



**GWANDA STATE UNIVERSITY**  
**FACULTY OF ENGINEERING AND ENVIRONMENT**  
**DEPARTMENT OF METALLURGICAL ENGINEERING**  
**ENGINEERING FAILURE ANALYSIS**  
**EMR3202**

This examination consists of 5 pages

**Time Allowed:** 3 hours  
**Total Marks:** 100  
**Special Requirements:** Graph paper and a scientific calculator  
**Examiner's Name:** Miss K.L Mahamba

**INSTRUCTIONS**

1. Answer any 5 questions
2. Each question carries 20 marks

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### QUESTION 1

- a. Briefly explain what you understand by failure analysis. [5]
- b. What are the factors that influence the level of performance of a part of a component? [5]
- c. Explain what the failure of engineering component is? [5]
- d. Using diagrams, comment on the differences between ductile and brittle fractures. [5]

### QUESTION 2

The following data applies to extruded and cold rolled nickel alloy (Nimonic 80A) at 750°C.

**Given data:**

Young's modulus = 140GPa

0.2% proof stress= 450 MPa

Elongation to fracture = 25% (short term tensile strength)

Mean coefficient of thermal expansion (20-750°C) =  $15.8 \times 10^{-6}$

The stress to cause a plastic creep strain in 3000 hrs. is

Stress (MPa)	110	130	160
Strain %	0.1	0.2	0.5

Estimate the coefficient  $n$  in a power law representation between stress and strain rate. What would be the total change in length of a bar of 50mm initial length at 20°C, when held at a stress of 150 MPa?

[20]

### QUESTION 3

In a Metallurgical Plant setup, a conveyor belt fails due to a taper roller bearing failure. Carry out a failure analysis for the bearing failure and give a detailed account of the failure showing the entire process. The Failure Mode and Effect Analysis method may be used, paying special attention to the failure modes and effects. [20]

### QUESTION 4

a. Outline the common types of mechanical failures that are encountered in engineering components and structures. [5]

b. Discuss how the following factors affect the fracture of a material:

i) Stress concentration. [5]

ii) Speed of loading. [5]

iii) Temperature. [5]

### QUESTION 5

a. The properties of some materials are profoundly influenced by the presence of imperfections (flaws), give an account of how these flaws affect the operation of the part or component. [5]

b. Describe the Griffith Crack Theory. [5]

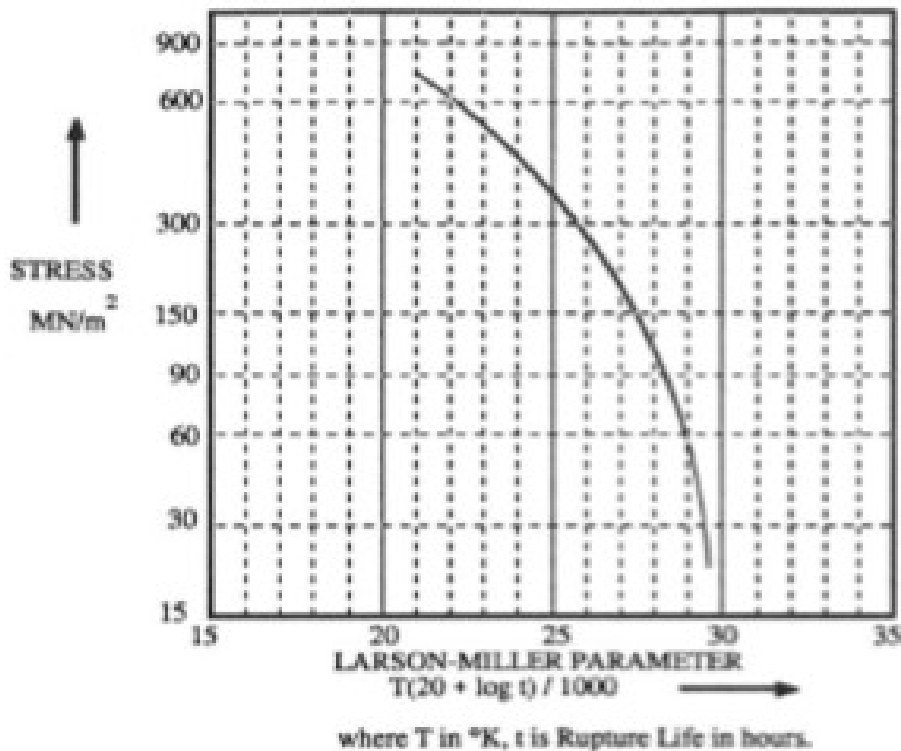
c. Using diagrams explain interfacial defects of a part. [5]

d. Define fatigue and specify the conditions under which it occurs. [5]

### QUESTION 6

- a. Using a diagram show how the Fault Tree Analysis is used in a failure analysis process. [10]
- b. Sharp ductile to brittle transition (DBTT) is observed in BCC and HCP metallic materials. Explain the ductile – brittle transition. [5]
- c. The creep rupture properties of nickel alloy are shown in Figure Q6. Using Figure Q6, Estimate the maximum operating temperature of a gas turbine blade made of this material, and which is to withstand a stress of 150 MPa for a duration of 10 000 h. What would be the new design life if the turbine engine ran 40 °C hotter? [5]

**FIGURE Q6: Stress vs Larson Miller parameters**



### **QUESTION 7**

The following are fault analysis techniques in common use. Give a brief explanation of each

- a. Fault Hazard Analysis. [5]
- b. Critical Path Analysis. [5]
- c. Common Cause Failure Analysis. [5]
- d. Barrier Analysis. [5]

### **QUESTION 8**

A power generating company has asked you to check if one of their steam turbines is safe enough to continue its operation. You have checked the main shaft and the blades and found that there is some degree of grain growth along with some voids formed within the grains and also at the grain boundaries.

- a. What is your conclusion as to whether it is safe to continue the use of the turbine?  
[5]
- b. What would be the likely failure mode if the shaft or blades fail?  
[5]
- c. Explain the most likely failure mechanism for the potential failure mode? [5]
- d. Which would be the best fault analysis technique to use?  
[5]

**END OF QUESTION PAPER**