UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2016/2017

COURSE NAME	:	ENGINEERING MATERIALS SELECTION
COURSE CODE	:	BDA 20402
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JUNE 2017
DURATION	:	2 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTION IN **SECTION A** 2. ANSWER ONLY **THREE (3)** QUESTION IN **SECTION B.**

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

SECTION A: COMPULSORY QUESTION

Q1 (a) Define the 'Material Index' and give THREE (3) factors that involve in design of structural elements.

(4 marks)

(b) A particular design asks to choose a material using $M = \frac{\lambda^2}{\rho^{1/3}}$. For a plot of log (λ) [Y-axis] versus log (ρ) [X-axis], determine the slope of the selection line.

(4 marks)

(c) Use the selection chart in **Figure Q1(c)**, to determine the subset of materials with a Young's modulus (E) less than 1 GPa and a selection index $M = \frac{\eta^2}{E}$ greater than $M = 1 \times 10^{-4} \left[\frac{1}{GPa}\right]$. Show your materials with a sketch on the selection chart in **Figure Q1(c)** clearly indicating the selection region.

(12 marks)

(d) Based on the materials that have been determined in the selection chart in **Figure Q1(c)**, what are the general properties of the materials selected.

(5 marks)

SECTION B

Q2 (a) Design deals with the physical principles, the proper functioning and the production of mechanical system. Describe briefly TWO (2) types of design. Give an example for each type to support your explanation.

(4 marks)

(b) "Product as technical system". Apply this statement on play station 3.

(10 marks)

(c) Portmeirion tableware is made from ceramic while silverware is made from metal. Compare these two materials in term of their properties and sketch their tensile test profile.

(8 marks)

(d) List THREE (3) types of additives for polymer application and and their function.

(3 marks)

Q3 (a) Ceramic product was sintered and has 335g when dry, 335g when its suspended in water and 235g when suspended in air. True density of the ceramic was 4g/cm^3. Calculate the percentage of closed porosity for this ceramic. In your opinion, what is the process that has been done for this ceramic? Justify your answer.

(10 marks)

(b) Explain briefly about liquid phase sintering.

(5 marks)

(c) Boron coated with SiC (Borsic) reinforced aluminium containing 40 vol% fibers is the important high temperature and light weight composite material.

Material	Density (g/cm^3)	Modulus of Elasticity (GPa)	Tensile strength (MPa)
Fibers	2.36	379	2760
Aluminium	2.70	69	35

Estimate:

(i) density of composites

(3 marks)

(ii) modulus of elasticity

(2 marks)

(iii) tensile strength parallel to the fiber axis

(2 marks)

(iv) modulus of elasticity perpendicular to the fibers

(3 marks)

Q4 (a) Discuss the differences between low, medium and high carbon steel.

(6 marks)

(b) As an engineer, you are requires to order tool steel for machining operation with tensile strength ≥1800 MPa and a % elongation of >10%. Refer to **Table Q4 (b1)** and **(b2)** for your selection.

(7 marks)

(c) A austenized 60 mm diameter 5140 alloy steel bar is quenched in agitated oil. Predict the Rockwell C (RC) hardness of this bar will be at:

(i) surface and

(ii) its center.

Refer **Figure Q4 (c1)** and **(c2)** for assistance and attach it together with your answer.

(12 marks)

Q5 As a design engineer at Korogi Music, you have taken a job to design a musical instrument as shown in **Figure Q5**. It is basically a series of differently shaped cantilever beams that, when hit with a plastic hammer it will vibrate and make a wonderful sound. The instrument should cost as low as possible and it must vibrate at a particular frequency, f1. The length, L is fixed but you can vary the cross sectional area, A. The equation for the vibration frequency of the cantilever is given

$$f_1 = \frac{K}{2\pi}\sqrt{\frac{EI}{\rho A L^4}}$$

Where K is a constant. Since the vibration frequency depends on the second moment, I, you can change the sound made by changing the shape. With the given equations,

$$Cost = (C_r \rho)(volume)$$

$$\emptyset_B^e = \frac{4\pi I}{A^2} \qquad \emptyset_B^f = \frac{16\pi I^2 I}{y_m^2 A^3}$$

(a) Derive the performance index for elastic bending, M for this design with considering the shape factor.

(20 marks)

(b) Why shape factor is important to consider in selecting material.

(5 marks)

-END OF QUESTIONS –

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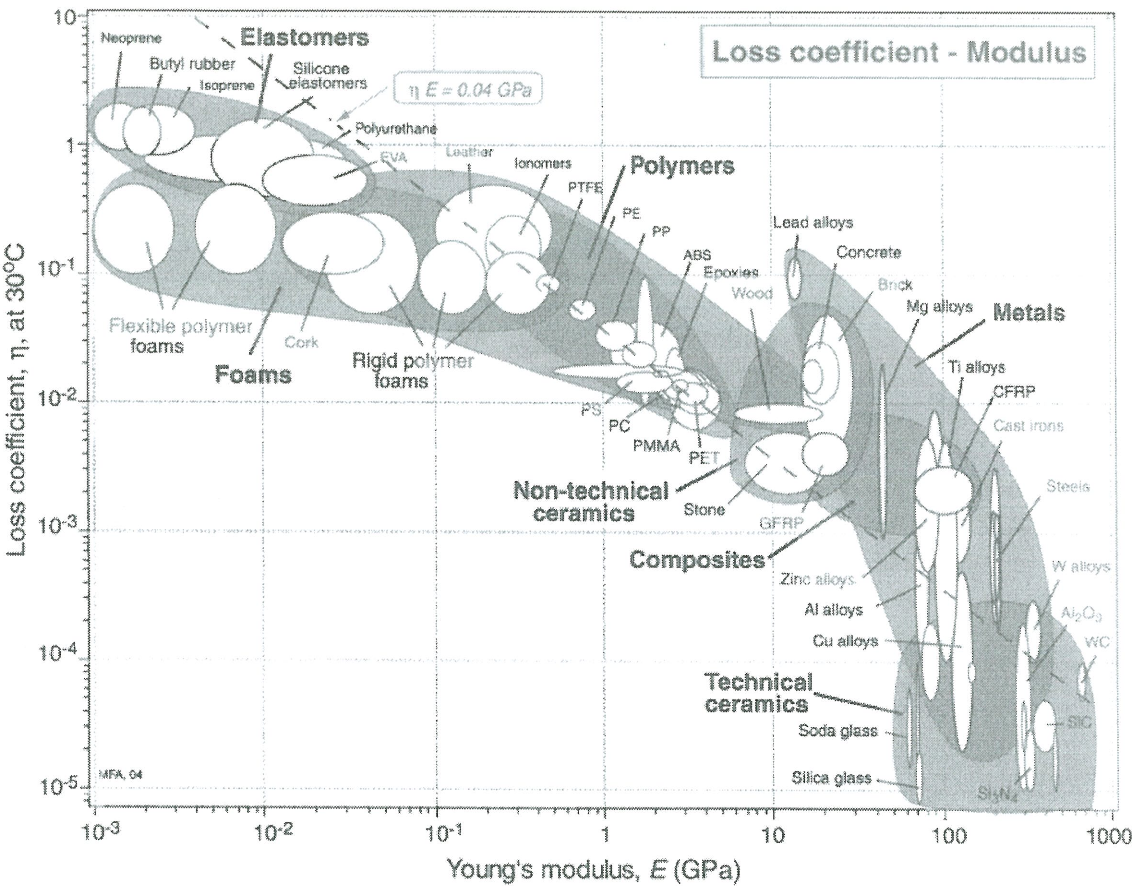

Figure Q1(c)

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Table Q4 (b1). SelectingTensile Strength of Tool Steels

Type	Condition	Tensile strength (MPa)
S7	Annealed	640
L6	Annealed	655
S1	Annealed	690
L2	Annealed	710
S5	Annealed	725
L2	Oil quenched from 855 °C and single tempered at 650 °C	930
L6	Oil quenched from 845 °C and single tempered at 650 °C	965
S5	Oil quenched from 870 °C and single tempered at 650 °C	1,035
S7	Fan cooled from 940 °C and single tempered at 650 °C	1,240
L2	Oil quenched from 855 °C and single tempered at 540 °C	1,275
L6	Oil quenched from 845 °C and single tempered at 540 °C	1,345
S5	Oil quenched from 870 °C and single tempered at 540 °C	1,520
L2	Oil quenched from 855 °C and single tempered at 425 °C	1,550
L6	Oil quenched from 845 °C and single tempered at 425 °C	1,585
L2	Oil quenched from 855 °C and single tempered at 315 °C	1,790
S7	Fan cooled from 940 °C and single tempered at 540 °C	1,820
S5	Oil quenched from 870 °C and single tempered at 425 °C	1,895
S7	Fan cooled from 940 °C and single tempered at 425°C	1,895
S7	Fan cooled from 940 °C and single tempered at 315 °C	1.965
L2	Oil quenched from 855 °C and single tempered at 205 °C	2,000
L6	Oil quenched from 845 °C and single tempered at 315 °C	2,000
S7	Fan cooled from 940 °C and single tempered at 205 °C	2,170
S5	Oil quenched from 870 °C and single tempered at 315 °C	2,240
S5	Oil quenched from 870 °C and single tempered at 205 °C	2,345

Table Q4(b2). Selecting Elongation of Tool Steels

Type	Condition	Tensile strength (MPa)
L6	Oil quenched from 845 °C and single tempered at 315 °C	4
L2	Oil quenched from 855 °C and single tempered at 205 °C	5
S5	Oil quenched from 870 °C and single tempered at 205 °C	5
S5	Oil quenched from 870 °C and single tempered at 315 °C	7
S7	Fan cooled from 940 °C and single tempered at 205°C	7
L6	Oil quenched from 845 °C and single tempered at 425 °C	8
S5	Oil quenched from 870 °C and single tempered at 425 °C	9
S7	Fan cooled from 940 °C and single tempered at 315°C	9
L2	Oil quenched from 855 °C and single tempered at 315 °C	10
S5	Oil quenched from 870 °C and single tempered at 540 °C	10
S7	Fan cooled from 940 °C and single tempered at 425°C	10
S7	Fan cooled from 940 °C and single tempered at 540°C	10
L2	Oil quenched from 855 °C and single tempered at 425 °C	12
L6	Oil quenched from 845 °C and single tempered at 540 °C	12
S7	Fan cooled from 940 °C and single tempered at 650°C	14
L2	Oil quenched from 855 °C and single tempered at 540 °C	15
S5	Oil quenched from 870 °C and single tempered at 650 °C	15
L6	Oil quenched from 855 °C and single tempered at 540 °C	20
S1	Annealed	24
L2	Annealed	25
L2	Oil quenched from 855 °C and single tempered at 540 °C	25
L6	Annealed	25
S5	Annealed	25
S7	Annealed	25

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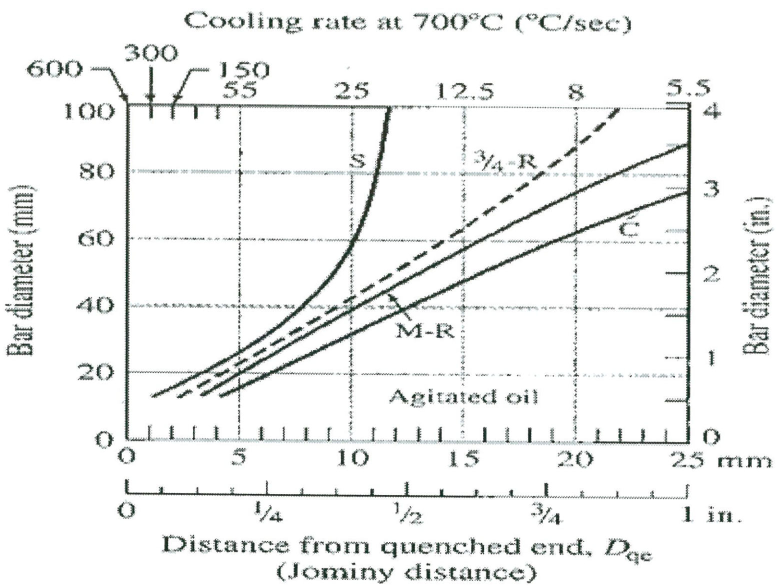

Figure Q4(c1)

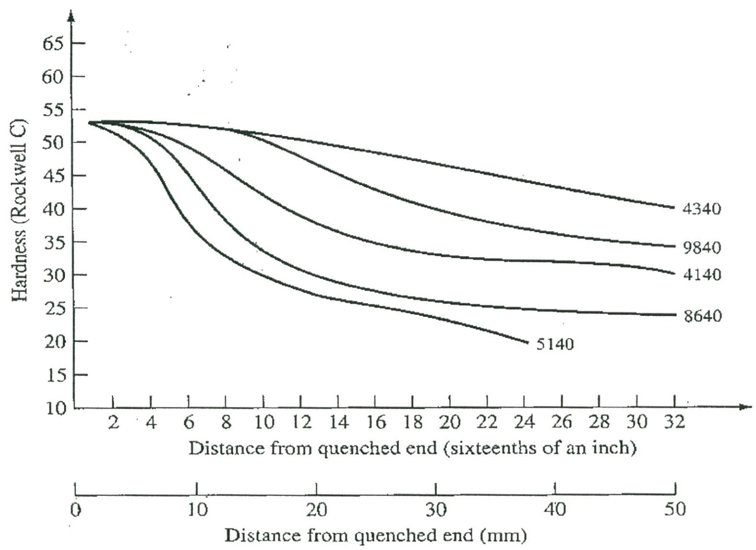

Figure Q4(c2)

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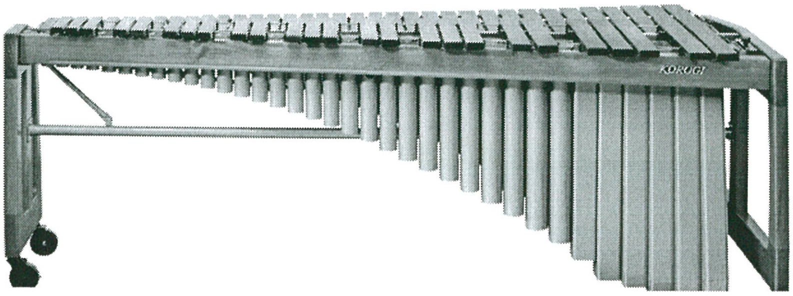

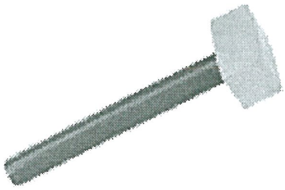

Figure Q5