UNIVERSITY OF GHANA

BSc. (ENG) MATERIALS SCIENCE AND ENGINEERING FIRST SEMESTER EXAMINATIONS: 2015/2016

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

COURSE CODE: COURSE TITLE (Credits)

MTEN305: MECHANICAL BEHAVIOUR OF MATERIALS

(2 Credits)

INSTRUCTION:

ANSWER ALL QUESTIONS (i.e. A total of 5 questions)
GRAPH SHEETS WILL BE PROVIDED
ALL REQUIRED FORMULAE ARE ON PAGE 4

TIME ALLOWED: ***TWO (2) HOURS***

1. Briefly define the following terms:
   a. Hardness
   b. Poisson's ratio
   c. Fatigue limit
   d. Fatigue life
   e. Fatigue strength
   f. Creep
   g. Steady-state creep rate
   h. Yield point
   i. Strain hardening
   j. Anelasticity

(20 points)

25

2. a) A tensile test is performed on a metal specimen, and it is found that a true plastic strain of 0.16 is produced when a true stress of 500 MPa is applied; for the same metal, the value K in the following equation:

$$\sigma_T = K\varepsilon_T^n$$

is 825 MPa. Calculate the true strain that results from the application of 600 MPa. **(7 points)**

b) Briefly describe the concept of the Variability of Material Properties, that is, why is it that even if we have a most precise measuring apparatus and a highly controlled test procedure, there will always be some scatter or variability in the data that are collected from specimens of the same material. **(6 points)**

c) The modulus of elasticity of nickel is 209 GPa. Determine the length of the bar when a force of 6.82 kN is applied to a 12.5 mm x 7.5 mm bar originally 900 mm long without causing plastic deformation. **(7 points)**

3. a) Why are hardness tests performed more frequently than any other mechanical test? **(3 points)**

b) The correlation between Brinell hardness and tensile strength is given by the following relationship:

TS (MPa) = 3.45 x HB

A 500 kg load is applied to a 10 mm diameter indenter, producing an impression on a steel plate having a tensile strength of 520 MPa. Estimate the diameter of the impression. **(7 points)**

c) A cylindrical steel bar 10 mm in diameter is to be elastically deformed. Using the data in Table 1 below, determine the force needed to produce a reduction of 3×10^{-3} mm in diameter.

Table 1. Room Temperature Elastic and Shear Moduli, and Poisson's Ratio for Various Materials.

	Modulus of Elasticity		Shear Modulus		
Material	**GPa**	**10^6 psi**	**GPa**	**10^6 psi**	**Poisson's Ratio**
Tungsten	407	59	160	23.2	0.28
Steel	207	30	83	12.0	0.30
Nickel	207	30	76	11.0	0.31

(10 points)

4. a) Briefly describe how you will carry out Charpy V-notch (CVN) impact fracture test. **(7 points)**

b) Why are measured fracture strengths for most brittle materials significantly lower than those predicted by theoretical calculations based on atomic bonding energies? **(6 points)**

c) A large plate is fabricated from a steel alloy that has a plane strain fracture toughness of 82.4 MPa$\sqrt{m}$. If, during service use, the plate is exposed to a tensile stress of 345 MPa, determine the minimum length of a surface crack that will lead to fracture. Assume a value of 1.0 for Y. **(7 points)**

5. a) Following is tabulated data that were gathered from a series of Charpy impact tests on a tempered 4340 steel alloy.

Temperature (^{0}C)	Impact Energy (J)
0	105
-25	104
-50	103
-75	97
-100	63
-113	40
-125	34
-150	28
-175	25
-200	24

i) Plot the data as impact energy versus temperature.
ii) Determine a ductile-to-brittle transition temperature corresponding to the average of the maximum and minimum impact energies.
iii) Determine a ductile-to-brittle transition temperature as that temperature at which the impact energy is 50 J. **(10 points)**

b) Calculate the maximum force that a 0.5 cm diameter Al_2O_3, having a yield strength of 241 MPa can withstand with no plastic deformation. Express your answer in Newtons. **(6 points)**

c) Define the following terms:
i) Stress concentration factor, K_t.
ii) Fracture toughness, K_C. **(4 points)**

$$BHN = HB = \frac{P}{\pi Dt} = \frac{2P}{\pi D\left[D - \sqrt{\left(D^2 - d^2\right)}\right]}$$

$$K_{1C} = Y\sigma\sqrt{\pi a}$$