Annexe A: New/Revised Course Content in OBTL+ Format

Course Overview

The sections shown on this interface are based on the templates UG OBTL+ or PG OBTL+
If you are revising/duplicating an existing course and do not see the pre-filled contents you expect in the subsequent sections e.g. Course Aims, Intended Learning Outcomes etc. please refer to Data Transformation Status for more information.

Expected Implementation in Academic Year	AY2025-2026
Semester/Trimester/Others (specify approx. Start/End date)	Semester 1
Course Author * Faculty proposing/revising the course	Professor Chen Zhong
Course Author Email	aszchen@ntu.edu.sg
Course Title	Failure Analysis: Fundamentals
Course Code	MS6005
Academic Units	3
Contact Hours	39
Research Experience Components	

Course Requisites (if applicable)

Pre-requisites	
Co-requisites	
Pre-requisite to	
Mutually exclusive to	MS4652 Failure Analysis
Replacement course to	
Remarks (if any)	Offering existing UG course to PG students. Students who have previously completed MS4652 Failure Analysis during their undergraduate programme will not be allowed to read MS6005 Failure Analysis: Fundamentals.

Course Aims

This course aims to introduce materials and engineering fundamentals required to carry out failure analysis (FA), covering topics from the FA procedure to the materials principles behind failures, and recommendation towards failure prevention, etc. This is a platform on which you will learn how to apply materials science and engineering knowledge to identify the basic modes of materials failure and investigate the root cause of the failure. With proper understanding of how the materials and the systems fail, you will be able to make proper suggestion to mitigate or prevent future failure through improved design or more appropriate choice of materials. This course intends to enhance your knowledge and application skills required as an MSE graduate and to increase your competitiveness in the job market.

Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

ILO 1	Understand the basic procedure in a failure analysis process.
ILO 2	Identify the failure mode and its mechanisms.
ILO 3	Choose appropriate materials testing and characterization tools for failure analysis.
ILO 4	Use engineering software to assist failure analysis.
ILO 5	Determine the root cause and recommend failure mitigation / prevention.

Course Content

Introduction to Failure Analysis: The roles of failure analysis and its general procedures.

Types of Failures and Failure Mechanisms: Various types of failures that occur in materials, including mechanical failures, corrosion, fatigue, and creep, etc., and their mechanisms.

Testing and Characterization Techniques: Testing and characterization techniques used in failure analysis, including microscopy, spectroscopy, and mechanical testing, etc.

Materials Properties and Failure Criteria: Properties of materials, e.g., mechanical, thermal, electrical, and chemical properties, and failure criteria.

Use of Engineering Software in Failure Analysis: Introduction of engineering software (e.g., finite element software) to assist the analysis of engineering failure and to improve the design.

Root Cause Analysis and Prevention: Identifying the root cause of a failure by examining the evidence, analysing the data, and developing hypotheses through case studies. Recommendations to prevent or mitigate similar failures.

Reading and References (if applicable)

1. ASM Handbook Vol. 11 Failure Analysis and Prevention & Vol. 11A Analysis and Prevention of Component and Equipment Failures, ASM International, 2021
2. Fractography and Failure Analysis, Jorge Luis González-Velázquez, Springer, 2018
3. Failure Analysis of Engineering Materials, Charlie R. Brooks and Ashok Choudhury, McGraw-Hill, 2002
4. Understanding How Components Fail, D. J. Wulpi, ASM International, 2013
5. A first course in the finite element method, Daryl L. Logan, Cengage Learning, 2022
6. Failure Analysis of High Technology Devices, Daniel J. D. Sullivan and Eric J. Carleton, De Gruyter, 2022
7. Failure Analysis: Fundamentals and Applications in Mechanical Components, Jose Luis Otegui, Springer, 2014
8. Handbook of Materials Failure Analysis with Case Studies from the Construction Industries, Abdel Salam Hamdy Makhlouf and Mahmood Aliofkhazraei, Butterworth-Heinemann, 2018

Note: The above listing comprises the foundational readings for the course and more up-to-date relevant readings will be provided when they become available.

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Introduction of failure analysis	1	References 1, 2	Online	Pre-recorded lecture, readings
2	Types of failures; Brittle and ductile fractures	2	References 1, 2, 3	Online	Pre-recorded lecture, readings, consultation
3	Fatigue failure; Wear failure	2	References 1, 2, 3	Online	Pre-recorded lecture, readings, consultation
4	Corrosion failure; High temperature failure	2	References 1, 2, 3	Online	Pre-recorded lecture, readings, consultation
5	Continual Assessment 1 (CA1): Individual Mid-Term Quiz	1, 2	N/A	In-person	Continual Assessment 1 (CA1): Individual Mid-Term Quiz
6	Materials testing and characterization	2	References 3, 4	Online	Pre-recorded lecture, readings, consultation
7	Materials properties and failure criteria	3	References 3, 4	Online	Pre-recorded lecture, readings, consultation
8	Finite element analysis - fundamentals	4	Reference 5	Online	Pre-recorded lecture, readings, consultation

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
9	Finite element analysis – use of software	4	Reference 5	In-person	Hands-on session in IT lab; Submission of Continual Assessment 3 (CA3): Lab Report
10	Special topics & case studies 1	1-5	References 1-8	Online	Pre-recorded lecture, readings, consultation
11	Special topics & case studies 2	1-5	References 1-8	Online	Pre-recorded lecture, readings, consultation
12	Continual Assessment 2 (CA2): Individual Final Quiz	3, 4	N/A	In-person	Continual Assessment 2 (CA2): Individual Final Quiz
13	Failure Analysis: an industrial perspective (Guest Lecture)	1-5	References 6, 7, 8	Online	Pre-recorded lecture, readings; Submission of Continual Assessment 4 (CA4): Project Assignment

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Flipped classroom (pre-recorded lectures) with consultation sessions	Lectures are pre-recorded. You are required to catch up or refresh necessary materials science and engineering knowledge to understand what are conveyed in this course. Help will be provided during the consultation session to assist you to learn how to integrate knowledges from different aspects of materials science and engineering in solving some intricate problems encountered.
Hands-on session using engineering software	You will learn how to use engineering software to identify the key factors that might be responsible for the failures. The tool can also help you improve the product reliability through improved design. Guidance, in the forms of handout, will be provided to assist you on the use of the software.
Project assignment	You will be assigned to analyze failure cases. During the process, you will collect information, hypothesize the root cause, and propose ways to verify your hypothesis. In the end, a failure analysis report will be submitted.
Case studies and sharing from industrial players	Case studies teach you the failure analysis procedure and analytical process through real engineering examples. You will also benefit through direct interaction with industrial expert in this area.

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Test/Quiz(Continual Assessment 1 (CA1): Individual Mid-Term Quiz)	1, 2		30	Individual	Holistic	Multistructural
2	Continuous Assessment (CA): Test/Quiz(Continual Assessment 2 (CA2): Individual Final Quiz)	3, 4		30	Individual	Holistic	Multistructural
3	Continuous Assessment (CA): Report/Case study(Continual Assessment 3 (CA3): Lab Report)	4		20	Individual	Analytic	Relational
4	Continuous Assessment (CA): Report/Case study(Continual Assessment 4 (CA4): Project Assignment)	1, 2, 3, 5		20	Individual	Analytic	Relational

Description of Assessment Components (if applicable)

Continual Assessment 1 (CA1): Individual Mid-Term Quiz
MCQ & Short Questions

Continual Assessment 2 (CA2): Individual Final Quiz
MCQ & Short Questions

Continual Assessment 3 (CA3): Lab Report
Lab Report Submission

Continual Assessment 4 (CA4): Project Assignment
Project Report (based on Pre-assigned Case Studies)

Formative Feedback

You are encouraged to approach the course instructor to clarify your doubts on the taught concepts and principles, to raise questions related to assignment topics. This interaction allows you to understand better what has been taught and to prepare yourself for the assessment. The discussions also enable the instructor to recognize where you are struggling and provide remedial measures to assist your learning.

Continuous assessment (CA) answers will be discussed immediately after each test. You will understand your strengths and weaknesses in understanding the fundamentals and plan remedial actions if necessary.

NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

Attributes/Competency	Level
Communication	Intermediate
Curiosity	Intermediate
Problem Solving	Advanced
Critical Thinking	Intermediate

Course Policy

Policy (Academic Integrity)

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values. As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Policy (General)

You are expected to complete all assigned readings, activities, assignments, attend all classes punctually and complete all scheduled assignments by due dates. You are expected to take responsibility to follow up with assignments and course related announcements. You are expected to participate in all project critiques, class discussions and activities.

Policy (Absenteeism)

In-class activities make up a significant portion of your course grade. Absence from class without a valid reason will affect your participation grade. Valid reasons include falling sick supported by a medical certificate and participation in NTU's approved activities supported by an excuse letter from the relevant bodies. There will be no make-up opportunities for in-class activities.

Policy (Others, if applicable)

Last Updated Date: 14-04-2025 08:55:14

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