

APSC 150 Case 3 (Materials) Quiz

Closed Book Exam

Answer all 20 multiple choice questions

1. Materials are typically broken out into either three or five categories. Which of the following statements is NOT correct
 - a. Metals, ceramics, and polymers are the three main categories when split into three categories
 - b. Metals, ceramics, glasses, polymers and elastomers are the five main categories when split into five categories
 - c. Another name for ceramics is plastics
 - d. Composites are the combination of two or more materials
 - e. Elastomers are polymers with which show recoverable behaviour up to a very high strain to failure

2. The industrial revolution was based on the ever increasing capabilities of which of the following materials
 - a. Iron and Steel
 - b. Aluminum
 - c. Bronze
 - d. Nylon
 - e. Portland Cement

3. Which one of the following statements is NOT correct
 - a. A technical system can be thought of as functional layout with different functional blocks, each with inputs and outputs of energy, material and information
 - b. A technical system can thought of as a series of assemblies each consisting of a number of components
 - c. The design work flow goes from: defining market need to concept to embodiment to detail design to product
 - d. In materials selection, the ability to satisfy a functional requirement is dependent on the availability of a material in an optimum shape, which in turn depends on the cost
 - e. When the cost of the product far exceeds the cost of the materials, materials selection is performance driven

The next five questions refer to a wire rope made from an engineering alloy with the following properties:

Density: $\rho = 3000 \text{ kg/m}^3$

Strength = 150 MPa

Young's Modulus: $E = 75 \text{ GPa}$

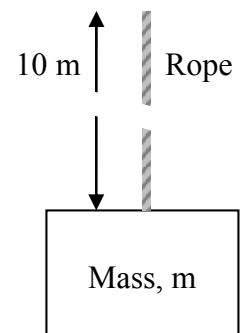
Cross section area: $A = 1 \text{ cm}^2$

Length: $L = 10\text{m}$

4. Imagine that the force on the wire rope is small, such that the material strength is not exceeded. What will happen to the wire rope?
- It will deform linearly with increasing force and will return to its original shape when the force is released
 - It will deform nonlinearly with increasing force and will return to its original shape when the force is released
 - It will deform plastically and not return to its initial shape
 - It will deform such that the strain ϵ remains proportional to stress σ
 - It will break

5. Imagine a mass, m , is supported from the rope in tension (as shown to the right). The material behaves elastically and experiences a stress of 75 MPa. By how much will this rope elongate?

- 1 mm
- 5 mm
- 10 mm
- 5 m
- 10 m

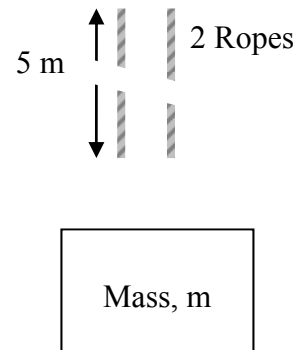


6. What is the mass of the rope?

- 3.011×10^4 kg
- 3.000×10^4 kg
- 301.1 kg
- 3.011 kg
- 3.000 kg

7. Now imagine the 10m rope is cut into two lengths of 5m. The two ropes are used in parallel to support the same mass, m , as shown to the right. How much different will the elongation in each 5m rope be compared to if a single 10 m rope was used?

- Four times more elongation in the 5 m ropes
- Two times more elongation in the 5 m ropes
- The same elongation in both cases
- Two times more elongation in the 10 m rope
- Four times more elongation in the 10 m rope



8. Imagine a new wire rope is being made from the same material above. How large a cross-sectional area would the wire rope need to have in order to support a force of 300 N without breaking?

- $5.00 \times 10^{-9} \text{ m}^2$
- $2.00 \times 10^{-6} \text{ m}^2$
- 0.111 m^2
- 2.00 m^2
- 5.00 m^2

9. Referring to the materials charts at the end of this quiz, identify an engineering alloy with approximately the same strength, σ_f , as high density polyethylene (HDPE)
- Zinc (Zn) alloys
 - Magnesium (Mg) alloys
 - Lead Alloys
 - Wood Products
10. The material index for a light strong tie is $M = \sigma/\rho$. Referring to the materials charts at the end of this quiz, rank the following three materials from best to worst based on this material index. For each material use the highest value indicated.
- Material 1: Balsa Parallel to Grain (a wood)
 Material 2: PTFE (an engineering polymer)
 Material 3: Titanium (Ti) alloy (an engineering alloy)
- Balsa – PTFE – Ti Alloy
 - Balsa – Ti Alloy – PTFE
 - PTFE – Balsa – Ti Alloy
 - Ti Alloy – Balsa – PTFE
 - Ti Alloy – PTFE – Balsa

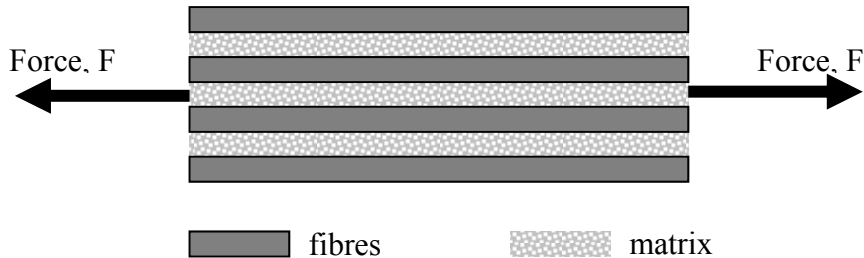
11. The maximum deflection in a cantilever beam of square cross-section subjected to an end load F is:

$$\delta = \frac{FL^3}{4Et^4}$$

where L is the plate length, and t is the beam thickness. The length is fixed. The maximum permissible stress is σ_f . The objective is to make the mass of the plate as small as possible. What is the material selection index for this application?

- $M = \sqrt{E}/\rho$
 - $M = E/\rho$
 - $M = \rho / (\sqrt{E})$
 - $M = \sqrt[3]{E}/\rho$
 - $M = \rho\sqrt{E}$
12. Continuing with the previous question, select the best engineering alloy for this application from the choices below. (Use the material selection charts at the end of this exam and assume the best possible performance for each material.)
- Al Alloys
 - Lead Alloys
 - Cu Alloys
 - Steels
 - Zn Alloys

13. Consider an engineered composite consisting of fibres and a polymer matrix as shown below. The Young's Modulus of the matrix material is E_m and the Young's Modulus of the fibre material is E_f (note: $E_m < E_f$). The volume fraction of fibres is v_f . The composite is loaded by a force, F , as shown.



- Which of the following statements about this composite is true? (Select only one response; if more than one statement is true, select e.)
- The stiffness of the fibres and matrix are equal
 - The stress in the fibres and the matrix are equal
 - The strain in the fibres and the matrix are equal
 - The force carried by the fibres is greater than the force carried by the matrix
 - At least two of the above are true
14. Considering the composite from the question above, which of the following statements a to d about the composite modulus, E_c , is/are FALSE? (Select only one response; if more than one statement is false, select e.)
- $E_c = E_m$ if $v_f = 0$
 - $E_c = E_m$ if $v_f = 1$
 - E_c for the loading shown is greater than if the forces were applied in the vertical direction
 - E_c is always greater than or equal to E_m , no matter the direction of loading
 - At least two of the above are false
15. When considering the total cost of an item, the three components of cost are
- Cost of material/batch size, capital cost, labour cost(/hour)/batch rate
 - Cost of material, capital cost/batch size, labour cost(/hour)
 - Cost of material, batch size, batch rate
 - Cost of material, capital cost/batch size, labour cost(/hour)/batch rate
 - Cost of material, capital cost, labour cost
16. The major consideration in the design and certification of aluminum structures for aircraft is
- Impact Damage
 - Overloads
 - Fatigue cracks
 - Environmental degradation
 - Combined environmental degradation and fatigue cracking

17. The major consideration in the design and certification of composite structures for aircraft is
- Combined environmental degradation and fatigue cracking
 - Overloads
 - Impact Damage
 - Fatigue cracks
 - Environmental degradation
18. The current certification approach for composite structures assumes that for limit load (the maximum load being per lifetime) that
- Damage is not a consideration
 - Any damage is non-detectable or acceptable
 - Any damage will occur with the flight crew's knowledge
 - Any damage is detectable, and to be found and repaired through maintenance
 - Damage must be monitored using in-flight instrumentation
19. Although composite materials are much more expensive than aluminum on a material weight basis, the cost of the finished structure is comparable because
- Manufacturing costs for composites are much lower since much larger and complex structures can be built in one step compared with aluminum
 - Significant discounts are available for composite materials bought in bulk
 - The composite structure is much lighter than the aluminum structure
 - Maintenance and repair costs for composite structures are much lower than for aluminum structures
 - Aluminum structures have to be inspected at great cost
20. The Boeing 787 airframe construction consists of
- Aluminum fuselage and aluminum wings
 - Aluminum fuselage and composite wings
 - Composite fuselage and aluminum wings
 - Composite fuselage and titanium wings
 - Composite fuselage and composite wings

