UNIVERSITY OF GHANA

BSc (Eng.) MATERIALS SCIENCE AND ENGINEERING

FIRST SEMESTER EXAMINATIONS 2017/2018

SCHOOL OF ENGINEERING SCIENCES

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

MTEN 305: MECHANICAL BEHAVIOUR OF MATERIALS

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

ANSWER ALL QUESTIONS

1.

a. Figure 1 shows the tensile engineering stress–strain behavior for a steel alloy.
   i. Determine the modulus of elasticity?
   ii. What is the proportional limit?
   iii. What is the yield strength?
   iv. What is the maximum tensile strength?

b. A load of 140,000 N is applied to a cylindrical specimen of a steel alloy (displaying the stress–strain behavior shown in **Figure 1**) that has a cross-sectional diameter of 10 mm.
   i. Will the specimen experience elastic and/ or plastic deformation? Why?
   ii. If the original specimen length is 500 mm, how much will it increase in length when this load is applied?

c. Show that the strain hardening exponent of a material that exhibits Hollomon's dependence of stress on strain is equal to the true strain corresponding to the ultimate tensile strength. The Hollomon's 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.

(20 Marks)

2.

a. Derive an expression for the critical resolved shear stress of a face centered cubic crystal with a direction normal oriented at theta (Θ) degrees to the loading axis and a slip direction oriented at phi (ϕ) degrees to the loading axis of a cylindrical specimen.

b. If the direction normal to the slip plane is oriented at 30° to the loading axis, and the slip direction oriented at an angle of 60° to the loading axis, estimate the yield stress of the single crystal. You may assume that the critical resolved shear stress is 100 MPa.

c. Using a simple sketch, explain the mixed nature of a circular dislocation loop. Explain why the circular dislocation loop is likely to evolve into an elliptical loop.

d. 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.

(20 Marks)

3.

a. Derive an expression for the evolution of strain in a solid that is loaded by a stress, σ and well characterized by the Voigt model. Sketch the time dependence of strain on a plot of strain versus time. You may assume that the material has a Young's modulus, E, and a viscosity, η.

b. 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.

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

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.

(20 Marks)

Please attach this page 3 to your answer booklet

CANDIDATE INDEX NUMBER..... SIGN:.....

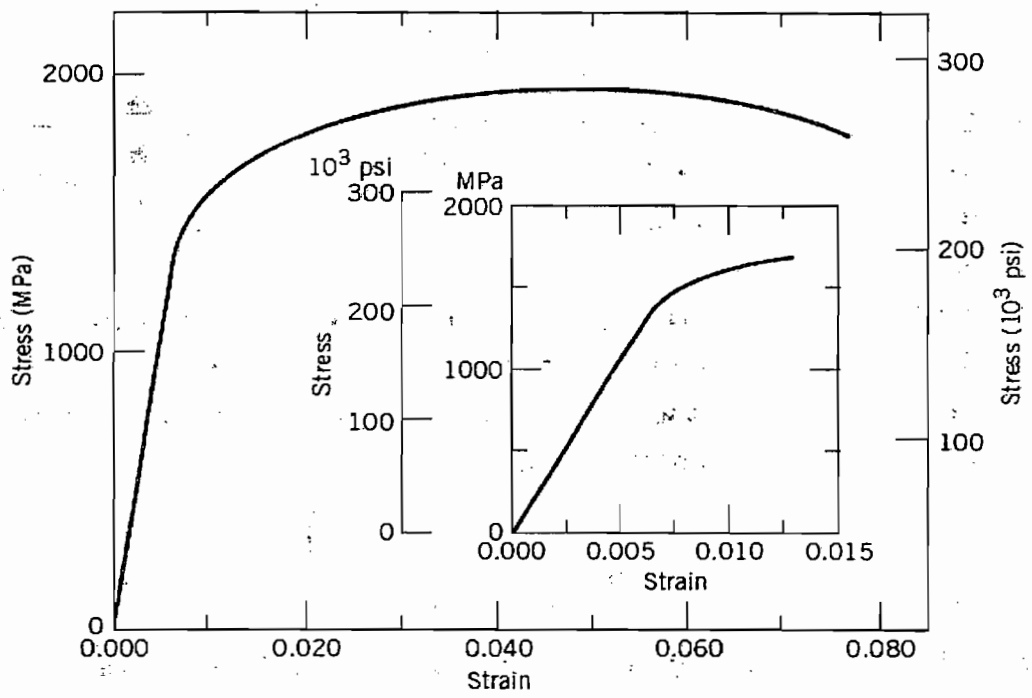

Figure 1 Stress-strain behavior of Steel alloy