MSE 2001-B: Exam #1

Answer Key

<Printed Name>

September 17th, 2010

In taking this test, I agree that I will not participate in cheating or any other forms of academic fraud inconsistent of university policies. I understand that if I am caught participating in these types of actions, my exam grade will immediately default to 0% and I will be unable to retake the exam. AK

<Initials>

Part I: Conceptual

True/False/Maybe: 20 points (2 point each)
(The answer to the following questions are either true, false, or maybe)

(1) __F__ Not all materials undergo changes in dimensions in response to mechanical forces.

(2) __F__ The yield strength of a material, σ_y, depends strongly on bar diameter or cross-sectional area.

(3) __F__ When testing the properties of a material, "dog bone" shaped samples are good for tensile and compressive tests.

(4) __F__ Ceramics are highly susceptible to oxidize.

(5) __F__ Brittle fractures are defined by rough, jagged, and pointed fracture surfaces.

(6) __T__ Composites typically combine the best properties of two materials to increase their performance compared to the individual materials alone.

(7) __M__ A polymer subjected to a constant force will begin to creep at room temperature.

(8) __F__ Resistivity and conductivity are not material properties and depend on a materials dimensions.

(9) __M__ Ceramic materials are considered insulators.

(10) __F__ Direct dissolution occurs only in the presence of an electrical charge.

Multiple Choice: 10 points (2 points each)
(Circle an answer that completes the following statements)

(1) A polymer will typically have a modulus between:

a). 1 – 1,000 MPa b). 1 – 10 GPa c). 100 – 1000 GPa

(2) HF (hydrofluoric acid) is a highly polar solvent. It would be best to store HF in a container made from ____.

a). polyethylene b). metal c). polar polymers

(3) A material with a Poisson's ratio of 0.5 will experience ___ in volume when stretched.

a). an increase b). a decrease c). no change

(4) Low-cycle fatigue is defined when a samples fails in under ____ cycles.

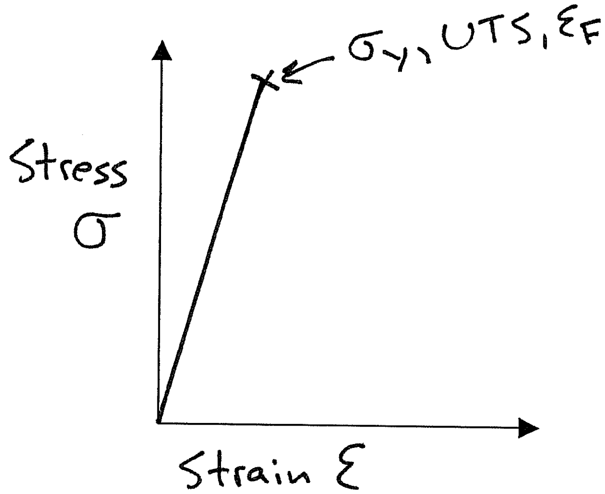
a). $10^1 – 10^2$ b). 10^3 - 10^4 c). 10^6 - 10^7

(5) The ____ stage of creep is linear and the most important to study, as it dominates the majority of the creep process.

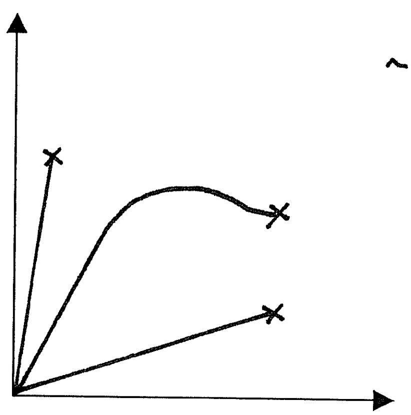
a). primary b). secondary c). tertiary

Short Answer: 40 points (10 points each)

(1) Sketch the strain-to-failure curve for a brittle material in tension (4points) and label the yield strength, ultimate tensile strength, and point of failure (6 points). Make sure to label each axis.



(2) Sketch the 3 possible strain-to-failure responses for a polymeric material. (8 points) What changes in test conditions could make a single polymer exhibit all 3 responses? (2 points)



~ Increase in Temperature or $\underbrace{\text{Strain Rate}}_{\text{+1 Bonus}}$. ↑ 2pts

(3) You are contracted by the US government to select a metal to build a tank. The tank will need to withstand sudden forces (i.e explosions and gunfire) and will be stationed in Antartica, which is very cold. What material property will let you know if the cold weather will be a problem (4 points)? How would you measure this material property (6 points)?

The ductile-to-brittle transition temperature (DBTT).

4pts

Perform Impact Testing over range of temperature

4pts

2pts

(4) List, in any order, 5 of the 10 steps to the design cycle of a biomedical device (2 point each).

1. Identify Need
2. Design Device
3. Choice of Material/Synthesis
4. Material Testing
5. Device Fabrication

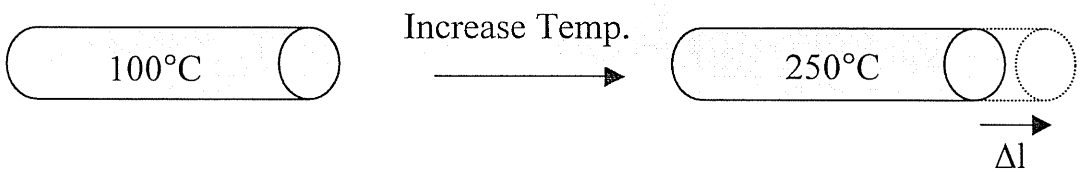
For extra credit, list the remaining 5. (½ point each).

6. Sterilization & Packaging
7. Device Testing
8. Regulatory Approval
9. Clinical Use
10. Explant Analysis

Part II: Quantitative

(1) A 7 m long metal bar is heated from 100°C to 250°C. The bar is made from aluminum, which has a thermal expansion coefficient of 25×10^{-6} 1/°C. Calculate the change in length of the bar. (15 points)

(Note: Thermal expansion coefficient is given in terms of strain per degrees Celcius).



1. Calculate Strain

$$\hookrightarrow \varepsilon = \alpha \cdot \Delta T$$
$$= (25 \times 10^{-6} \tfrac{1}{°C})(150°C)$$
$$= \underline{3.75 \times 10^{-3}}$$

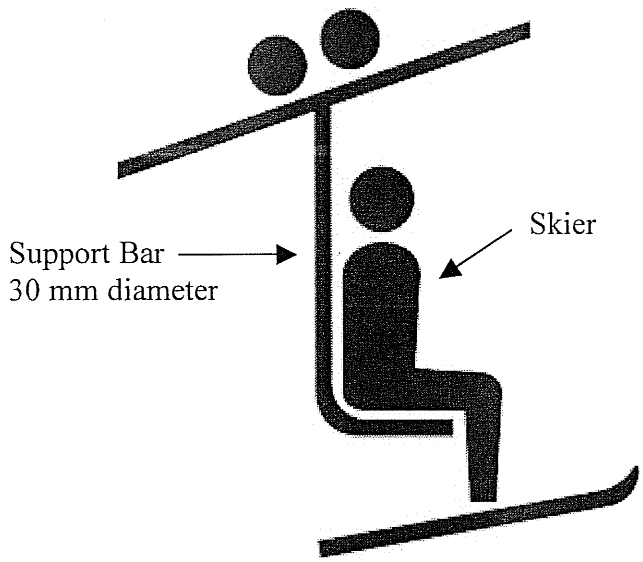
8pts

2. Change in Length

$$\hookrightarrow \varepsilon = \frac{\Delta l}{l_o}$$
$$\Rightarrow \Delta l = \varepsilon \times l_o$$
$$= (3.75 \times 10^{-3})(7m)$$
$$= \boxed{2.63 \times 10^{-2} m} \text{ or } 26.3mm$$

7pts

(2) A 4 mm diameter solid steel bar is used to support a chair on a ski lift. The bar is repeatedly loaded in tension as people get on and off the ski lift. The typical skier weighs 800N and 4 skiers ride the lift at a time. The modulus of the steel bar is 200 GPa. The yield strength of the steel bar is 300 MPa. Does the supporting bar yield when 4 skiers ride the lift? (10 points) Do you worry about the bar failing under fatigue and why? (5 points)



1. Calculate Stress

↳ $\sigma = \frac{F}{A} = \frac{F}{\frac{\pi}{4}d^2}$

$= \frac{(800N)\times 4}{\frac{\pi}{4}(4mm)^2}$

$= \underline{254.6\ MPa}$ ← 6pts

2. Does bar yield?

↳ 254.6 MPa < 300 MPa → $\boxed{\text{No}}$ ← 4pts

3. Worry About Fatigue

↳ Rule of Thumb → $S_e \leq 0.5\ \sigma_y$ ← 3pts

⇒ $S_e \leq 150$ MPa

$\boxed{\text{Yes!}}$ → σ = 254 MPa, which is greater than S_e (or 150MPa