ENGG9743 Fuel Cycle, Waste and Life Cycle Management

Course Outline – Semester 2, 2015

Never Stand Still | Faculty of Engineering | School of Electrical Engineering and Telecommunications

Course Staff

Course Convener: Prof. John Fletcher, Room 131, john.fletcher@unsw.edu.au
Lecturers: Dr Lou Vance, Dr Dan Gregg, Dr Kapila Fernando

Consultations: You are encouraged to ask questions on the course material, after the lecture class times in the first instance, rather than via email. ALL email enquiries should be made from your student email address with ENGG9743 in the subject line, otherwise they will not be answered.

Keeping Informed: Announcements may be made during classes, via email (to your student email address) and/or via online learning and teaching platforms – in this course, we will use Moodle https://moodle.telt.unsw.edu.au/login/index.php. Please note that you will be deemed to have received this information, so you should take careful note of all announcements.

Course Summary

Contact Hours

The course will be delivered on Tuesday evenings, 6-9pm, in G3 of the Electrical Engineering building. The subject will be supported by tutorial sheets and coursework assignments with staff support from the School of Electrical Engineering and Telecommunications.

Context and Aims

The nuclear fuel cycle is a vital aspect of nuclear engineering and this class covers the cycle from extraction to storage. Fuel cycles vary with reactor technology and the course will review each of the existing processes in use. The course will also review improvements made in recycling processes.

The waste management and decommissioning aspects of this course focuses on the growing need in the nuclear industry to understand the physics and engineering aspects of decommissioning plant and dealing with contaminated waste, including storage options for short- and long-term storage.

This course is designed to give an in-depth, practical knowledge of the nuclear fuel cycle from the metallurgy of Uranium to the disposition of spent reactor fuel. It will provide details of current and future nuclear reactor designs for the generation of electricity, their life cycle and decommissioning. This course will not only provide a comprehensive study of the traditional fuel cycle (the Uranium/Plutonium once-through cycle), but it will also discuss the closure of the nuclear fuel cycle as well as fuel cycles that may be the future of nuclear power, such as the Thorium fuel cycle. The course also provides an introduction to the principles and practices of waste management and disposal. Case studies will be used to demonstrate the principles of life cycle management and decommissioning.

Assessment

Coursework Assignments (x3)	10% each
Final Exam (3 hours)	70%

Course Details

Credits

This is a 6 UoC course and the expected workload is 10 hours per week.

Relationship to Other Courses

This is a postgraduate course convened by School of Electrical Engineering and Telecommunications. It is a core class on the MEngSci Nuclear Engineering specialization and can be taken as an elective by 3rd or 4th year students from other schools and faculties on the approval of home school and the ENGG9743 course convener.

Pre-requisites and Assumed Knowledge

A pre-requisite for this course is ENGG9741 Introduction to Nuclear Engineering or equivalent. It is essential that you are familiar with basic engineering principles and mathematical skills before this course is attempted. Prior understanding of nuclear fission is useful as is a grounding in chemistry and physics.

Following Courses

None.

Learning outcomes

After successful completion of this course, you should be able to:

1. Describe the fundamentals of Uranium mining, milling and conversions

2. Describe current and novel Uranium enrichment methods

3. Explain fuel fabrication techniques

4. Describe and explain fuel performance, burn-up and storage

5. Detail fuel reprocessing techniques

6. Describe the Thorium fuel cycle

7. Explain the classification of waste and its conditioning

8. Develop safety cases and assessments for repositories

9. Describe decommissioing options and their assessment

10. Describe the operation, advantages and disadvantages of proposed Gen IV reactor systems

This course is designed to provide the above learning outcomes which arise from targeted graduate capabilities listed in ***Appendix A***. The targeted graduate capabilities broadly

support the UNSW and Faculty of Engineering graduate capabilities (listed in ***Appendix B***). This course also addresses the Engineers Australia (National Accreditation Body) Stage I competency standard as outlined in ***Appendix C***.

Syllabus

1. Mining, milling and enrichment
2. Fuel fabrication
3. Nuclear reactors
4. Spent fuel
5. Reprocessing nuclear fuel
6. Predispoal
7. Near surface disposal
8. Site selection

Lecturers

Lou Vance: Lou is currently Chief Research Scientist at ANSTO and has 45 years of experience researching in the nuclear engineering sector. He has held a Leverhulme visiting professorship at the University of Cambridge, UK in 2008. He has research experience at institutions in the US, UK and Canada and for many years has been an active contributor to various international conferences on radioactive waste and its immobilisation.

Kapila Fernando: Dr Kapila Fernando is the Nuclear Services Strategic Planning and Implementation Manager at ANSTO. He is responsible for developing and maintaining waste management capabilities to support nuclear medicine production, reactor operations, and research at ANSTO. Kapila has 15 years of experience in process engineering and management, including 12 years in the Nuclear Industry. He completed his undergraduate degree in Chemical Engineering at UNSW in 1997. In 2007 he completed is PhD, also at UNSW. Kapila has a Diploma in Management and is qualified to provide training to small groups. He has provided training to students and professionals in radioactive waste classification, handling and processing. Kapila has research experience in ion exchange, cyanide management and cement chemistry, with 10 publications in these areas. He currently leads the ANSTO contribution to an ARC funded collaborative project investigating the water transmission through cementitious material.

Dan Gregg: Daniel Gregg is a research scientist with over 15 years of experience in Chemistry and Materials Science. Daniel completed his Bachelor of Chemistry with first class honours at Victoria University in Wellington, New Zealand, following which he worked for a year as a research chemist in industry. Daniel completed his PhD in Materials Chemistry within the Inorganic and Synthetic Materials Chemistry group at Trinity College Dublin. He then completed two postdoctoral positions in Ireland, conducting groundbreaking research in Materials Science including the development of a novel family of ‘soft’ materials with application as nano-wires. During this time Daniel was appointed a teaching fellow in the School of Chemistry where he enjoyed two years as course coordinator and lecturer for a second year Chemistry course. In 2009, Daniel relocated to Melbourne, Australia, where he worked for a year in industry, applying his experience to the development of new pharmaceutical drug candidates. Daniel then moved to Sydney in 2010 where he was appointed Research Scientist in the Institute of Materials Engineering at ANSTO. He currently leads the Nuclear Wasteforms Research Activity group where he focuses on the development of materials with utility in the nuclear fuel cycle and next generation nuclear energy systems. Daniel is a member of the International Scientific Advisory Committee, for the Materials Research Society Symposium on the Scientific Basis for Nuclear Waste

Management. Aside from his research, Daniel is an enthusiastic science communicator and a keen promoter of science to high school and university students.

Teaching Strategies

Delivery Mode

The teaching in this course aims at establishing a good fundamental understanding of the areas covered using:

- Formal face-to-face lectures, which provide you with a focus on the core analytical material in the course, together with qualitative, alternative explanations to aid your understanding;
- Tutorials, which allow for exercises in problem solving and allow time for you to resolve problems in understanding of lecture material;

Learning in this course

You are expected to attend all lectures, and tutorials in order to maximise learning. In addition to the lecture notes/video, you should read relevant sections of the recommended text. Reading additional texts will further enhance your learning experience. Group learning is also encouraged. UNSW *assumes* that self-directed study of this kind is undertaken in addition to attending face-to-face classes throughout the course.

Tutorial classes

You should attempt all of your problem sheet questions in advance of attending the tutorial classes. The importance of adequate preparation prior to each tutorial cannot be overemphasized, as the effectiveness and usefulness of the tutorial depends to a large extent on this preparation. Group learning is encouraged. Answers for these questions will be discussed during the tutorial class and the tutor will cover the more complex questions in the tutorial class. In addition, during the tutorial class, 1-2 new questions that are not in your notes may be provided by the tutor, for you to try in class. These questions and solutions may not be made available on the web, so it is worthwhile for you to attend your tutorial classes to gain maximum benefit from this course.

Assessment

The assessment scheme in this course reflects the intention to assess your learning progress through the semester. Ongoing assessment occurs through assignment checkpoints.

Assignments

The assignments allows self-directed study leading to the solution of partly structured problems, essays and presentations. Marks will be assigned according to how completely and correctly the assignments have been addressed, and the understanding of the course material demonstrated by the report.

Assignment deadlines will be confirmed during the semester.

Final Exam

The exam in this course is a standard closed-book 3 hour written examination. The examination tests analytical and critical thinking and general understanding of the course

material in a controlled fashion. Questions may be drawn from any aspect of the course, unless specifically indicated otherwise by the lecturer. Marks will be assigned according to the correctness of the responses. *Please note that you must pass the final exam in order to pass the course.*

Relationship of Assessment Methods to Learning Outcomes

	Learning outcomes									
Assessment	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Assignment 1	✓	✓	✓	✓						
Assignment 2					✓	✓				
Assignment 3							✓	✓	✓	✓
Final exam	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Course Resources

Textbooks

1. Basic Nuclear Engineering

Author: Foster and Wright

ISBN 978-0205078868

Publisher Allyn and Bacon

2. Nuclear Chemical Engineering

Author: Benedict, Pigford, Levi

ISBN 978-0070045316

Publisher McGraw-Hill

3. Comprehensive Nuclear Materials Book

Author: Rudy Konings

ISBN 978-0080560274

Year Published 2012

4. Nuclear Energy: Principles, practices and prospects

Author: David Bodansky

ISBN 978-0387207780

Year Published 2005

On-line resources

Moodle

As a part of the teaching component, Moodle will be used to disseminate teaching materials. Assessment marks will also be made available via Moodle: https://moodle.telt.unsw.edu.au/login/index.php.

Mailing list

Announcements concerning course information will be given in the lectures and/or on Moodle and/or via email (which will be sent to your student email address).

Other Matters

Academic Honesty and Plagiarism

Plagiarism is the unacknowledged use of other people's work, including the copying of assignment works and laboratory results from other students. Plagiarism is considered a form of academic misconduct, and the University has very strict rules that include some severe penalties. For UNSW policies, penalties and information to help you avoid plagiarism, see http://www.lc.unsw.edu.au/plagiarism. To find out if you understand plagiarism correctly, try this short quiz: https://student.unsw.edu.au/plagiarism-quiz.

Student Responsibilities and Conduct

Students are expected to be familiar with and adhere to all UNSW policies (see https://my.unsw.edu.au/student/atoz/ABC.html), and particular attention is drawn to the following:

Workload

Students need to actively manage their workload. It is typically expected that you will spend at least **ten to twelve hours per week** studying a 6 UoC course, from Week 1 until the final assessment, including both face-to-face classes and *independent, self-directed study*. In periods where you need to need to complete assignments or prepare for examinations, the workload may be greater. Over-commitment has been a common source of failure for many students. You should take the required workload into account when planning how to balance study with employment and other activities.

Attendance

Regular and punctual attendance at all classes is expected. UNSW regulations state that if students attend less than 80% of scheduled classes they may be refused final assessment.

General Conduct and Behaviour

Consideration and respect for the needs of your fellow students and teaching staff is an expectation. Conduct which unduly disrupts or interferes with a class is not acceptable and students may be asked to leave the class.

Work Health and Safety

UNSW policy requires each person to work safely and responsibly, in order to avoid personal injury and to protect the safety of others.

Special Consideration and Supplementary Examinations

You must submit all assignments and attend all examinations scheduled for your course. You should seek assistance early if you suffer illness or misadventure which affects your course progress. All applications for special consideration must be **lodged online through myUNSW within 3 working days of the assessment**, not to course or school staff. For more detail, consult https://my.unsw.edu.au/student/atoz/SpecialConsideration.html.

Continual Course Improvement

This course is under constant revision in order to improve the learning outcomes for all students. Please forward any feedback (positive or negative) on the course to the course convener or via the Course and Teaching Evaluation and Improvement Process. You can also provide feedback to ELSOC who will raise your concerns at student focus group meetings. As a result of previous feedback obtained for this course and in our efforts to

provide a rich and meaningful learning experience, we have continued to evaluate and modify our delivery and assessment methods.

Administrative Matters

On issues and procedures regarding such matters as special needs, equity and diversity, occupational health and safety, enrolment, rights, and general expectations of students, please refer to the School and UNSW policies:
http://www.engineering.unsw.edu.au/electrical-engineering/policies-and-procedures
https://my.unsw.edu.au/student/atoz/ABC.html

Appendix A: Targeted Graduate Capabilities

Electrical Engineering and Telecommunications programs are designed to address the following targeted capabilities which were developed by the school in conjunction with the requirements of professional and industry bodies:

- The ability to apply knowledge of basic science and fundamental technologies;
- The skills to communicate effectively, not only with engineers but also with the wider community;
- The capability to undertake challenging analysis and design problems and find optimal solutions;
- Expertise in decomposing a problem into its constituent parts, and in defining the scope of each part;
- A working knowledge of how to locate required information and use information resources to their maximum advantage;
- Proficiency in developing and implementing project plans, investigating alternative solutions, and critically evaluating differing strategies;
- An understanding of the social, cultural and global responsibilities of the professional engineer;
- The ability to work effectively as an individual or in a team;
- An understanding of professional and ethical responsibilities;
- The ability to engage in lifelong independent and reflective learning.

Appendix B: UNSW Graduate Capabilities

The course delivery methods and course content directly or indirectly addresses a number of core UNSW graduate capabilities, as follows:

- Developing scholars who have a deep understanding of their discipline, through lectures and solution of analytical problems in tutorials and assessed by assignments and written examinations.
- Developing rigorous analysis, critique, and reflection, and ability to apply knowledge and skills to solving problems. These will be achieved by the interactive checkpoint assignments and exams.
- Developing capable independent and collaborative enquiry, through a series of tutorials spanning the duration of the course.

Appendix C: Engineers Australia (EA) Professional Engineer Competency Standard

	Program Intended Learning Outcomes	
PE1: Knowledge and Skill Base	PE1.1 Comprehensive, theory-based understanding of underpinning fundamentals	✓
	PE1.2 Conceptual understanding of underpinning maths, analysis, statistics, computing	✓
	PE1.3 In-depth understanding of specialist bodies of knowledge	✓
	PE1.4 Discernment of knowledge development and research directions	
	PE1.5 Knowledge of engineering design practice	✓
	PE1.6 Understanding of scope, principles, norms, accountabilities of sustainable engineering practice	
PE2: Engineering Application Ability	PE2.1 Application of established engineering methods to complex problem solving	✓
	PE2.2 Fluent application of engineering techniques, tools and resources	✓
	PE2.3 Application of systematic engineering synthesis and design processes	✓
	PE2.4 Application of systematic approaches to the conduct and management of engineering projects	
PE3: Professional and Personal Attributes	PE3.1 Ethical conduct and professional accountability	
	PE3.2 Effective oral and written communication (professional and lay domains)	✓
	PE3.3 Creative, innovative and pro-active demeanour	✓
	PE3.4 Professional use and management of information	✓
	PE3.5 Orderly management of self, and professional conduct	
	PE3.6 Effective team membership and team leadership	