



UNIVERSITY OF GHANA

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**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)

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:

$$\sigma_T = K \epsilon_T^n$$

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:

$$TS \text{ (MPa)} = 3.45 \times HB$$

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.

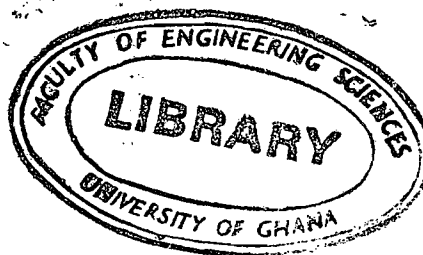
Material	Modulus of Elasticity		Shear Modulus		Poisson's Ratio
	GPa	10^6 psi	GPa	10^6 psi	
Tungsten	407	59	160	23.2	0.28
Steel	207	30	83	12.0	0.30
Nickel	207	30	76	11.0	0.31

(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 $82.4 \text{ MPa}\sqrt{\text{m}}$. 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 ($^{\circ}\text{C}$)	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_{Ic} . (4 points)



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

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