UNIVERSITY OF GHANA

BSc (Eng.) MATERIALS SCIENCE AND ENGINEERING

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

FIRST SEMESTER EXAMINATIONS 2016/2017

MTEN 305: MECHANICAL BEHAVIOUR OF MATERIALS

FIRST SEMESTER **TIME: TWO (2) HOURS**

ANSWER ALL QUESTIONS

1.

a. Using a simple sketch of the stress-strain behavior of a typical ductile metal or alloy, label the following important mechanical properties that characterize the elastic and plastic behavior of materials: Young's modulus; proportional limit; resilence; 0.2% offset yield stress; ultimate tensile strength; plastic strain to failure, and toughness. ***(7 Marks)***

b. Show that the strain hardening exponent of a material that exhibits Hollomon dependence of stress on strain is equal to the true strain corresponding to the ultimate tensile strength. The Hollomon equation relates the flow stress, σ, to the true strain, ε, via the expression $\sigma = A\varepsilon^n$, where A is a material constant, and n is the strain hardening exponent. ***(15 Marks)***

c. A rod of length 2 mm and diameter 2.5 mm is loaded with 200 N weights. If the diameter decreases to 2.2 mm, compute the following:

   i. The final length of the rod.
   ii. The true stress and true strain at this load
   iii. The reduction in area.
   iv. Determine the engineering stress and engineering strain.
   v. Based on your calculations above, briefly compare and contrast the relationship between the true strain, engineering strain, true stress and engineering stress.

(18 Marks)

d. Briefly explain how dislocations multiply via Frank-Read sources. Explain the implications of such interactions for the strengthening of solids via dislocation interactions. ***(10 Marks)***

e. Describe in your own words four strengthening mechanisms (i.e., grain size reduction, solid-solution strengthening, strain hardening and precipitation strengthening). Be sure to explain how dislocations are involved in each of the strengthening techniques.

(10 Marks)

2.

a. A thin plate of Al is subjected to a state of stress represented by the tensor below. Determine the principal stresses associated with this state. Describe the resulting stress state using Mohr's circle approach. Indicate the maximum shear stress on your plot. State what is unique about the principal stress. ***(10 Marks)***

$$\left[\sigma_{ij}\right]=\begin{bmatrix} 0 & 0 & 300 \\ 0 & -400 & 0 \\ 300 & 0 & -800 \end{bmatrix} MPa$$

b. Determine the principal stresses for the state of stress. What is unique about the principal stress? ***(5 Marks)***

$$\begin{bmatrix} 0 & 240 & 300 \\ -240 & 200 & 0 \\ 0 & 0 & -280 \end{bmatrix} MPa$$

c. If the uniaxial yield strength of the plate material is 150 MPa, use Tresca and Von Mises criteria to determine whether yielding will occur. Comment on the relative accuracies of the two methods. ***(10 Marks)***

d. Consider two planes of atoms subjected to a homogenous shear stress (**Figure 1**). The shear stress is assumed to act in the slip plane along the slip direction. The distance between the atoms in the slip direction is ***b*** and the spacing between the adjacent lattice planes is ***a***. The shear stress causes a displacement, ***x*** in the slip direction between the pair the pair of adjacent lattice planes.

i. Derive an expression for the theoretical shear strength of a perfect crystal. ***(10 Marks)***

ii. Given that the Shear Modulus of Iron (Fe), G = 65.0 GPa, Calculate the maximum shear strength of Iron (Fe). ***(5 Marks)***

iii. Explain briefly the relationship between the measured shear strength and the theoretical shear strength. ***(5 Marks)***

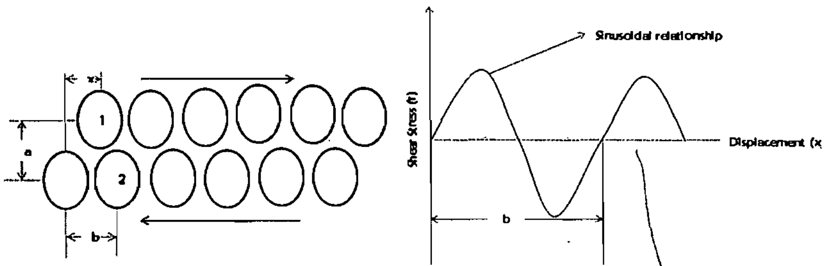

Figure 1

B. AGYEI-TUFFOUR