

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

Course Overview

Expected Implementation in Academic Year (New format)	AY2026-2027
Semester/Trimester/Others (specify approx. Start/End date)	Semester 1
Course Author * Faculty proposing/revising the course	Dr Alfred Tok ling Yoong
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Course Title	Failure Analysis of Engineering Materials (Forensic Investigations)
Course Code	MS6004
Academic Units	2
Contact Hours	26
Research Experience Components	

Course Requisites (if applicable)

Pre-requisites	
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

Failure Analysis is a critical aspect in all aspects of practical engineering, and is important in every field of engineering like mechanical, structural, civil, microelectronics, chemical etc. It is particularly important in mechanical and structural engineering, where the understanding of the causes and mechanisms of failure is crucial for designing safe and reliable structures and systems, for preventing repeat failures and for forensic purposes. Graduate engineers have been equipped with the fundamentals of materials science & engineering, mechanical structure design as well as materials / mechanical characterisation tools. These postgraduate courses thus aims to complement student's fundamental knowledge with the practical aspect of failure analysis.

The Failure Analysis of Engineering Materials (Forensic Investigations) course proposes to prepare engineers to analyse failures in non-standard engineering items (eg. knives, household furniture etc) to determine cause of failure (in cases that may be related to human injury / death), and whether the underlying cause of failure is a natural engineering failure or caused by external manipulation (eg. stabbing, hitting etc). In addition, the wider aspect of engineering forensics like evidence collection/handling/ documentation, reconstruction, ethics as well as fire and explosive damage investigations are included in this course.

Course's Intended Learning Outcomes (ILOs)

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

ILO 1	Understand basic and advanced observations of failed non-standard items related to forensic investigations.
ILO 2	Learn to form failure mechanism hypotheses in articles related to forensic investigations.
ILO 3	Design testing methods to test failure mechanism hypotheses and sub-hypotheses through materials characterisation. Learn issues surrounding testing of forensic articles.
ILO 4	Analysis and Documentation of Results. Analyse materials testing results in the context of the failure mechanism hypotheses. Comprehensive but succinct documentation and presentation of results.
ILO 5	Integrate various sub-hypotheses into a reasonable conclusion.

Course Content

Introduction to Failure Analysis (Forensics)

This topic introduces the principles and scope of failure analysis in forensic engineering, highlighting its role in determining root causes of failure, liability, and responsibility in engineering-related incidents involving damage or injury.

Materials Failure, Reconstruction & Fracture

Students examine common failure mechanisms such as fracture, fatigue, corrosion, and wear, and learn how failed components are reconstructed to infer loading conditions, service history, and failure sequence.

Case Study I: Structural Failure Analysis

This case study applies failure analysis methodologies to real-world structural failures, emphasising the interaction between material behaviour, design assumptions, loading conditions, and environmental effects.

Forensics Investigation Process & Evidence Handling

This topic covers systematic forensic investigation procedures, including scene documentation, evidence collection, preservation, chain of custody, and reporting to ensure technical and legal integrity.

Forensic Microscopic Investigations of Materials Failures

Students are introduced to optical and electron microscopy techniques used to identify fracture features, microstructural changes, and damage mechanisms that reveal the origin and progression of failure.

Fire & Explosive Damage Investigations

This section examines material responses to fire and explosive events, including thermal degradation, burn patterns, blast effects, and residue analysis to distinguish accidental damage from deliberate acts.

Case Study II: Grenfell Fire Analysis + Tutorial

The Grenfell Tower fire is analysed as a comprehensive case study to integrate materials behaviour, fire dynamics, façade systems, regulatory failures, and forensic investigation outcomes through guided tutorial discussions.

Ethics & Challenges in Forensics Investigations

This topic explores ethical responsibilities, professional conduct, bias avoidance, and technical limitations faced by forensic engineers when providing expert opinions in legal and societal contexts.

Reading and References (if applicable)

1. What is Forensic Engineering? National Academy of Forensic Engineers.

<https://www.nafe.org>

2. National Transportation Safety Board. (2008). Collapse of I-35W Highway Bridge (NTSB/HAR-08/03).

<https://www.nts.gov/investigations/AccidentReports/Reports/HAR0803.pdf>

3. Introduction to Forensic Engineering.

<https://www.taylorfrancis.com/books/mono/10.4324/9781003068877/introduction-forensic-engineering-randall-noon>

4. Structural Design for Fire Safety

<https://www.wiley.com/en-be/Structural+Design+for+Fire+Safety%2C+2nd+Edition-p-9780470972892>

5. Grenfell Tower Inquiry Phase 1 Report (2019).

<https://webarchive.nationalarchives.gov.uk/ukgwa/20250320040117/https://www.grenfelltowerinquiry.org.uk/phase-1-report>

6. Forensic Engineering

<https://www.taylorfrancis.com/books/mono/10.1201/9781420037029/forensic-engineering-kenneth-carper>

7. Hull, D., & Clyne, T. W. (2019). An Introduction to Composite Materials (3rd ed.). Cambridge University Press.

<https://www.cambridge.org/highereducation/books/an-introduction-to-composite-materials/402C0AAFF04754C676E22D2B1F9080DB#overview>

8. National Society of Professional Engineers (NSPE). (2019). Code of Ethics.

<https://www.nspe.org/career-growth/nspe-code-ethics-engineers>

9. Institute of Electrical and Electronics Engineers (IEEE). (2020). IEEE Code of Ethics.

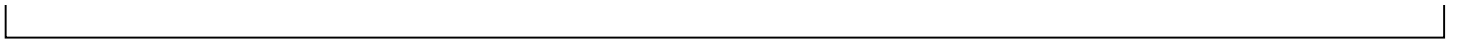
<https://www.ieee.org/about/corporate/governance/p7-8>

10. American Society of Civil Engineers. (2021). ASCE code of ethics. <https://www.asce.org/career-growth/ethics/code-of-ethics/>

11. Engineers Australia. (2022, August). Code of Ethics and Guidelines on Professional Conduct. Engineers Australia

<https://www.engineersaustralia.org.au/sites/default/files/2022-08/code-ethics-guidelines-professional-conduct-2022.pdf>

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



Planned Schedule

Week or Session	Topics or Themes	ILO	Delivery Mode	Activities	Readings
1	Introduction to Failure Analysis for Forensic Investigations	1-5	Online	Online Class (live)	1,3,6
2	Materials Failure, Reconstruction & Fracture	1-3	Online	Prerecorded Lecture	2,3,7
3	Materials Failure, Reconstruction & Fracture	1-3	Online	Prerecorded Lecture	2,3,7
4	Case Study 1: Structural Failure Analysis	1-5	Online	Online Class (live)	2,3,7
5	Forensic Investigation Process & Evidence Handling	4	Online	Online Class (live)	1, 6
6	Forensic Microscopic Investigations of Materials Failures	1-4	Online	Online Class (live)	7
7	Continual Assessment (CA1 Individual) Briefing and Q&A	1-5	Online	Online Class (live)	N/A
8	Fire & Explosive Damage Investigations	1-3	Online	Online Class (live)	4,5
9	Ethics & Challenges in Forensics Investigations Submission of Continuous Assessment 1 (CA1): Individual Project Written Submission (Fracture)	4	Online	Prerecorded Lecture Submission of Continuous Assessment 1 (CA1)	8,9,10,11
10	Case Study 2: Grenfell Fire Analysis	1-5	Online	Online Class (live)	4,5

Week or Session	Topics or Themes	ILO	Delivery Mode	Activities	Readings
11	Continual Assessment 2 (CA2 Individual) Briefing and Q&A	1-5	Online	Online Class (live)	N/A
12	CA2 Consultation	1-5	Online	Online Class (live)	N/A
13	Submission of Continuous Assessment 2 (CA2): Individual Project Written Submission (Fire Investigation)	1-5	Online	Online Class (live) Submission of Continuous Assessment 2 (CA2)	N/A

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Blended learning with active use of multi-media resources (TEL)	This will permit flexibility of access to learning materials, activities and assessments and can help you develop independent learning and critical thinking skills.
Showing real-world applications	Most of the concepts that are dealt in the course have real-world implications and applications. Therefore, they are used as examples while discussing the related concepts.
Weekly Consultation	Weekly consultation hours will be available to encourage discussions that will reinforce students' understanding on various concepts and applications. Instead of providing answers directly to students' queries, they will be guided to think and make intelligent guesses based on sound principles. This approach will cultivate critical thinking.

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Description of Assessment Component	Team/Individual	Rubrics	Level of Understanding
1	Continuous Assessment (CA): Report/Case study(Continuous Assessment 1 (CA1): Individual Project Written Submission (Fracture))	1-2		40	Individual Assignment (Report) on Fracture Mechanism and Microscopy	Individual	Holistic	Multistructural
2	Continuous Assessment (CA): Report/Case study(Continuous Assessment 2 (CA2): Individual Project Written Submission (Fire Investigation))	1-5		60	Individual Assignment (Report) on Fire Investigation	Individual	Holistic	Relational

Description of Assessment Components (if applicable)

Formative Feedback

- In-video tutorial classes and discussions / feedback during group presentations
- Grading and general feedback after each CA.
- You are encouraged to attend coordinator's consultation hours to clarify any doubts in the lecture and discuss any issues, if needed.

NTU Graduate Attributes/Competency Mapping

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

Attributes/Competency	Level
Ethical Reasoning	Intermediate
Problem Solving	Intermediate
Transdisciplinarity	Intermediate
Critical Thinking	Intermediate
Systems 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)

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