) Compute the stress ratio and stress range of metal **[5 Marks]**
d) Calculate the curvature of the crack in the material. **[2 Marks]**

**Formula Bank**

$$\sigma_i = \frac{E_i F}{\sum E_i A_i} + \frac{-E_i M c_i}{\sum E_i I_i}$$



EXAMINER: Kutor & Tetteh