

National Exams December 2018

16-Mec-B8 Engineering Materials

3 Hours Duration

NOTES:

1. If doubts exist as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. Any non-communicating calculator is permitted. This is an open book exam.
3. Any **five** of the **eight** problems given constitute a complete paper.
4. All problems are of equal value.

1- A box is to be placed on a bracket attached to the engine in an automobile. Two polymeric materials have been short-listed as primary candidates for this application, namely ABS and phenolic.

- a- Compare the two materials in terms of strength, impact resistance, manufacturing methods, chemical resistance, heat resistance and cost.
 - b- What material would you select and why?
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2- The presence of carbon, while producing the necessary hardening of conventional high tensile steels, causes brittleness and distortion, which makes machining difficult and cold forming impracticable. Welded fabrication is also impracticable or very expensive. To overcome some of these difficulties, some types of steels were developed from which carbon is either eliminated entirely or present only in very small amounts. The hardening of such steels is achieved by the addition of other elements such as nickel, cobalt and molybdenum.

What in your opinion are the main reasons for carbon to cause brittleness and the associated machining and welding difficulties of conventional steels? Also explain how the replacement of carbon with nickel, cobalt and molybdenum help alleviate these difficulties.

3- Advanced fiber-reinforced plastic composites are now commonly used in aircraft structural design for both primary and secondary load bearing applications.

- a- Present four different processing methods that may be used to consolidate those composites
 - b- Discuss the main advantages and disadvantages of each method in relationship to such considerations as mechanical properties, geometrical aspects, processing speeds, cost, size, etc.
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4- A ductile metal wire of uniform cross-section is loaded in tension until it just begins to neck. The curve of true stress σ vs. true strain ϵ for this wire approximates to:

$$\sigma = 218 \epsilon^{0.33} \text{ MPa}$$

- a- Assuming that the volume is conserved, derive a differential equation relating the true stress to the true strain at the point of necking.
 - b- Estimate the ultimate tensile strength of the metal and the work required to take 1 m³ of the wire to necking.
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5- Consider a homogeneous bar of length L and a rectangular cross section of width b and thickness t . When the bar is stretched by a small amount ΔL the cross sectional dimensions are reduced by the amounts Δb and Δt . If this corresponds to a case of perfect plasticity where the volume of the bar is the same before and after deformation, what is the Poisson's ratio for this material?

6- Floor beams of a transport airplane have been designed using an aluminum alloy containing 4 wt% Cu and 1 wt% Mg for a total weight of 85000 N. A customer has ordered the airplane but requested that its total weight be reduced by 10000 N for fuel saving purposes. An engineer in the design and analysis department suggested that more than 90% of that weight saving objective can be realized by replacing the aluminum alloy of the floor beams with an aluminum-lithium one containing 3 wt% Li and 1 wt % Cu. Is this possible? Answer the question by estimating the weight savings that will take place using the Al-Li alloy. Assume weighted averages of density and use the following densities for the mentioned materials:

$$\text{Al} = 2.70 \text{ g/cm}^3 \quad \text{Cu} = 8.92 \text{ g/cm}^3 \quad \text{Mg} = 1.74 \text{ g/cm}^3 \quad \text{Li} = 0.53 \text{ g/cm}^3$$

7- A 0.9 kg magnesium sacrificial anode in a hot water heater is used up in 14 years.

- a- What is the anode reaction?
- b- What is the average corrosion current supplied by the anode?

Use an electromechanical valence of 2 and an atomic mass of 24.3 amu for Mg.

8- Discuss the following two applications where corrosion is an issue:

- a- Steel screws used as fasteners on aluminum siding experienced severe corrosion. Would you have expected this, why or why not? Explain why this might have occurred.
- b- A brass faucet is connected to an iron pipe. Discuss this coupling from a corrosion viewpoint and explain which metal is likely to corrode and why?