UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	ENGINEERING MATERIALS SELECTION
COURSE CODE	:	BDA 20402
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	DECEMBER 2019 /JANUARY 2020
DURATION	:	2 HOURS
INSTRUCTION	:	PART A – **COMPULSORY** PART B – ANSWER **THREE (3)** QUESTIONS **ONLY**

THIS QUESTION PAPER CONSISTS OF **ELEVEN (11)** PAGES

PART A : COMPULSORY

Q1 (a) Can you state the 'performance' equation?

(3 marks)

(b) Express the slope of the selection line for the design if the index, $M = \frac{E^{2/3}}{\rho^2}$?

(5 marks)

(c) A design uses Young's Modulus, $E > 100$ MPa^2/GPa and performance index, $M = \frac{\sigma^2}{E} > 100$ MPa. Identify the selected materials by using **Figure Q1(c)** and attach it with your answer script.

(7 marks)

(d) An engineer wants to design a mirror for large telescope. Mirror as circular disc with specific diameter, $2R$ and mean thickness, t, supported at its periphery. When horizontal, it will deflect under its own weight, m; when vertical it will not deflect significantly. This distortion must be small enough that it does not interfere with performance. In practice, the deflection, δ of the midpoint of the mirror must be less than the wavelength of light. Additional requirements are no creep and low thermal expansion. Refer **Table Q1(d)** for the design details.

(i) What is the performance, p, for ths design?

(2 marks)

(ii) Determine the material index, M, for this design.

(4 marks)

(iii) If $M = 2$, identify the best material for the design. Show your work on **Figure Q1(d)**, and attach it with your answer script.

(4 marks)

PART B: ANSWER THREE (3) QUESTIONS ONLY

Q2 (a) List all types of selection methods.

(3 marks)

(b) Explain 'design' from the perspective of material selection.

(5 marks)

(c) Sketch a labeled diagram to show essential components in a vacuum cleaner.

(7 marks)

(d) Megat Terawis prefers to use aluminium for his *keris*, whereas mild steel is Megat Panji Alam's favourite. Compare both metals from the perspective of interrelated constraints and sustainable design.

(10 marks)

Q3 (a) Define 'successful product'.

(3 marks)

(b) Material 'X' can be strengthen by heat and mechanical techniques, but still ductile enough to be deformed. Explain the mechanical properties of X by using a stress-strain diagram.

(5 marks)

(c) Mr. Fazlan performs a tensile and a compression tests on a ceramic material. How would you use the stress-strain diagram in sketching both tensile and compression results?

(7 marks)

(d) Various conditions of an aircraft's wing-span are shown in **Figure Q3(d)**. Examine the mechanical properties issues and solutions in all given conditions.

(10 marks)

Q4 (a) Define steel classification by means of alloying content.

(3 marks)

(b) Describe 'cast iron' and its classification.

(5 marks)

(c) Demonstrate how Jominy's End Quench Test is carried out and the outcome.

(7 marks)

(d) A factory wants to produce round steel bars with the criteria as follows:

Criteria A: Diameter of 37.5 mm with a hardness of 35 HRC at ½-radius position in its cross section.
Criteria B: Diameter of 75 mm with a hardness of 42.5 HRC at ¾-radius position in its cross section.

Later, all round steel bars were heat-treated in a reducing atmosphere (non-scaling atmosphere) and quenched in an agitated water bath at an equivalent velocity of 60 m/min. Show your work on **Figure Q4d(i)-(ii)** and **Table Q4(d)**. Attach both table and figures in your answer script.

(i) Determine the value of as-quenched hardness for A and B?

(3 marks)

(ii) Determine the Jominy equivalent cooling distance, J for A and B?

(3 marks)

(iii) Identify the possible alloy steels that can fulfill A and B.

(4 marks)

Q5 (a) List THREE(3) ways to increase ceramic porosity.

(3 marks)

(b) By using FIVE (5) examples, explain main roles of additive or filler during polymer compounding.

(5 marks)

(c) A ceramic body weight 275 g when dry, 200 g when suspended in water, and 290 g when wet. The true density of a ceramic is 5.12 g/cm^3. Calculate the percentage of:

(i) apparent porosity.

(2 marks)

(ii) total porosity.

(3 marks)

(iii) closed porosity.

(2 marks)

(d) How would you distinguish composite materials according to the type of reinforcements (or fillers)?

(10 marks)

END OF QUESTION

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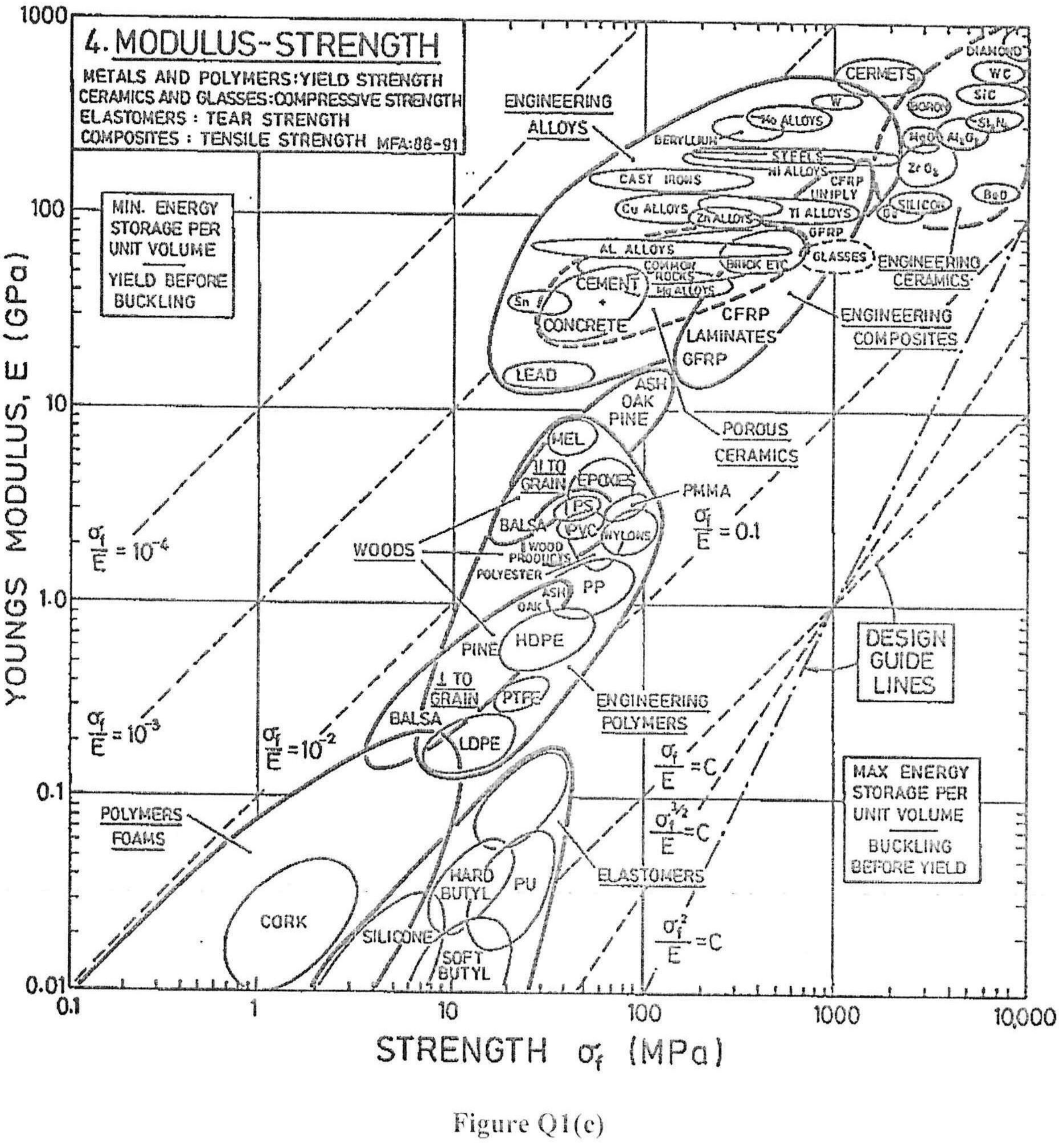

Figure Q1(c)

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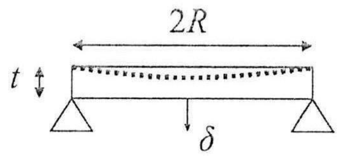
Table Q1(d)

Design	Equation
Mass of the mirror, m	$m = \rho \pi R^2 t$
Elastic deformation, δ	$\delta = \left(\frac{3}{4}\pi\right)\left(\frac{mgR^2}{Et^3}\right)$
Schematic illustration	

Where, ρ = density; E = Young's Modulus; g = gravity

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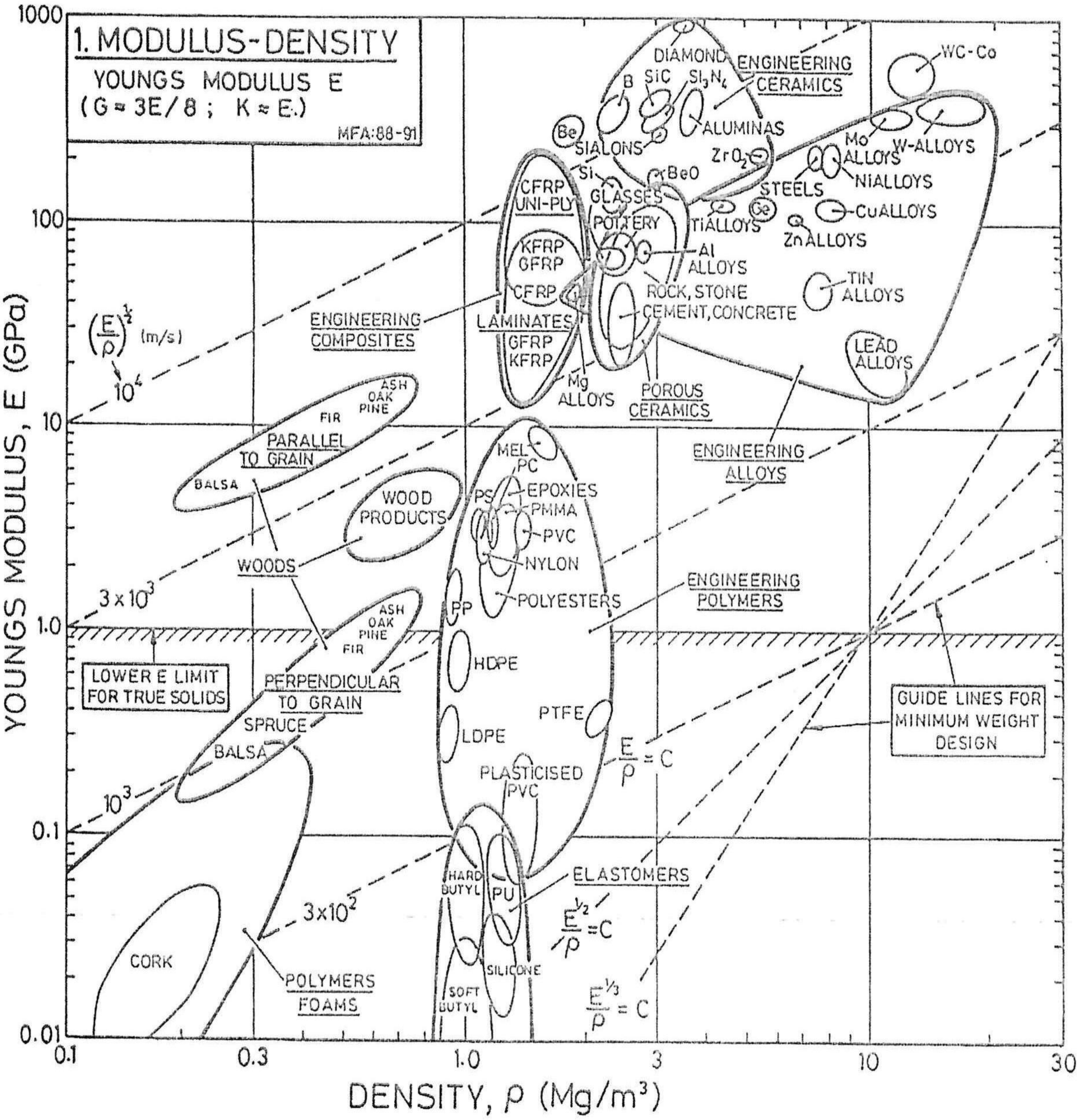

Figure Q1(d)

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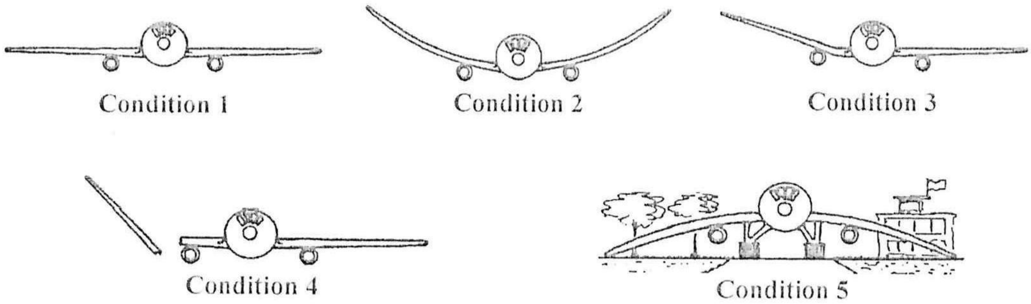

Figure Q3(d)

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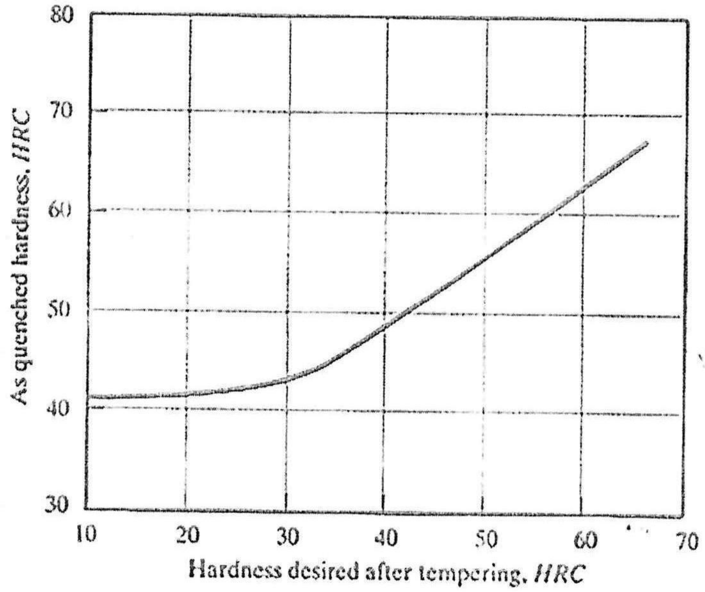

Figure Q4(d)(i)

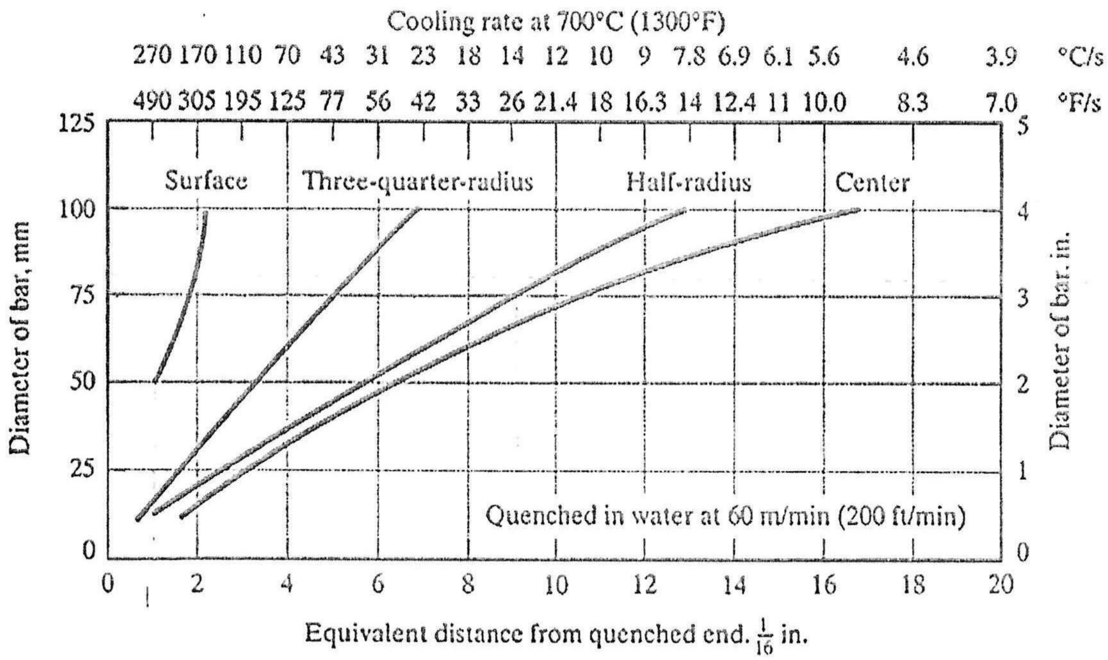

Figure Q4(d)(ii)

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Table 4(d)

Classification of H steels according to minimum hardnesses at various Jominy equivalent cooling distances from quenched end.

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	
10½	6150, 50B60
11	4140
11½	81B45, 8650, 5152
12	86B30
13	51B60
14	8655
15	4142
15½	8750
18	4145, 8653, 8660
19	9840, 86B45
20	4147
24	4337, 4150
32	4340
36+	E4340, 9850

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	
1	4027, 4028, 8625
1½	8627, 1038
2	4032, 1042, 1146, 1045
2½	4130, 5130, 8630, 4037, 1050, 5132
3	1330, 5046, 1541
3¼	1050
3½	1335, 5135, 4042, 4047
4	8635, 1141
5	8637, 1340, 5140, 50B46, 4053, 9260, 15B37
5½	5145, 4063
6	4135, 4640, 4068, 1345
6½	8640, 8740, 5150, 94B30
7	4137, 8642, 6145, 9261, 50B40
7½	8742, 50B44, 5155
8	8645, 5147
8½	4140, 6150, 5160, 9262, 50B50
9	50B60
9½	81845, 8650, 86B30
10	5152
11	51B60, 8655
11½	4142
12	8750
13	8653, 8660
14	9840, 4145
16	85B45, 4147
17	4337
18	4150
22	4340
26	4161
30	E4340
36	9850

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
50 HRC	
1	4032, 5132, 1038
1½	1335, 5135, 8635, 4037, 1042, 1146, 1045
2	4135, 1541, 15B35, 15B37
2¼	1050
2½	1050
3	4042
3½	8637, 5140, 5046, 4047
4	4137, 1141, 1340
4½	4640, 5145, 50B46
5	8640, 8740, 4053, 9260
5½	8642, 4063, 1345, 50B40
6	8742, 6145, 5150, 4068
6½	4140, 8645
7	9261, 50B44, 5155
7½	5147, 6150
8	5160, 9262, 50B50
8½	4142, 81B45, 8650
9½	5152, 50B60
10	4337, 8750, 8655
10½	4145, 51B60
11	9840
11½	8653, 8660
12	8645
13	85B45
14	4340, 4147
20	4150
22	E4340
	9850, 4161