MNE6132: MATERIALS IN NUCLEAR ENGINEERING

Effective Term
Semester A 2026/27

Part I Course Overview

Course Title
Materials in Nuclear Engineering

Subject Code
MNE - Mechanical Engineering
Course Number
6132

Academic Unit
Mechanical Engineering (MNE)

College/School
College of Engineering (EG)

Course Duration
One Semester

Credit Units
3

Level
P5, P6 - Postgraduate Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
Nil

Precursors
Nil

Equivalent Courses
Nil

Exclusive Courses
Nil

Part II Course Details

Abstract

Materials play a crucial role in nuclear reactors. This course aims to provide an overview of the fundamental principles governing materials degradation in nuclear systems, drawing upon the understanding from neutron-atom and ion-atom interactions to radiation damage theory and defect reactions. The properties of nuclear fuel assemblies, fuel rod materials, core internal structural materials, reactor pressure vessel, and primary circuit-piping systems in nuclear reactors will be examined in detail. We will explore commonly employed materials in present and future reactors, such as steels, Zr alloys utilized in fuel assemblies, and carbides designed for high-temperature applications. The implications of irradiation damage to the mechanical performance of materials will be discussed.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Describe the basic structure and properties of nuclear materials used for nuclear reactor systems.		x		
2	Explain the principles and mechanisms of materials degradation under the irradiation environment based on neutron-solid and ion-solid interactions.		x	x	
3	Identify the key considerations for materials choice in nuclear reactor systems.			x	
4	Apply the concepts, principles, and methods learned for the design and development of materials under nuclear reactor conditions.			x	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	Lecture	To take place in the classroom. The main teaching activities will be in the form of lectures, which will be given related to the topics in the keyword syllabus.	1, 2, 3, 4	2 hrs/week

2	Tutorial	To take place in the classroom. The tutorials are problem-solving and Q&A sessions for strengthening students' understanding of the contents of the lectures. The course project will also help in the learning practice.	1, 2, 3, 4	1 hr/week

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Test/Assignments	1, 2	10		
2	Mini-projects	3, 4	20		
3	Final presentation	3, 4	20		

Continuous Assessment (%)

50

Examination (%)

50

Examination Duration (Hours)

2

Additional Information for ATs

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

Assessment Rubrics (AR)

Assessment Task

Test/Assignments

Criterion

Ability to understand the basic concepts related to radiation damage.

Excellent

(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Not even reaching marginal levels

Assessment Task
Mini-projects

Criterion
Ability to understand and explain in detail and apply the learned knowledge to the analysis of materials response in nuclear reactors.

Excellent
(A+, A, A-) High

Good
(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Final presentation

Criterion
Ability to apply the fundamentals of ion-solid interactions to solve emerging problems in nuclear engineering.

Excellent
(A+, A, A-) High

Good
(B+, B, B-) Significant

Fair
(C+, C, C-) Moderate

Marginal
(D) Basic

Failure
(F) Not even reaching marginal levels

Assessment Task
Examination

Criterion
Ability of in-depth understanding of the key concepts, principles, methods, and applications of materials under the nuclear reactor environments.

Excellent
(A+, A, A-) High

Good

(B+, B, B-) Significant

Fair

(C+, C, C-) Moderate

Marginal

(D) Basic

Failure

(F) Not even reaching marginal levels

Additional Information for AR

Note: For a student to pass the course, at least 30% of the maximum mark for both coursework and examination should be obtained.

Part III Other Information

Keyword Syllabus

Neutron-solid interactions, Ion-solid interactions, stopping power, ion range, displacement cross section, damage cross section, displacement per atom (dpa), displacement theory, nuclear fuels, nuclear structural materials, dislocations, radiation-induced hardening and embrittlement, void swelling, Helium bubble.

Reading List

Compulsory Readings

	Title
1	“Fundamentals of Radiation Materials Science: Metals and Alloys.” 2nd Ed., Gary Was, Springer, 2007.
2	“Comprehensive Nuclear Materials.”, Netherlands: Elsevier Science, 2020.

Additional Readings

	Title
1	“Light-Water Reactor Materials”, Donald R. Olander and Arthur T. Motta, 2014.
2	“Aging and Life Extension of Major Light Water Reactor Components”, Ed. V.N. Shah and P.E. MacDonald, Elsevier Science Publishers B.V., ISBN 0-444-89448-9, (TK9203.L45A35), 1993.
3	“An Introduction to Nuclear Materials: Fundamentals and Applications”, Murty, K. L., Charit, I., Germany: Wiley, 2013.
4	“Structural Materials for Generation IV Nuclear Reactors.”, Pascal Yvon, Netherlands: Elsevier Science, 2016.
5	Students are encouraged to find out related publications to widen their knowledge in the subjects.