No.	Information of NE 5025 Reactor Engineering	
1	Unit name:	Reactor Engineering
2	Code:	NE 5025
3	Classification:	Major subject
4	Credit value:	3.5
5	Semester / Year Offered:	2/5
6	Pre-requisite:	NE 4024 Introduction to Reactor Engineering
7	Mode of delivery:	Lecture, Classwork, Discussion
8	Assessment system and breakdown of marks:	Tutorial, Classwork activity, Written Exam
	Assignment / Classwork	10 %
	Tutorial	20 %
	Written Exam	70 %
9	Academic staff teaching unit:	Department of Nuclear Technology
10	Course outcome of unit: After completion of this course, students will be able to 1. generalized various components of NPP with pressurized water reactors 2. generalized various components of NPP with boiling water reactors 3. generalized various components of NPP with heavy water reactors 4. generalized small modular reactor system 5. analyze nuclear fuel resources and uranium enrichment system 6. analyze nuclear fuel fabrication and recycling system	
11	Synopsis of unit: This course is devoted to nuclear power reactors. It begins with a historical perspective that looks at the development of many reactor concepts through the research/test reactor stage and the demonstration reactor that was actually a small power station. Today these reactors have faded into history, but some of the concepts are re-emerging in new research and development programs. Sometimes these reactors are referred to as "Generation I." Chapters in the course deal with the reactors that are currently in operation as well as those that are currently starting through the licensing process, the so called Generation II and Generation III reactors. This is followed by a discussion of reactor systems that are being proposed to eliminate the high- pressure water cooled systems that require sustained emergency power to shut down. The final chapter in the section introduces the Generation IV	

	reactor concepts. There is no attempt within this section to discuss research and test reactors, military or navel reactors, or space-based reactors and nuclear power systems. There is also no attempt to describe the electric-generating portion of the plant except for the steam conditions passing through the turbines. Twenty percent of the electrical energy generated in the United States is generated in nuclear power plants. These plants are PWRs and boiling water reactors (BWRs). The Generation II PWRs were manufactured by Westinghouse, Combustion Engineering, and Babcock and Wilcox, whereas the BWRs were manufactured by General Electric. These reactor systems are described in Chapters 2 and 3. The descriptions include the various reactor systems and components and a general discussion of how they function. The discussion includes the newer systems that are currently being proposed that have significant safety upgrades. Chapters 4 describe the CANDU reactor. The CANDU reactor is the reactor of choice in Canada. This reactor is unique in that it uses heavy water (sometimes called deuterium oxide) as its neutron moderator. Because it uses heavy water as a moderator, the reactor can use natural uranium as a fuel; therefore, the front end of the fuel cycle does not include the uranium enrichment process required for reactors with a light water neutron moderator. The second section is devoted to the nuclear fuel cycle and also facilities processes related to the lifecycle of nuclear systems. The fuel cycle begins with the extraction or mining of uranium ores and follows the material through the various processing steps before it enters the reactor and after it is removed from the reactor core. This section includes nuclear fuel reprocessing, even though it is not currently practiced in the United States, and also describes the decommissioning process that comes at the end of life for nuclear facilities. A separate chapter discusses the fuel cycles that can be used when the reactor fuel is reprocessed. The first three chapters of this section discuss the mining, enrichment, and fuel fabrication processes. The primary fuel used in reactors is uranium, so there is little mention of thorium as a potential nuclear fuel. The primary enrichment process that was originally used in the United States was gaseous diffusion. This was extremely energy intensive and has given way to the use of gas centrifuges. During fuel fabrication, the enriched gaseous material is converted back to a solid and inserted into the fuel rods that are used in the reactor. The last chapter discuss the storage of spent fuel, fuel reprocessing, fuel recycle, and waste disposal. Spent fuel is currently stored at the reactor sites where it is stored in spent fuel pools immediately after discharge and can later be moved to dry storage using shielded casks. Fuel reprocessing and fuel recycle are currently not done in the United States, but the chemical separation processes used in other countries are described. Waste disposal of low-level nuclear waste and transuranic nuclear waste are being actively pursued in the United States. The section also includes a discussion of the proposed Yucca Mountain facility for high-level waste and nuclear fuel.
12	Topic: 1. PRESSURIZED WATER REACTORS 2. BOILING WATER REACTORS 3. HEAVY WATER REACTORS 4. SMALL MODULAR REACTORS

	5. NUCLEAR FUEL RESOURCES 6. URANIUM ENRICHMENT 7. NUCLEAR FUEL FABRICATION 8. NUCLEAR FUEL RECYCLING
13	Main reference: NUCLEAR ENGINEERING HANDBOOK, 2nd Edition, Kenneth D. Kok, 2017
14	Additional references: (1) INTRODUCTION TO NUCLEAR ENGINEERING, 3rd Edition, John R. Lamarsh and Anthony J. Baratta (2) ELEMENTARY NUCLEAR AND REACTOR PHYSICS, M.A. Wazed Miah

<table>
<tr><th>No.</th><th colspan="2">Information of NE 5026 MathCAD</th></tr>
<tr><td>1</td><td>Unit name:</td><td>MathCAD</td></tr>
<tr><td>2</td><td>Code:</td><td>NE 5026</td></tr>
<tr><td>3</td><td>Classification:</td><td>General subject</td></tr>
<tr><td>4</td><td>Credit value:</td><td>2.5</td></tr>
<tr><td>5</td><td>Semester / Year Offered:</td><td>2/5</td></tr>
<tr><td>6</td><td>Pre-requisite:</td><td>NE 4024 Introduction to Reactor Engineering
NE 5025 Reactor Engineering</td></tr>
<tr><td>7</td><td>Mode of delivery:</td><td>Presentation , Practical, Classwork,</td></tr>
<tr><td rowspan="3">8</td><td>Assessment system and breakdown of marks:</td><td>Practical Exam, Tutorial, Classwork activity</td></tr>
<tr><td>Practical/Practical Exam</td><td>60 %</td></tr>
<tr><td>Tutorial</td><td>40 %</td></tr>
<tr><td>9</td><td>Academic staff teaching unit:</td><td>Department of Nuclear Technology</td></tr>
<tr><td>10</td><td colspan="2">Course outcome of unit:
After completion of this course, students will be able to
1. understand the function of mathematical programmable language
2. apply the MathCAD program with complex mathematical calculation
3. apply the MathCAD program with critical calculation of fuel lattice cell
4. solve neutron-physics problems with MathCAD program
5. graph 2D graphics in MathCAD program</td></tr>
<tr><td>11</td><td colspan="2">Synopsis of unit:
MathCAD is the industry standard technical calculation tool for engineers worldwide. MathCAD delivers all the solving capabilities, functionality, and robustness needed for calculation, data manipulation, and engineering design work. Calculation standardization and reuse through MathCAD ensures standards compliance. By combining calculations, graphs, text, and images in one document, MathCAD enables knowledge capture and publication that aid management of large projects. MathCAD allow the students to document their calculations in the language of mathematics, because MathCAD combines a powerful computational engine, accessed through conventional math notation, with a full-featured word processor and graphing tools.</td></tr>
<tr><td>12</td><td colspan="2">Topic:
1. Welcome to Mathcad
2. Getting Started with Mathcad
3. Online Resources
4. Working with Math</td></tr>
</table>

	5. Range Variables and Arrays 6. Working with Text 7. Mathcad Worksheets 8. Calculating in Mathcad 9. Solving 10. Inserting Graphics and Other Objects 11. 2D Plots 12. 3D Plots 13. Symbolic Calculation
13	Main reference: User's Guide, Mathcad 14.0, February 2007
14	Additional references: (1) INTRODUCTION TO NUCLEAR ENGINEERING, 3rd Edition, John R. Lamarsh and Anthony J. Baratta (2) NUCLEAR ENGINEERING HANDBOOK, 2nd Edition, Kenneth D. Kok, 2017

No	Information of Radiation Spectrometry and Counting Statistics	
1	Unit name:	Radiation Spectrometry and Counting Statics
2	Code:	NE 51034
3	Classification:	Major
4	Credit value:	2.5
5	Semester/ Year Offered:	1/5
6	Pre-requisite:	Successfully taken course in properties of radiation and radioactivity ,basic principle of gas filled detector, scintillation detectors and semiconductor detectors
7	Mode of delivery:	Regular lectures, PPT presentation
8	Assessment system and breakdown of marks:	Assignment, class activity, presentation, project
	Class Activity and Presentation	20%
	Assignment/Home work	10%
	Q & A	70%
9	Academic staff teaching unit:	Department of Nuclear Technology
10	Course outcome of unit: After completion of this course, students will be able to 1. Analyzes the results obtained from experiments and determine the statistical errors of radiation measurements. 2. Analyzes measured energy spectrum for determination of energy resolution, efficiency and calibration of a multichannel analyzer in spectroscopic measurements. 3. Identify the energy deposition in the detector for X-ray and Gamma ray with different types of detection system of scintillation detectors, proportional counter, semiconductor detectors and crystal spectrometer. 4. Comprehend basic principle of charged particle spectroscopy system for measurement of electron, alpha, proton, deuteron and triton with different spectrometers. 5. Explain the neutron detection and spectroscopy with different measurement methods and neutron measurement systems.	

	6. To identify and address seek their educational needs (life-long learning)
11	Synopsis of unit: The subject of the course covered the error analysis of the radiation detection and measurements, radiation spectroscopy system with photon (gamma and X-ray), charged particle spectroscopy system and neutron detection and spectroscopy systems. Error analysis of experimental results for determination of statistical error, standard deviation and error propagations and error reduction are studied for practical radiation counting measurements. Basic principles gamma photon energy deposition in the different types of detection systems: scintillation detectors, semiconductor detectors are studied for practical gamma spectroscopic measurements. The spectrum analysis for the determination of resolution, efficiency and calibration of the measurement system are studied. The charged particle spectroscopic measurements for different charge particles with various spectrometers are studied. The neutron detection for different neutron energy ranges according to foil activation ,proton recoil method, threshold activation method , time of flight methods are studied.
12	Topic: 1. Errors of Radiation Counting 2. Introduction to Spectroscopy 3. Photon(gamma ray and X-ray)Spectroscopy 4. Charged Particle Spectroscopy 5. Neutron Detection and Spectroscopy
14	Main references: Nicholas Tsoulfanidis and Sheldon Landsberger ,4^{th} Edition, Measurement and Detection of Radiation by Taylor & Francis Group,2015 (Internet Downloadable)
15	Additional references: Knoll, G. F., Radiation Detection and Measurement, 4th ed. Wiley, New York, 2010.

Dr Khaing Nyunt Myaing

Professor

Department of Nuclear Technology

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No	Information of Introduction to X- ray Spectroscopy	
1	Unit name	Introduction to X-ray spectroscopy
2	Code	NE 51035
3	Classification	Major Subject
4	Credit value	3
5	Semester / year Offered	1/6
6	Pre-requisite	NA
7	Mode of delivery	Text
8	Assessment system and breakdown of marks	Tutorial, Assignment, Exam
	Assignment	5%
	Tutorial	10%
	Exam	35%
9	Academic staff teaching unit	Department of Nuclear Technology
10	Course outcome of unit	After teaching of this course, students will be able to 1. Explain the principle of interaction of x-rays with matter 2. Discuss about characteristics of most important x-ray sources 3. Understand the operation of main optical elements and detectors for x-rays. 4. Understand the principles of X-ray fluorescence and x-ray absorption spectroscopy, 5. Know the necessary experimental equipment, and understand basic methods for analysis and interpretation of measurement spectra, and understand what kind of structural information about the investigated material can be obtained by individual spectroscopic methods. 6. Understand the applications of the technique
11	Synopsis of unit	X-ray spectroscopy is an excellent method to determine the structure of compound. However, this technique requires the availability of a compound as a single crystal. X-ray spectroscopy is the method of choice for structural determination where the other parameters such as bond lengths and bond angles are also determined. The discovery of x- rays and the polarization and reflection experiments that demonstrated the wave nature of x-rays. The emission spectrum and the two principle mechanism for production of x-rays. Describe their three processes, photoelectric absorption, Compton scattering and pair production which show the nature of x-rays. Explain the absorption of x-ray in materials. Present an important practical applications of x-ray.
12		
13		
14	Main references:	Gamma-and x-ray spectrometry with semiconductor dectors, 1988 Klaus Debertin and Richard G.Helmer
15	Additional references:	Modern Atomic and Nuclear Physics, Fujia yang and Joseph H. Hamalton, International Edition 1996

NE 51051- Introduction to X-ray Spectroscopy Course outcomes and Indicators

	Learning Outcomes	Learning Indicators
	1. Recognize the regions of electromagnetic spectrum and relate it to spectroscopic methods 2. Differentiate and understand the difference between atomic and molecular energy levels 3. Relate energy levels with absorption and emission in various regions of electromagnetic spectrum 4. Understand the basic principles of x-ray fluorescence 5. Recognize the components of instrumentation 6. Understand the applications of the technique	1. Exercises on software for the analysis of x-rays spectra under supervision of the course principal- 2. Individual analysis of x-rays spectra under supervision of the course principal 3. Presentation of the results of the analysis to other students in the group and open discussion about the analysis topic under supervision of the course principal

No	Information of Radioactive waste management	
1	Unit name:	Radioactive waste management
2	Code:	NE-51014
3	Classification:	Major Subject
4	Credit value:	3.5
5	Semester/ Year Offered:	2/5
6	Pre-requisite:	NE 1011 Introduction to radiation and radioactivity NE 4013 Radiation Protection and radiation shielding
7	Mode of delivery:	Presentation, discussion, class work
8	Assessment system and breakdown of marks:	Written exam, Tutorial, Assignment
	Written Exam	70%
	Tutorial	20%
	Assignment	10%
9	Academic staff teaching unit:	Department of Nuclear Technology
10	Course outcome of unit: After completion of this course, students will be able to 1. discuss different radiation exposure pathways radioactive waste 2. classify different types of radioactive waste 3. identify general approaches to the management of radioactive wastes 4. apply radioactive waste management system in practical applications 5. identify to all activities involving radioactive waste, including spent and disused sealed sources, associated with the use of radioactive material in medicine, industry, research, agriculture and education. 6. identify some recommendations on developing and implementing management systems for the pretreatment, treatment, conditioning and storage of radioactive waste.	
11	Synopsis of unit: The purpose of this lecture is to provide an overview of radioactive waste arising and classification, waste characteristics and management options. It introduces the overall management system for a programme of activities for waste management, incorporating the individual management systems of a series of operators that carry out successive steps in the	

	processing, handling, storage and disposal of waste.
12	Topic: Radioactive waste management Introduction The Radioactive Waste Classification Scheme The Management System Management Responsibility Resource Management Process Implementation Measurement, Assessment And Improvement Protection Of Human Health And The Environment Roles And Responsibilities General Safety Considerations Predisposal Management Of Radioactive Waste Acceptance Of Radioactive Waste Into Disposal Facilities Record Keeping And Reporting
13	Main references: 1. Introduction to Radiation Protection, 4th Edition, Alan Martin and Samuel A. Harbison 2. Classification of Radioactive Waste, General Safety Guide, IAEA, General Safety Guide, IAEA, No. GSG-1 3. The management system for processing, handling and storage of radioactive waste, Safety Guide, IAEA, No.GS-G-3.3 4. Management of waste from the use of radioactive material in medicine, industry, agriculture, research and education. IAEA, Safety Standard Series No. WS-G-2.7
14	Additional references: 1.Basic principles of radioactive waste management, Joint guidance from the Office of Nuclear Regulation, the Environment Agency, the Scottish Environment Protection Agency and Natural Resources Wales to nuclear licensees, February 2015 2. The Management System for the Disposal of Radioactive Waste, Safety Guide, No. GS-G-3.4 3. The Management System for Technical Services in Radiation Safety, Safety Guide, No. GS-G-3.2