



UNIVERSITY
OF
JOHANNESBURG

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| <u>PROGRAM</u> | : National Diploma <i>Metallurgical Engineering</i> |
| <u>SUBJECT</u> | : MECHANICAL METALLURGY |
| <u>CODE</u> | : TMP 31-1 |
| <u>DATE</u> | : SUMMER SSA EXAMINATION 2017 10 JANUARY 2017 |
| <u>DURATION</u> | : (SESSION 3) 15:00 - 18:00 |
| <u>WEIGHTING</u> | : 60% |
| <u>TOTAL MARKS</u> | : 120 |

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| <u>EXAMINER</u> | : Fortunate Moyo |
| <u>MODERATOR</u> | : Jose Prozzi |
| <u>NUMBER OF PAGES</u> | : 5 |

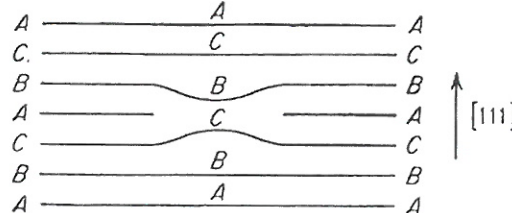
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| <u>INSTRUCTIONS</u> | : Calculators are permitted |
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Section A**45 marks**

Answer all questions in this section

Question 1

1.1 Name the dislocation in the figure below. [2]



1.2 List 3 ways in which a structural metallic member can fail. [3]

1.3 Suggest a word or phrase for the following descriptions. [6]

- a) Triaxial stress state where all the stresses are equal
- b) Minimum stress required to cause slip in a crystal
- c) Deformation bands associated with the yield point phenomenon
- d) A fracture that is fibrous and has shear lips
- e) Defect caused by the improper stacking sequence of close packed planes
- f) Time-dependent yielding at elevated temperatures and constant loading

Question 2

2.1 What is the effect of alloying on the following properties? Respond with increase, decrease or none [5]

- a) Ductility
- b) Elastic modulus
- c) Critical resolved shear stress
- d) Fatigue strength
- e) Creep resistance

2.2 Choose the most suitable answer. [9]

- a) A body that does not contain voids or empty spaces within it is said to be
 - A. Homogenous
 - B. Continuous
 - C. Isotropic
- b) Which is false with regards to plastic deformation?
 - A. Deformation is permanent and is retained after the load has been removed.
 - B. Deformation depends only on the initial and final stress state.
 - C. Deformation cannot be described by elastic constants.

- c) Stress rupture is an example of
 - A. Sudden fracture
 - B. Progressive fracture
 - C. Delayed fracture
 - d) Non-conservative movement of screw dislocations is called
 - A. Cross slip
 - B. Climb
 - C. Diffusion
 - e) Which of these metals has the largest number of slip systems?
 - A. Molybdenum
 - B. Copper
 - C. Magnesium
 - f) Interstitial solid solutions are formed when
 - A. The solute atoms are larger than the solvent atoms
 - B. The solute atoms are smaller than the solvent atoms
 - C. The solute atoms have the same size as the solvent atoms
 - g) This is not a requirement in fibre strengthening.
 - A. The fibres must be stiff.
 - B. The fibres must be chemically stable
 - C. The fibres must be thermally stable.
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- h) The main disadvantage of the Charpy test is that
 - A. it requires large testing machines and large specimens
 - B. it is difficult to correlate results with service performance
 - C. it requires a skilled welder

Question 3

3.1 Calculate the principal stresses and maximum shear stress for this stress state. [7]

$$\sigma_x = 45 \text{ MPa} \quad \sigma_y = 120 \text{ MPa} \quad \tau_{xy} = 45 \text{ MPa}$$

3.2 Distinguish deformation by slip and by twinning. [6]

3.3 Describe the interaction of fine particles with dislocations. [4]

3.4 Suggest 3 sources of dislocations in metals. [3]

Section B**75 marks**

Answer only 5 questions in this section. Where more than 5 questions are attempted, only the first 5 will be considered.

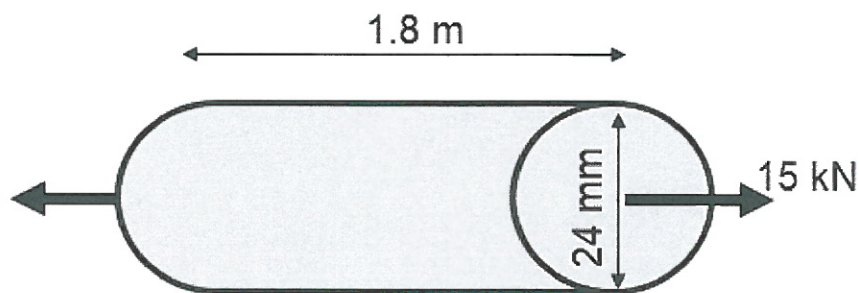
All questions carry 15 marks each.

Question 4

4.1 Describe 3 kinds of stress. [3]

4.2 The rod in the figure below has a diameter of 24 mm, and a length of 1.8 m. It carries a load of 15kN. Calculate the new length and diameter of the rod under this load. [9]

Take: Elastic modulus = 110 GPa, Shear modulus = 41.4 GPa, Poisson's ratio = 0.33



4.3 Explain why stress concentration has such a negative influence on brittle materials. [3]

Question 5

5.1 What is a dislocation? [1]

5.2 Name and discuss 3 methods of observing dislocations. [9]

5.3 With the aid of a diagram, describe the forces between two dislocations. [5]

Question 6

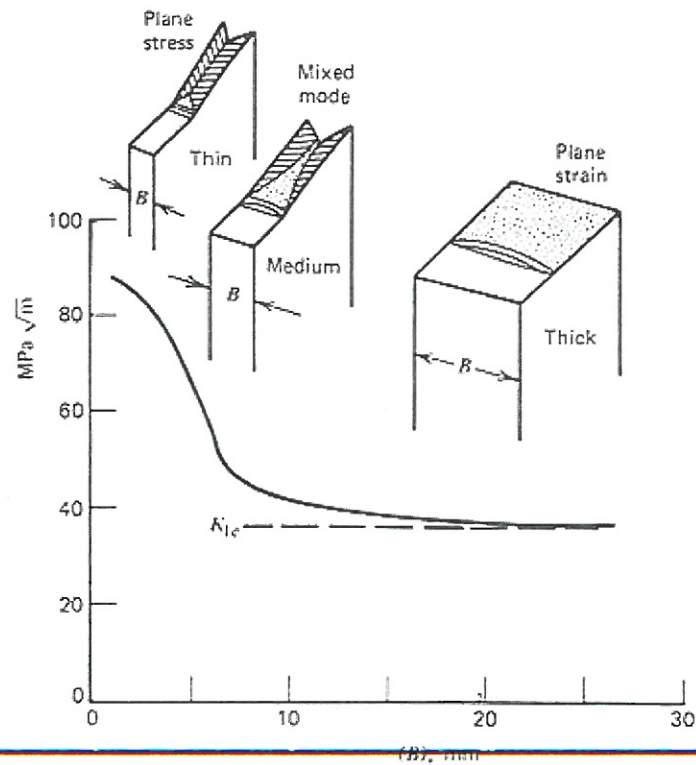
6.1 What is strain hardening? [1]

6.2 With the aid of a clearly labelled flow curve, discuss the strain hardening behaviour of FCC crystals. [9]

6.3 How does the orientation of the FCC crystal and temperature affect the flow curve in question 6.2? [5]

Question 7

Examine the graph in the figure below.



7.1 Name the test associated with this graph. [1]

7.2 Define K_{IC} in the graph, and discuss four factors that influence it. [10]

7.3 How would you ensure that the value of K_{IC} obtained by this test method is valid? [4]

Question 8

8.1 Define the term 'endurance limit.' [1]

8.2 A rod is subjected to a fluctuating stress from a maximum of 660 MPa (tensile) to a minimum of 200 MPa (compressive). Calculate the endurance limit of the rod, given that its ultimate tensile strength is 1090 MPa. [8]

8.3 Using appropriate S-N curves, explain how you would approximate the endurance limit of structural steel A36 and aluminium 2014 T6 alloys. [6]

Question 9

9.1 Name 2 metallurgical changes associated with the tertiary stage of creep. [2]

9.2 Compare and contrast creep and stress rupture tests. [8]

9.3 Describe how deformation mechanism maps may be used to predict creep. [5]

Question 10

10.1 Define stress corrosion cracking and name two metal-environment combinations that would result in stress corrosion cracking. [3]

10.2 Describe how stress corrosion cracking occurs and suggest how it may be linked to hydrogen embrittlement. [6]

10.3 Discuss 3 factors that influence ductile-brittle transition temperature. [6]

TOTAL MARKS: 120