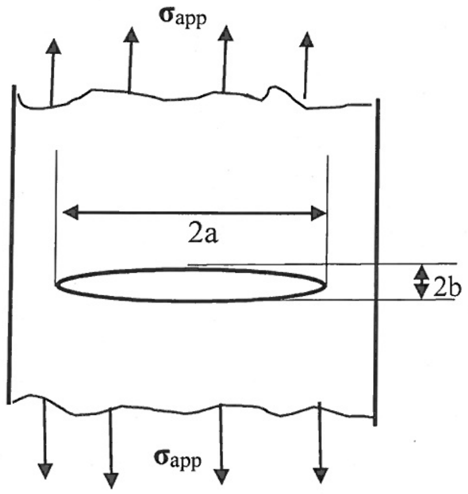
UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACCALAUREUS TECHNOLOGIAE *ENGINEERING METALLURGY*
SUBJECT	:	**MECHANICAL METALLURGY IV**
CODE	:	**TMP42-2**
DATE	:	WINTER SSA EXAMINATION 2016 26 JULY 2016
DURATION	:	15:00 - 18:00
WEIGHT	:	40 : 60
TOTAL MARKS	:	100

EXAMINER	:	DR S BHERO	
MODERATOR	:	MR JM PROZZI	5138
NUMBER OF PAGES	:	3 PAGES	

INSTRUCTIONS	:	ANSWER ALL QUESTIONS
REQUIREMENTS	:	TWO GRAPH SHEETS, CALCULATOR

Question 1 (40 marks)



Inglis found that for an elliptical internal hole subjected to an applied stress σ_{app} was magnified at the ends of the major axis of the ellipse so that

$$\frac{\sigma_{max}}{\sigma_{app}} = 1 + \frac{2a}{b}$$

where σ_{max} = maximum stress at end of the major axis, σ_{app} = applied stress, a = half major axis, and b = half minor axis

The radius of curvature ρ at the end of the ellipse is given by

$$\rho = \frac{b^2}{a}$$

1.1 Derive an expression for σ_{max} in terms of σ_{app}, a and ρ. (4)

1.2 Since a >> ρ, show that the expression you derived in 1.1 reduces to $\sigma_{max} \approx 2\sigma_{app}\sqrt{\frac{a}{\rho}}$ (4)

1.3 What is the magnitude of the maximum stress at the tip of a surface crack having a radius of curvature 0.264 nm and crack length 1 μm, when a tensile of 57 MPa is applied? (4)

1.4 Explain the change in stress in 1.3 implications of cracks in a stressed component? (4)

1.5 Explain the practical implication of the expression in 1.2 when ρ is very small. (4)

1.6 Explain the implication $\sigma_{max} \approx 2\sigma_{app}\sqrt{\frac{a}{\rho}}$, when ρ is larger, say ρ = a/4, ρ = a and ρ = 4a. (4)

1.7 From expressions you derived in 1.6, what is the practical solution to a very thin crack? (4)

1.8 Derive σ_{max} when ρ = 16a and what happens to orientation and effect of crack when ρ >> a? (4)

1.9 What is the implication of ρ → ∞, what is practical design of structures to avoid fracture. (4)

1.10 Use equations (1) and (2) to derive σ_{max} and ρ when a = b. What is shape and effect of crack. (4)

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Question 2 (30 marks)

Some metals exhibit a phenomenon of ductile-to-brittle transition temperature (DBTT).

2.1 Sketch graphs showing ductile-to-brittle transition and nil-ductility temperature (NDT) and explain the different in terms of incidence of fracture. (5)

2.2 How would you adjust chemical composition and grain size to improve the DBTT of steel. (5)

2.3 Why does a Charpy impact tester require a special foundation and why should it be calibrated? (5)

2.4 What is the relationship between area under stress-strain curve if a tenslile test and Charpy values and expain why they give different values. (5)

2.5 How is DBTT affected by sample size of brittle steels and sharpness of notch in ductile steels. (5)

2.6 Use a sketch to illustrate that FCC metals and high strength steels do not show ductile to brittle transition behaviour and explain the difference in behaviour giving reason reasons. (5)

Question 3 (30 marks)

The equichohesive temperature (ECT) is the temperature at which the strength of grain boundaries is equal to the strength of grain interior.

3.1 At low temperatures below about half the absolute melting point (T_m), metals deform by twinning and/or slip and fail in a transgranular manner.

3.1.1 What is the relative strength of grains and grain boundaries below T_m and why? (3)

3.1.2 Explain the strengthening mechanisms in metals below T_m. (3)

3.1.3 What is the relative strength of grains and grain boundaries above T_m and what are the causes? (3)

3.1.4 What is the mode of fracture above T_m and what strengthing mechanisms would you offer? (3)

3.1.5 Sketch a graph for strength of grains relative to grain boundaries versus temperature. (3)

3.1.6 How would you distinguish between twin bands and slip lines using metallography? (3)

3.2 If strain rate is raised from $\dot{\varepsilon}_1$ to $\dot{\varepsilon}_2$;

3.2.1 What is the change in ECT and why? (3)

3.2.2 Is the mode of fracture at $\dot{\varepsilon}_2$ and low temperature intergranular or transgranular, why? (3)

3.2.3 At very low $\dot{\varepsilon}$ and high temperature, is the mode of fracture intergranular or transgranular, why? (3)

3.2.4 What is the effect of low strain rate and high temperature and ECT? (3)