MNE6133: PHYSICAL EFFECTS OF RADIATION DAMAGE

Effective Term
Semester A 2026/27

Part I Course Overview

Course Title
Physical Effects of Radiation Damage

Subject Code
MNE - Mechanical Engineering

Course Number
6133

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
MNE6138 Fundamentals of Nuclear Engineering

Equivalent Courses
Nil

Exclusive Courses
Nil

Part II Course Details

Abstract

This course primarily explores the impact of radiation damage on material properties through advanced characterization techniques, based on which the underlying physical mechanisms for irradiation damage will be analyzed. The topics cover the features of different types of radiation sources (energetic neutrons and ions), the interaction mechanisms of radiation with matter, radiation-induced defect production, and the influence of radiation on the microstructure and macroscopic properties of materials. Particular emphasis will be put on characterization techniques for radiation damage, alongside strategies for minimizing such damage through material design and process optimization. The course equips students with theoretical and practical knowledge to understand and evaluate material behavior in radiation environments, serving as a vital guide for students and researchers in fields related to radiation materials, nuclear engineering, material science, and engineering.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Understand the fundamentals of radiation damage in nuclear materials and its underlying mechanisms.		x		
2	Explain the degradation of materials in radiation environments.		x	x	
3	Identify the techniques for characterizing radiation damage in nuclear materials.			x	
4	Apply the concepts, principles, and methods learned for the design and development of candidate materials for advanced nuclear power systems.			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	40		

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 basic concepts related to microfluidics.

Excellent

(A+, A, A-) 75%-100%

Good

(B+, B, B-) 60%-74%

Fair

(C+, C, C-) 45%-59%

Marginal

(D) 40%-44%

Failure

(F) <40%

Assessment Task

Mini-projects

Criterion

Ability to explain in detail and apply the learned knowledge to the analysis and design of systems using microfluidic components for scientific research and practical applications.

Excellent

(A+, A, A-) Strong evidence of critical thinking; good capacity to analyze; superior grasp of subject matter; evidence of extensive knowledge of the project concerned.

Good

(B+, B, B-) Evidence of grasp of subject matter, some evidence of critical thinking and analysis; reasonable understanding of concepts; ability to develop the project.

Fair

(C+, C, C-) Student who is profiting from the project; understanding of the subject matter; evidence of familiarity with the project.

Marginal

(D) Basic familiarity with the subject matter to enable the student to use knowledge in the project.

Failure

(F) Little evidence of familiarity with the subject matter to accomplish the project.

Assessment Task

Examination

Criterion

Ability to understand the key concepts, principles, methods, and applications of microfluidic systems used in both scientific research and real-world products.

Excellent

(A+, A, A-) 75%-100%

Good

(B+, B, B-) 60%-74%

Fair

(C+, C, C-) 45%-59%

Marginal

(D) 40%-44%

Failure

(F) <40%

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

Radiation damage effects, neutron sources, ion sources, neutron and ion irradiation, neutron-matter interactions, ion-matter interactions, characterization techniques, transmission electron microscope, scanning electron microscope, nanoindentation.

Reading List

Compulsory Readings

	Title
1	“Fundamentals of Radiation Materials Science: Metals and Alloys”, Gary S. Was, Springer, 2017.
2	“Ion-Solid Interactions: Fundamentals and Applications”, Michael Nastasi, James Mayer, James K. Hirvonen, Cambridge University Press; 1st edition, 1996.

Additional Readings

	Title
1	“Characterisation of Radiation Damage by Transmission Electron Microscopy”, M.L Jenkins, M.A Kirk, CRC Press, 2000.
2	“Structural Alloys for Nuclear Energy Applications”, G. Robert Odette and Steven J. Zinkle, Elsevier, 2019.
3	Students are encouraged to find out related publications to widen their knowledge of the subjects.