UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	ENGINEERING MATERIALS SELECTION
COURSE CODE	:	BDA 20402
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JULY / AUGUST 2023
DURATION	:	2 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUSCTED VIA **CLOSED BOOK.** 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK.

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1 (a) **Figure Q1(a)** shows the stress-strain curve of materials A – E. Explain the possible properties for each material.

(7 marks)

(b) By using "water bottle" as an example, show that design is dictated by materials.

(8 marks)

(c) Numerous decorative cubes made of aluminium, steel, copper and titanium is accidentally mixed up. If the cubes are all similar in colour, dimension (10 cm × 10 cm × 10 cm), and closed pores (60%). How would you identify each and every cube easily without damaging them? You may use appropriate sketches with labels in your answers. Note that high-end apparatus or techniques shall not be considered. Given. density (g/cm^3): aluminium = 2.7, steel = 7.8, copper = 8.8, titanium = 4.5.

(10 marks)

Q2 (a) What is "design process"? Explain in details.

(7 marks)

(b) How would you solve the design of a calculator according to the conventional and alternative approach?

(8 marks)

(c) The FKMP's aircraft replica (**Figure Q2(c)**) is an iconic structure of UTHM. Based on FOUR (4) selection factors, analyse the properties which suit the replica.

(10 marks)

Q3 (a) Sketch the region and propose all possible materials for $M = \frac{E^{1/4}}{C_R \rho} \geq 2$ (GPa/Mgm^3) and $E \geq 20$ GPa in **Figure Q3(a). Attach the figure in your answer script**.

(10 marks)

(b) Fiber from palm oil was used as materials for furniture (fiber board). By using your knowledge of the strategy for materials selection, criticize the use of fiber for the furniture in terms of screening and ranking, supporting information, local condition and property limit.

(15 marks)

Q4 (a) You have been asked to help a world-famous sculpture artist with a new project. Part of the design calls for an array of long, slender cantilever beams extending from the side of a building. The artist has a fixed length in mind for each beam, and for esthetic purposes, she wants the beams to be square cross sections ($b \times b$) that are as thin as possible (smallest possible b). Each beam has a limit on the end deflection, DELTA (δ), and also, it should not break under load. Identify design requirements for this product:

(i) Function
(ii) Objective
(iii) Constraint
(iv) Free variable

(5 marks)

(b) You are required to select materials with a Young's modulus (E) less than 1 GPa and a performance index $M = \eta^2/E$ greater than $M = 1 \times 10^{-4}$ [1/GPa]. Sketch clearly your selection region on the selection chart in **Figure Q4(b)** and **please attach Figure Q4(b) with your answer script**.

(5 marks)

(c) You have been asked to design a replacement power strut (**Figure Q4(c)**) for a steam powered railroad engine as part of a refurbishment for a local museum. The strut is used to drive the main wheel with the thrust from the steam piston, and acts as the brake by locking the piston and the drive wheel in an emergency stop. For esthetic reasons, the replacement strut must be a rectangular cross section beam the same height, h, and length, L, as the original, but the width, b, is free to vary. The strut is subject to two constraints:

- The strut must not yield in tension due to an end load, F_T, when in the power stroke, and;
- The strut cannot buckle when a compressive end load, F_B is applied during an emergency stop.

In addition, we want the cost of the strut to be small, so our measure of performance is cost (in dollars) as small as possible. The important equations are:

Tensile Failure Load [N], $F_T = \sigma_f bh$

Tensile Buckling Load [N], $F_b = \frac{\pi^2 Ebh^3}{48L^2}$

Cost [US\$], $D[US\$] = C\rho Lbh$, where C = cost/kg [\$/kg] is a material property

(i) Derive the performance index, $M_{failure}$, for the failure load constraint.
(5 marks)

(ii) Derive the performance index, $M_{buckling}$, for the buckling load constraint.
(5 marks)

(iii) Derive the coupling equation for this design and list the axes of the selection chart you must use, as well as the slope to use.
(5 marks)

~ END OF QUESTIONS ~

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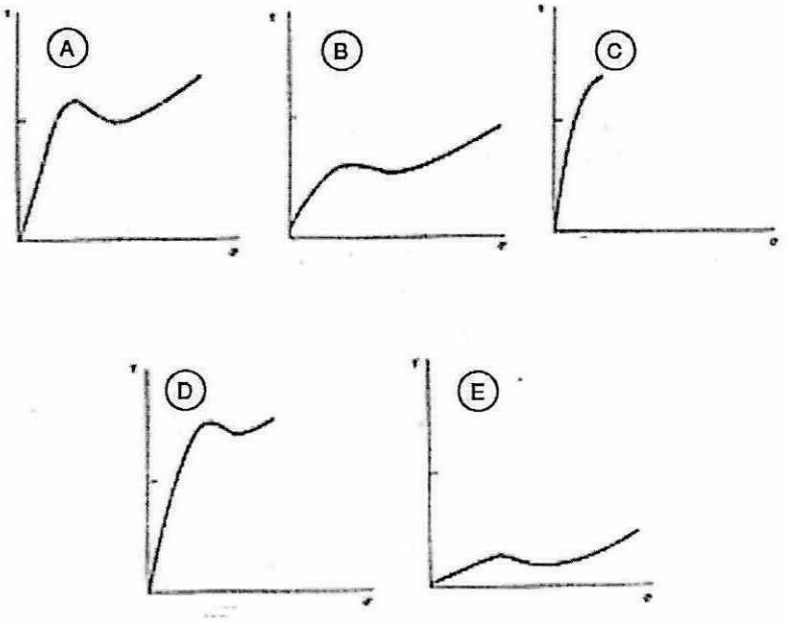

Figure Q1(a)

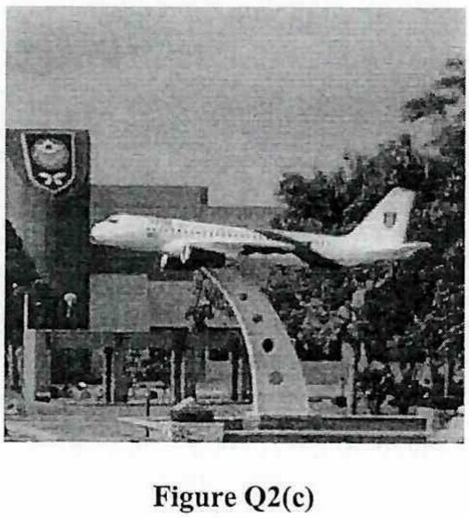

Figure Q2(c)

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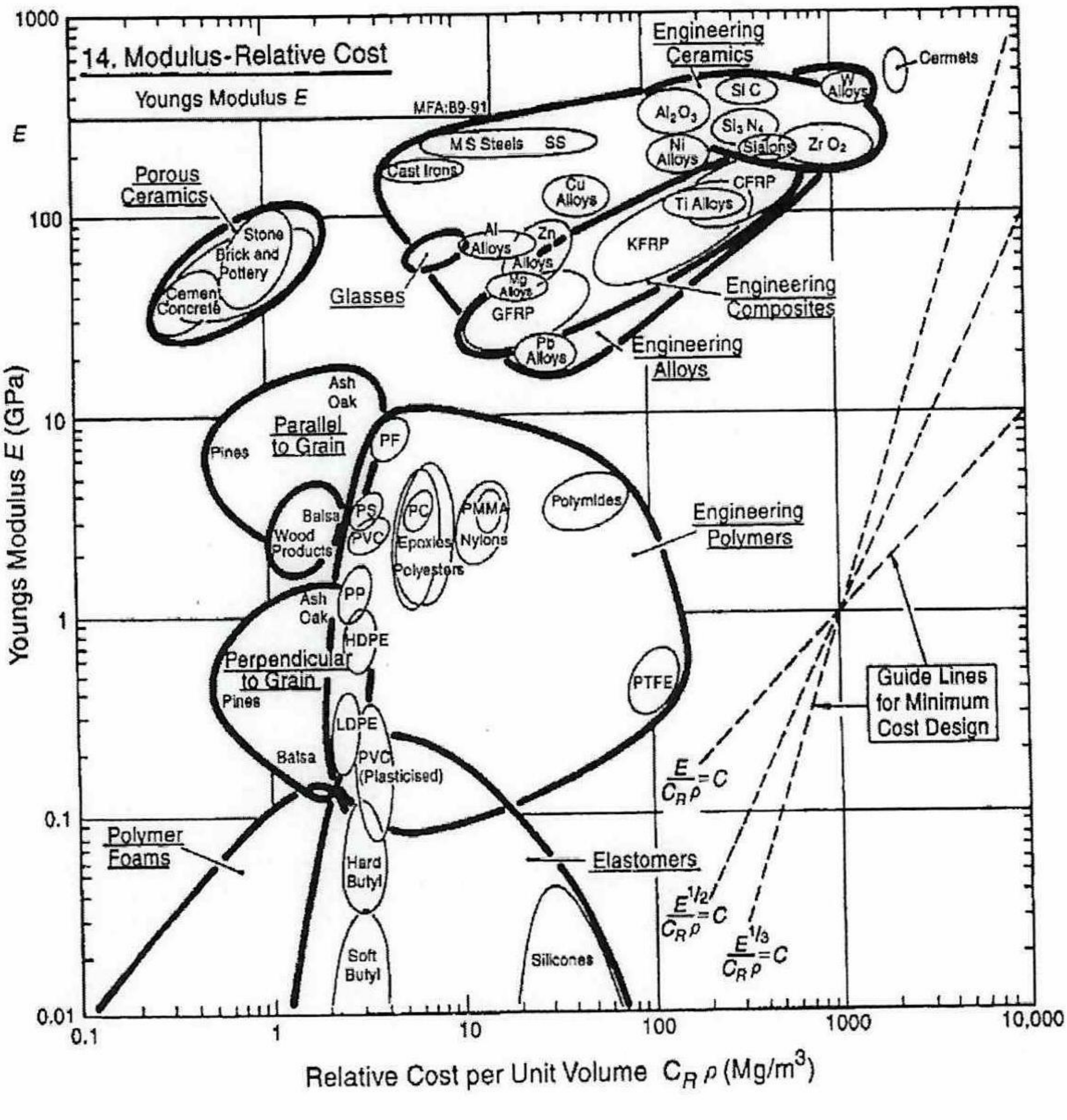

Figure Q3(a)

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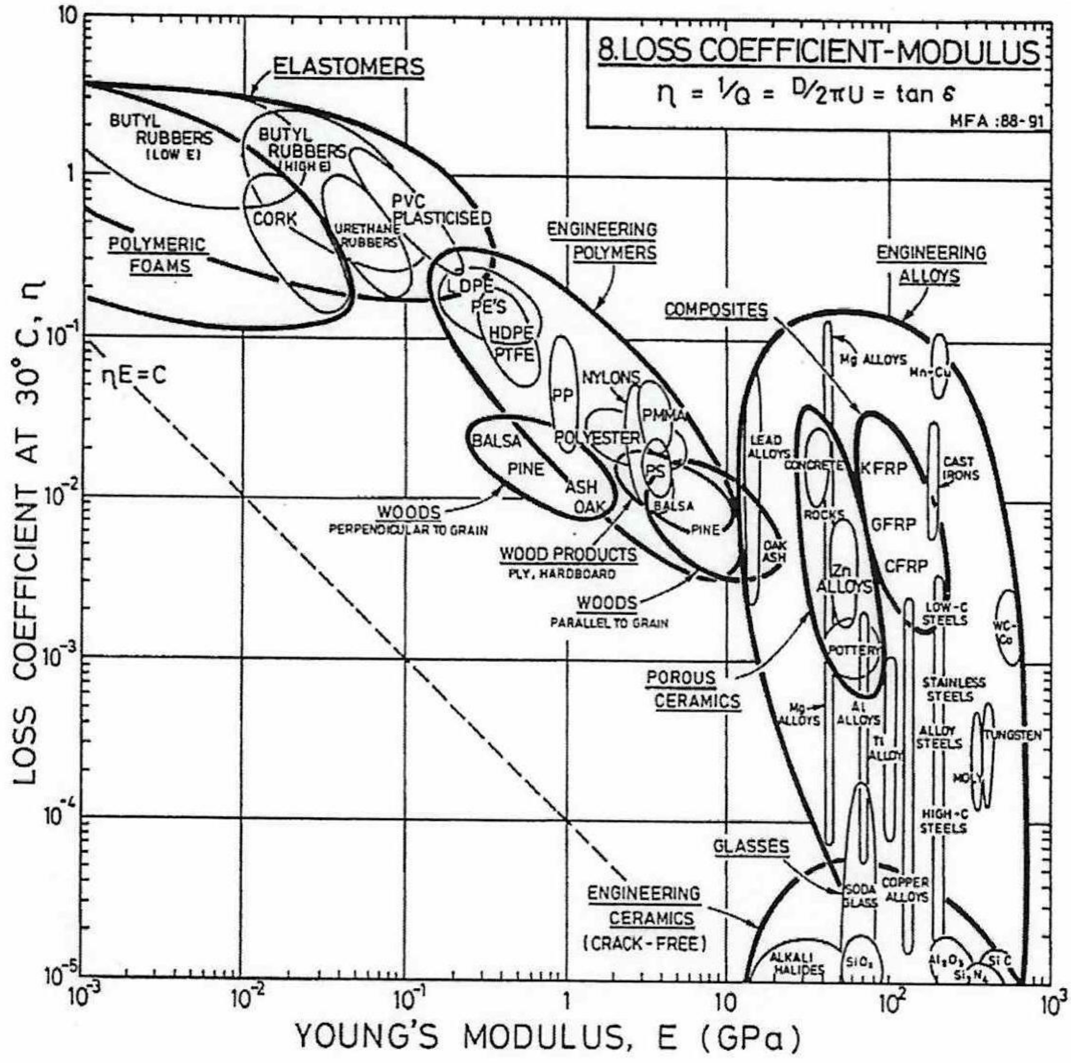

Figure Q4(b)

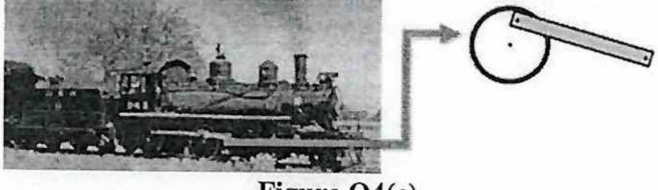

Figure Q4(c)