Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2018/2019

COURSE NAME	:	ENGINEERING MATERIALS SELECTION
COURSE CODE	:	BDA 20402
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	DECEMBER 2018 / JANUARY 2019
DURATION	:	2 HOURS
INSTRUCTION	:	PART A – COMPULSORY PART B – ANSWER **THREE (3)** QUESTIONS **ONLY**

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

PART A

Q1 (a) What are "soft constraints" and "hard constraints"?

(3 marks)

(b) 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)

(c) You are required to select materials with a Young's modulus (E) less than 1 GPa and a performance index $M = \frac{\eta^2}{E}$ greater than $M = 1 \times 10^{-4} \left[\frac{1}{GPa}\right]$.
Sketch clearly your selection region on the selection chart in **Figure Q1c** and list THREE (3) materials which are included in the selection.
Note: Attached **Figure Q1c** with your answer script.

(7 marks)

(d) You are asked to design a new type of disposable fork for a fast food restaurant. The tines of the fork can be modeled as a cantilever beam under an end load. We are told that the size and shape of the forks are fixed, but that the thickness of the tines can vary.
The design statement is as follows;

- The length, L, and width, w, are fixed;
- We want to minimize the cost of the forks;
- The tines must not fail under a buckling end load, F_{buckle};
- The tines must not fail with a bending end load, F_{break}..

Given the equations below, answer the following questions.

$$Cost = (C_r\rho)(volume); \quad F_{buckle} = \frac{9\pi^2 EI}{4L^2}; \quad I = \frac{wt^3}{12}$$

$$F_{break} = \left(\frac{I}{y_m}\right)\frac{\sigma_f}{L}; \quad \left(\frac{I}{y_m}\right) = \frac{wt^2}{6}$$

(i) Derive the performance index for the buckling constraint, M1.

(5 marks)

(ii) Derive the performance index for the failure constraint, M2.

(5 marks)

PART B

Q2 (a) List THREE (3) types of selection methods.

(3 marks)

(b) Sketch and a diagram that helps structure thinking about alternative design.

(5 marks)

(c) How would you organize the facts that show the role of materials in design?

(7 marks)

(d) A device is required to allow access to water in a corked bottle with convenience, at modest cost, and without contaminating the water. Analyse the concept, embodiment, and detail design of the device.

(10 marks)

Q3 (a) List THREE (3) facts that indicate a successful product.

(3 marks)

(b) Explain Hugh Dubberly's approach on successful product.

(5 marks)

(c) How would you use a stress-strain diagram to show:

(i) 0.2% proof strength

(ii) Toughness

(7 marks)

(d) Can you make a distinction between polymeric materials by using stress-strain diagram?

(10 marks)

Q4 (a) Define the meanings of Nxxxxx according to designation of Unified Numbering System (UNS) for nickel alloys.

(3 marks)

(b) Titanium has been proved a suitable material for application involves elevated or high temperature such as aerospace components, gas turbine and jet engine. Discuss the titanium properties that allow it for the stated applications.

(5 marks)

(c) You need to produce a diesel block engine. Choose a suitable type of cast iron for the fabrication of diesel engine block. Explain your answer and sketch the microstructure of the selected cast iron.

(7 marks)

(d) 'Forged in Fire' contestants are given a task to forge a sword. The contestants need a 75 mm diameter round steel bar with a Brinell hardness 325 HB at the central position in its cross section. The steel will be heat treated in a reducing atmosphere (non-scaling atmosphere) and oil quenched at an equivalent velocity of 60 m/min. What shall be the types of steel that suit the sword design?

Note: Show your analysis step by step by using **Figure Q4d (i-iii)** and **Table Q4d**. Please attach them together with your answer script.

(10 marks)

Q5 (a) Define a compounding process of polymer.

(3 marks)

(b) Strength of ceramic body will be obtained through sintering. Describe the sintering process of a ceramic material.

(5 marks)

(c) Effect of fiber orientation and length, a continuous fiber composite can face a longitudinal and transverse loading condition. Illustrate both loading conditions with appropriate figures that show the position of matrix, fiber and load in the composite.

(7 marks)

(d) Padu Engineering is the main manufacturer of polymer product for Hockey Field. Polymer material use should be strong and stiff, short-term heat resistance, friction and wears resistance and resist to environmental effect. Cost is one of a significant concern for the manufacturer. Being a material engineer for this company, you are required to examine and state suitable polymer material by using **Table Q5d (i)** and **Table Q5d (ii)**. (Attach **Table Q5d (ii)** with your answer script).

(10 marks)

~ END OF QUESTIONS ~

FINAL EXAMINATION

SEMESTER / SESSION : SEM I / 2018/2019
COURSE NAME: ENGINEERING MATERIALS SELECTION

PROGRAMME CODE : BDD
COURSE CODE : BDA 20402

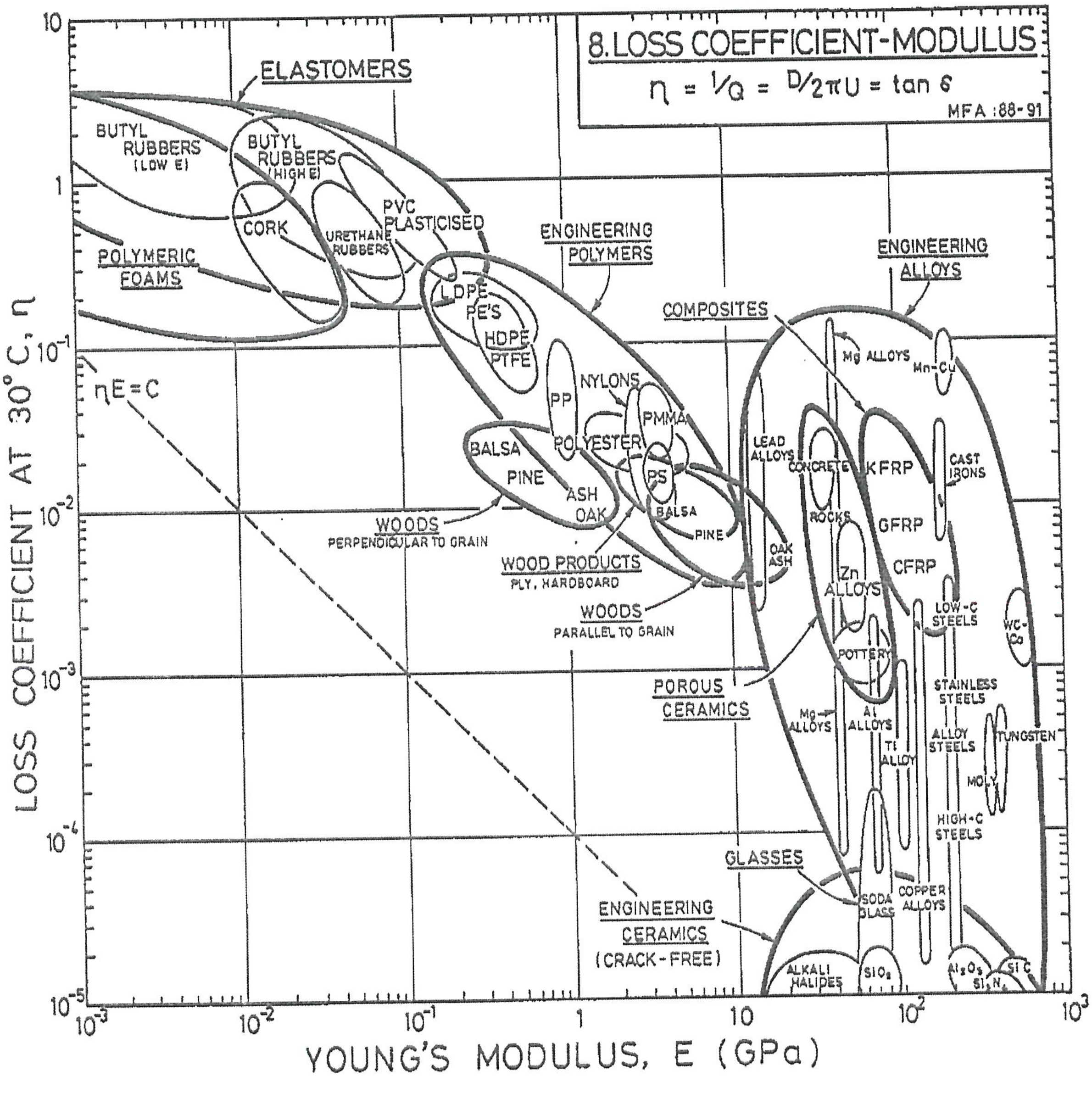

FIGURE Q1(c)

FINAL EXAMINATION

SEMESTER / SESSION : SEM I / 2018/2019
COURSE NAME: ENGINEERING MATERIALS SELECTION

PROGRAMME CODE : BDD
COURSE CODE : BDA 20402

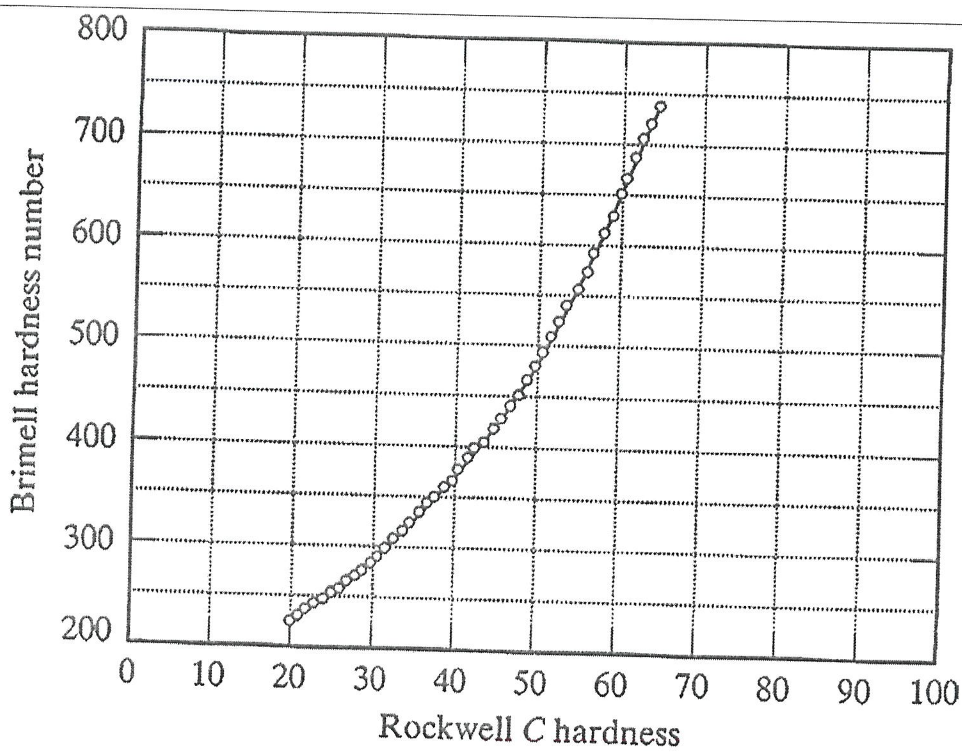

FIGURE Q4d (i)

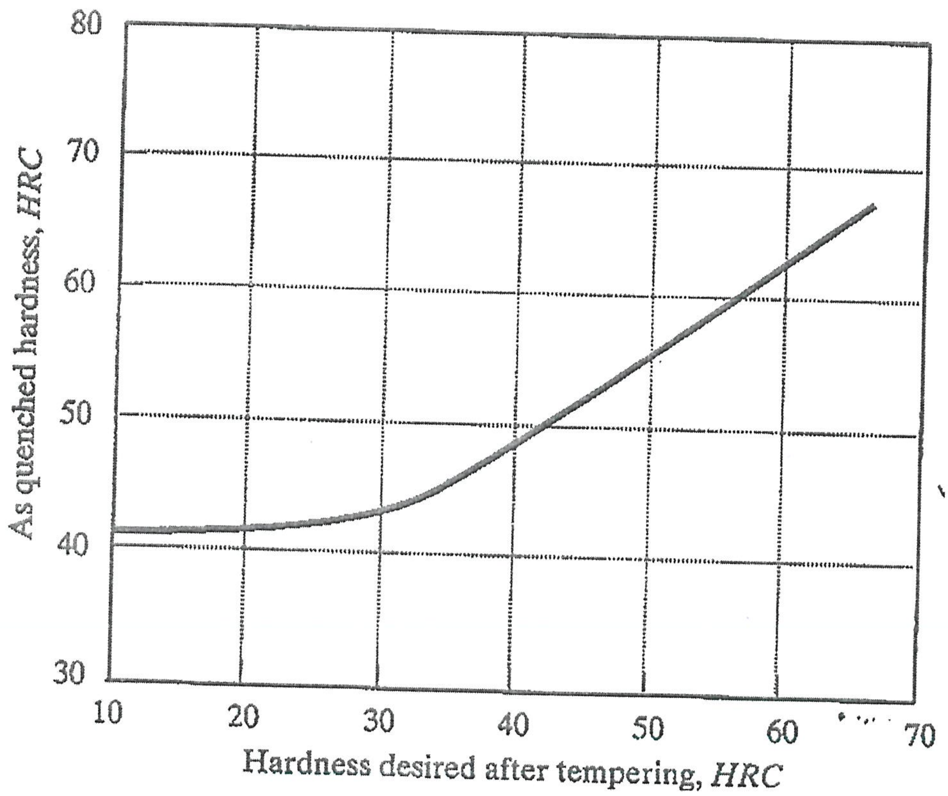

FIGURE Q4d (ii)

PEPERIKSAAN AKHIR

SEMESTER / SESSION : SEM I / 2018/2019
COURSE NAME: ENGINEERING MATERIALS SELECTION

PROGRAMME CODE : BDD
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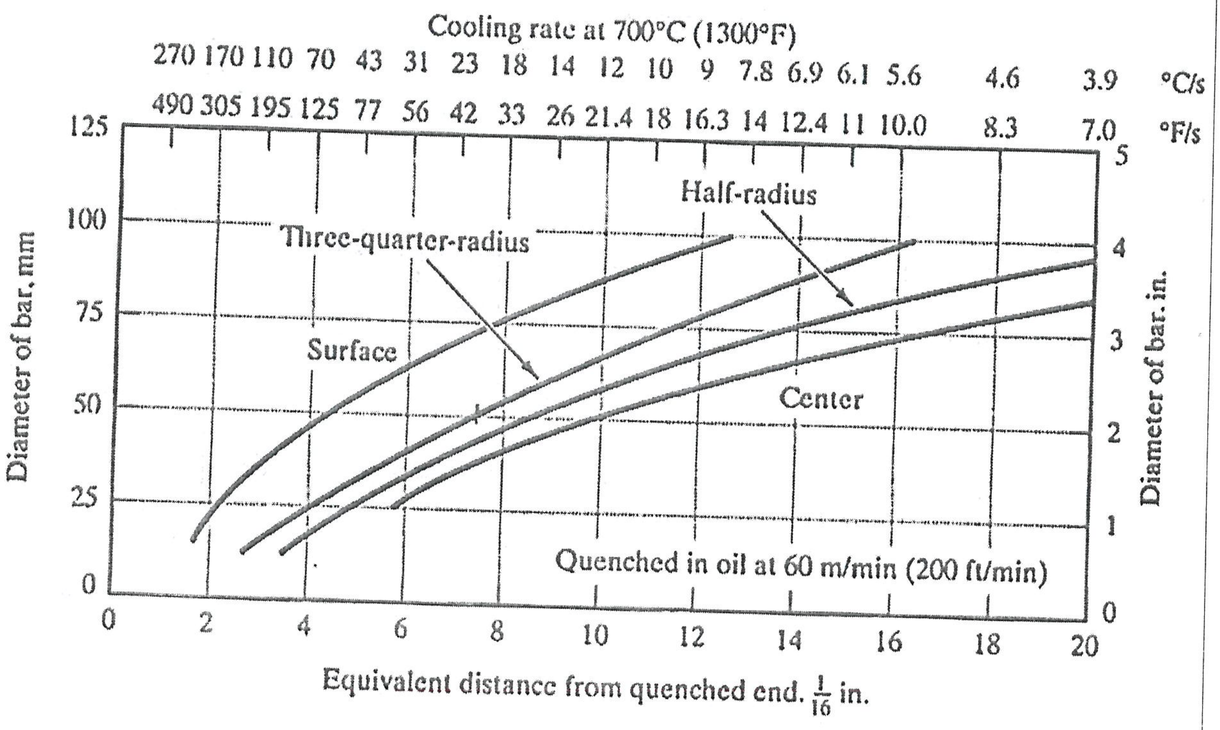

FIGURE Q4d (iii)

FINAL EXAMINATION

SEMESTER / SESSION : SEM I / 2018/2019
COURSE NAME: ENGINEERING MATERIALS SELECTION

PROGRAMME CODE : 2 BDD
COURSE CODE : BDA 20402

Table Q4(d)

Distance from quenched end, 1/16th in.	H steels with a minimum hardenability curve that intersects the specified hardness at the indicated distance from the quenched end of the hardenability specimen
40 HRC (Continued)	
$10\frac{1}{2}$	6150, 50B60
11	4140
$11\frac{1}{2}$	81B45, 8650, 5152
12	86B30
13	51B60
14	8655
15	4142
$15\frac{1}{2}$	8750
18	4145, 8653, 8660
19	9840, 86B45
20	4147
24	4337, 4150
32	4340
36+	E4340, 9850
45 HRC	
1	4027, 4028, 8625
$1\frac{1}{2}$	8627, 1038
2	4032, 1042, 1146, 1045
$2\frac{1}{2}$	4130, 5130, 8630, 4037, 1050, 5132
3	1330, 5046, 1541
$3\frac{1}{4}$	1050
$3\frac{1}{2}$	1335, 5135, 4042, 4047
4	8635, 1141
5	8637, 1340, 5140, 50B46, 4053, 9260, 15B37
$5\frac{1}{2}$	5145, 4063
6	4135, 4640, 4068, 1345
$6\frac{1}{2}$	8640, 8740, 5150, 94B30
7	4137, 8642, 6145, 9261, 50B40
$7\frac{1}{2}$	8742, 50B44, 5155
8	8645, 5147
$8\frac{1}{2}$	4140, 6150, 5160, 9262, 50B50
9	50B60
$9\frac{1}{2}$	81B45, 8650, 86B30
10	5152
11	51B60, 8655
$11\frac{1}{2}$	4142
12	8750

Distance from quenched end, 1/16th in.	H steels with a minimum hardenability curve that intersects the specified hardness at the indicated distance from the quenched end of the hardenability specimen
45 HRC (Continued)	
13	8653, 8660
14	9840, 4145
16	85B45, 4147
17	4337
18	4150
22	4340
26	4161
30	E4340
36	9850
50HRC	
1	4032, 5132, 1038
$1\frac{1}{2}$	1335, 5135, 8635, 4037, 1042, 1146, 1045
2	4135, 1541, 15B35, 15B37
$2\frac{1}{4}$	1050
$2\frac{1}{2}$	4042
3	8637, 5140, 5046, 4047
$3\frac{1}{2}$	4137, 1141, 1340
4	4640, 5145, 50B46
$4\frac{1}{2}$	8640, 8740, 4053, 9260
5	8642, 4063, 1345, 50B40
$5\frac{1}{2}$	8742, 6145, 5150, 4068
6	4140, 8645
$6\frac{1}{2}$	9261, 50B44, 5155
7	5147, 6150
$7\frac{1}{2}$	5160, 9262, 50B50
8	4142, 81B45, 8650
$8\frac{1}{2}$	5152, 50B60
$9\frac{1}{2}$	4337, 8750, 8655
10	4145, 51B60
$10\frac{1}{2}$	9840
11	8653, 8660
$11\frac{1}{2}$	8645
12	85B45
13	4340, 4147
14	4150
20	E4340
22	9850, 4161

FINAL EXAMINATION

SEMESTER / SESSION : SEM I / 2018/2019
COURSE NAME: ENGINEERING MATERIALS SELECTION

PROGRAMME CODE : BDD
COURSE CODE : BDA 20402

Table Q5b (i): Rating of design properties of some thermoplastics (1 – most desirable; 6 – least desirable)

Resin Group ⇩ / Design Criteria ⇨	Strength & Stiffness		Toughness		Short-term heat resistance		Long-term heat resistance		Environmental resistance		Dimensional moulding accuracy		Dimensional stability		Friction & wear resistance		Cost	
Styrenics • ABS • SAN • Polystyrene	2 1 3	3	1 2 3	6	1 2 3	6	1 2 3	6	1 2 3	6	3 1 2	1	2 1 3	5	3 1 2	6	3 2 1	2
Olefins • Polyethylene • Polypropylene	2 1	5	2 1	4	2 1	4	2 1	5	2 1	3	1 1	5	1 1	5	2 1	3	1 2	1
Nylons • 6 • 6/6 • 6/10, 6/12 • Polyester • Polyacetal	2 1 3 4 5	1	2 3 1 4 5	1	2 1 3 2 5	2	2 1 3 1 2	4	5 4 3 2 1	4	1 2 2 2 3	4	4 3 2 1 2	4	3 2 3 4 1	2	1 2 4 1 1	3
Arylates • Modified PPO • Polycarbonate • Polysulfone • Polyethersulfone	4 2 2 1	3	3 1 2 3	2	4 3 2 1	3	4 3 2 1	3	3 4 2 1	5	4 1 2 3	1	4 3 2 1	2	4 3 1 2	4	1 2 3 4	4
High Temp. Resin • PPS • Polyamide-imide	1 2	2	2 1	4	2 1	1	2 1	1	1 2	2	1 2	4	2 1	1	2 1	4	1 2	5
Fluorocarbons • FEP • ETPE	2 1	6	1 2	2	2 1	2	1 2	1	1 2	1	2 1	6	2 1	6	1 2	1	2 1	6

FINAL EXAMINATION

SEMESTER / SESSION : SEM I / 2018/2019
COURSE NAME: ENGINEERING MATERIALS SELECTION

PROGRAMME CODE : BDD
COURSE CODE : BDA 20402

Table Q5b (ii): Worksheet for the selection of a thermoplastic matrix resin

Materials Characteristics →	Strength & Stiffness	Toughness	Short-term heat resistance	Long-term heat resistance	Environmental resistance	Dimensional moulding accuracy	Dimensional stability	Friction & wear resistance	Point Sub-total	Cost	Point Total
Resin ↓ / *Design Criteria* →											
Styrenics • ABS • SAN • Polystyrene											
Olefins • Polyethylene • Polypropylene											
Nylon • 6 • 6/6 • 6/10, 6/12 • Polyester • Polyacetal											
Arylates • Modified PPO • Polycarbonate • Polysulfone • Polyethersulfone											
High Temp. Resin • PPS • Polyamide-imide											
Fluorocarbons • FEP • ETPE											