MSE3110: DEFORMATION AND FRACTURE

Effective Term
Semester A 2024/25

Part I Course Overview

Course Title
Deformation and Fracture

Subject Code
MSE - Materials Science and Engineering
Course Number
3110

Academic Unit
Materials Science and Engineering (MSE)

College/School
College of Engineering (EG)

Course Duration
One Semester

Credit Units
3

Level
B1, B2, B3, B4 - Bachelor's Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
AP2102/ MSE2102 Introduction to Materials Engineering

Precursors
AP2104/ MSE2104 Mechanics of Solids

Equivalent Courses
AP3110 Deformation and Fracture

Exclusive Courses
Nil

Part II Course Details

Abstract

The course aims at introducing the various deformation and failure behaviours of materials. Upon successful completion of the course, students are expected to be equipped with sufficient knowledge to apply various criteria for mechanical design against failures.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Describe the mechanisms of various types of plastic deformation & mechanical failure including yielding, creep, fatigue and brittle facture.	33		x	
2	Explain the physical mechanisms and the corresponding failure criteria of different types of plastic deformation & brittle fracture.	33		x	
3	Apply different criteria for designing simple mechanical components against failure.	34		x	

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Learning and Teaching Activities (LTAs)

	LTAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lectures	Students will engage in formal lectures to gain knowledge about various types of plastic deformation & mechanical failure.	1, 2, 3	2hrs/week
2	Tutorial	Students will be encouraged to discuss the characteristics and applications of failure mechanisms. They will also practice problem solving relating to design against failure.	1, 2, 3	0.5hr/week
3	Laboratory Work	Students will gain hands-on experience relating to deformation and failure of materials, as well as the relevant materials testing techniques.	1, 2	3 hrs/week

4	Literature Study Report or Assignment	Students will gain and practice self-learning skills through working on the assignements or literature review relating to the key concepts in the course.	1, 2, 3	0.5hr/week

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Mid-term test	1, 2, 3	15	
2	Lab reports	1, 2	15	
3	Literature study report or assignment	1, 2, 3	10	
4	Examination	1, 2, 3		

Continuous Assessment (%)

40

Examination (%)

60

Examination Duration (Hours)

2

Additional Information for ATs

For a student to pass the course, at least 30% of the maximum mark for the examination must be obtained.

Assessment Rubrics (AR)

Assessment Task

1. Mid-term test

Criterion

Describe the mechanisms of various types of plastic deformation & mechanical failure including yielding, creep, fatigue and brittle facture.
Relate the physical mechanisms and the corresponding failure criteria of different types of plastic deformation & brittle fracture.
Apply different criteria for designing simple mechanical components against failure.

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not reaching marginal level

Assessment Task

2. Lab report

Criterion

Describe the observed types of plastic deformation & mechanical failure including yielding, creep, fatigue and brittle fracture.
Relate the physical mechanisms and the corresponding failure criteria of different types of plastic deformation & brittle fracture.

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not reaching marginal level

Assessment Task

3. Literature study report or assignment

Criterion

Summarize the key concepts in the literature relating to the mechanisms of various types of plastic deformation & mechanical failures.
Compare the concepts and identify the major issues or technological advancements relating to the mechanical failures of engineering materials.

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not reaching marginal level

Assessment Task

4. Examination

Criterion

Describe the mechanisms of various types of plastic deformation & mechanical failure including yielding, creep, fatigue and brittle facture.
Relate the physical mechanisms and the corresponding failure criteria of different types of plastic deformation & brittle fracture.
Apply different criteria for designing simple mechanical components against failure.

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)

Basic

Failure (F)

Not reaching marginal level

Part III Other Information

Keyword Syllabus

- Introduction
  Different types of mechanical failure and how they are influenced by various factors such as external loading (e.g., different modes of loading, amplitude, rate, etc), external environments (e.g., moisture, temperature, pollution, pH), material properties, etc.
- Dislocation theory
  Types of dislocation, energy of dislocation, line tension in dislocation, force on dislocation, Burger circuit, dislocation movement, interaction between parallel and perpendicular dislocations.
- Strengthening mechanism
  Stress and strain of crystal with deformation. Energies of dislocation. Dislocation movement and plastic deformation. Dislocation interaction and multiplication. Strain hardening. Solid solution hardening. Upper yield point in mild steel. Grain size control. Precipitation hardening.
- Yield criteria
  Yield criteria. Post-yield behaviour. Applications to plane stress and plane strain problems.
- Brittle fracture
  The Griffiths criterion. The stress intensity factor. Critical fracture energy and its determination. Crack-tip plasticity. Extensive plasticity. Design and fracture mechanics in practice. Leak-before-break criteria.
- Fatigue
  Micromechanics of fatigue. The bulk approach to fatigue. Fracture mechanics approach. Applications to design. Various factors influencing fatigue life. Fatigue and non-destructive testing.
- Time-dependent behaviour
  Creep and stress relaxation. Different stages of creep. Mechanisms of creep. Deformation mechanism map. Creep-resistant alloys. Design against creep. Superplasticity. Material behaviour at strain rates above 10 s-1. Strain rate and fracture toughness.

Reading List

Compulsory Readings

	Title
1	Nil

Additional Readings

	Title
1	M F Ashby and D R H Jones, “Engineering materials 1: an introduction to their properties and applications”, Butterworth-Heinemann, 2012, 4nd edition.
2	Richard W. Hertzberg, Richard P. Vinci, and Jason L Hertzberg, “Deformation and fracture mechanics of engineering materials”, Wiley, 5th edition, 2013.
3	http://en.wikipedia.org/wiki/Liberty_ship
4	http://news.bbc.co.uk/onthisday/hi/dates/stories/october/19/newsid_3112000/3112466.stm
5	http://en.wikipedia.org/wiki/De_Havilland_Comet