UNSW SYDNEY Australia's Global University

School of Mechanical and Manufacturing Engineering

Term 1, 2019
Course Outline

ENGG9741
Introduction to Nuclear Engineering

Course Staff

Convener: Dr Edward Obbard, Room 402G, Ainsworth Bld J17 e.obbard@unsw.edu.au
Lecturers: Prof. Robin Grimes FRS, Dr. Patrick Burr, Dr. Edward Obbard

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 ENGG9741 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 partially delivered in intensive mode with lectures every evening in week 3 (4th - 8th March) plus weekly lectures until weeks 2-8. The subject will be supported by video lectures, tutorial sheets and coursework assignments. A final revision tutorial will be provided on week 10.

	Day	Time	Week	Location
Lectures	Monday-Thursday 18th - 21st February	6 pm – 9 pm	1	RedC M032
Lectures	Thursday	6 pm – 9 pm	3-9	RedC M032
Revision Tutorial	Thursday	6 pm – 9 pm	10	RedC M032

Context and Aims

This course provides students with an introduction to the key elements of nuclear engineering. It is aimed at giving students the basic background knowledge, understanding and vocabulary to demonstrate what differentiates nuclear engineering from other engineering disciplines, and to understand later courses on the Nuclear Engineering MEngSci stream.

The course will introduce a variety of themes including nuclear fission, reactor physics and engineering, the historical context of nuclear engineering, the impact of radiation on matter, fuel fabrication and the fuel cycle, radioactive wastes and storage methods, reactor accidents, and nuclear safety and licensing.

The material will be presented by a team of leading researchers in nuclear engineering. The course material is advanced in nature, due to its interdisciplinary content, its delivery in an intensive mode, and the breadth of topics covered. Hence, students taking this course must have the skills of an Honours level graduate engineer such that they are capable of undertaking self-directed reading and learning in engineering systems, performing individual research, and have the required maths and engineering skills.

Indicative Lecture Schedule – lectures will include tutorial time

WEEK		**Summary of Lecture Program**
Week 1 **18th Feb.**		Intensive Lectures:
Monday	Prof Grimes	Introduction, history, radiation fundamentals
Tuesday	Prof Grimes	Reactor designs, nuclear operational systems
Wednesday	Prof Grimes	Nuclear fuel cycle
Thursday	Prof Grimes	Nuclear waste and waste management
Week 2		No lecture
Week 3	Patrick Burr	Nuclear Physics, Radiation damage in materials
Week 4	Patrick Burr	Reactor Physics
Week 5	Ed Obbard	Reactor Kinetics
Week 6	Ed & Patrick	**Student presentations due (28th March 2019)**
Week 7	Ed Obbard	Nuclear Safety + Davis Besse
Week 8	Patrick Burr	Reactor Accidents 1 - TMI, Fukushima
Week 9	Ed Obbard	Reactor Accidents 2 - Chernobyl **Essay Assignment Due (18th April 2019)**
Week 10	Ed Obbard	Revision tutorial

Assessment

Assignments (x2)	50%
Final Exam (2 hours)	50%

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

Course Details

Credits

This is a 6 UoC course and the expected workload is 30 hours per week during the intensive mode period with 13 hours per week after the completion of the intensive mode period.

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 ENGG9741 course convener.

Pre-requisites and Assumed Knowledge

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 grounding in chemistry and physics.

Following Courses

The course is a pre-requisite for ENGG/YENGG9742, ENGG9743 and ENGG9744.

Learning outcomes

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

1. Evaluate real-world questions relating to nuclear engineering, and
2. Deconstruct the issues that led to past reactor accidents.

To achieve these high-level learning outcomes the course will instruct you how to:

3. Describe basic reactor engineering concepts and designs, with their historical and societal context;
4. Correctly use the SI units and nomenclature of nuclear engineering;
5. Describe the effects of radiation on matter;
6. Discuss the nuclear fuel cycles and waste storage strategies;
7. Perform calculations related to nuclear reactions;
8. Examine the physics of fission reactors and calculate fundamental parameters.

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**.

The course provides several competency areas of the IAEA International Nuclear Management Academy guidelines for a masters in Management of Nuclear Technology. These are listed in **Appendix D**

Syllabus

Learning outcome	**Syllabus**
1	(Essay and presentations)
2	Nuclear licensing, Nuclear safety principles, Radiological safety, Reactor accidents: TMI, Chernobyl, Fukushima Daichi; Nuclear incidents: Davis Besse
3	Energy production, history of nuclear engineering, reactor designs, nuclear plant systems, Nuclear design principles
4	Radiation, radioactivity, dose, particles and their interactions
5	Alpha, beta, gamma and neutrons radiation, material defects, the origin of swelling and material degradation mechanisms
6	The fundamental fuel cycle technologies and fuel types.

7	Binding energy, the fission process and energy release and radiation absorption and shielding
8	Harnessing of energy, roles of the moderator and the coolant, neutron life cycle, criticality, reactor transients and reactor dynamics, reactivity control

External Lecturers

Prof Robin Grimes: Since 2002 Robin has been Professor of Materials Physics at Imperial College and in 2013 was appointed the Foreign and Commonwealth Office Chief Scientific Advisor, responsible for providing advice to the UK Foreign Secretary, Ministers and officials on science, technology and innovation. In April 2018 he was elected a Fellow of the Royal Society, the world's oldest independent scientific academy.

He joined the Materials Department at Imperial College in 1995. Robin has authored over 240 peer-reviewed publications. He is currently a member of the editorial boards for Journal of Materials Science and Journal of Nuclear Materials. In 2002 he was awarded the Rosenhain Medal and in 2010 the Griffith Medal of the IOM3, of which society he is a Fellow. From 2008 until 2013 he was Director of the Imperial Centre for Nuclear Engineering and from 2010 to 2013 he was Director of the Imperial College Rolls Royce University Technology Centre in Nuclear Engineering. He was appointed Principal Investigator of the Research Councils Nuclear Champion consortium in 2010. In 2011 he was Specialist Advisor to the House of Lords Select Committee on Science and Technology for their report on Nuclear Research and Development Capabilities.

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.

Assignments

The assignments allow 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.

An individual presentation assignment will be set in Week 3, for delivery in class on Thursday, 19 April, Week 7, and an essay assignment will be set in Week 3, for delivery Thursday 10 May, Week 7, by uploading it to the course Moodle page.

Final Exam

The exam in this course is a standard closed-book 2 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.

Course Resources

Textbooks

Basic Nuclear Engineering
Author: Foster and Wright
ISBN 978-0205078868
Publisher Allyn and Bacon

Nuclear Chemical Engineering Author: Benedict, Pigford, Levi
ISBN 978-0070045316
Publisher McGraw-Hill

Reactor Accidents Author: David Mosey
ISBN 978-1903077450
Publisher Progressive Media Markets

Lecture Video Sample

Samples of Professor Grimes Lectures can be viewed here: http://youtu.be/G3ol5o5726Y and http://youtu.be/LdYtVfHinX0

On-line resources

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 particularly given the intensive mode delivery of this class. It is typically expected that you will spend at **least ten to fifteen 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://student.unsw.edu.au/special-consideration.

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 myExperience 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.

The current course learning outcomes have been refined and restructured to conform to the more stringent requirements of the UNSW 3+ academic calendar. The syllabus and the learning outcomes have been aligned with the IAEA International Nuclear Management Academy competency areas for masters' courses in Management of Nuclear Technology. Increasing emphasis has been moved to the assignment exercises, over the previously greater emphasis on a much longer, 3 hour exam.

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://student.unsw.edu.au/guide.

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	✓

Appendix D: IAEA International Nuclear Management Academy (INMA) learning outcomes for masters' level course in Nuclear Technology Management

INMA Competency Area*	**INMA Competency Level**
1.1 Energy production, distribution and markets	**1**
1.8 Nuclear licensing, licensing basis and regulatory processes	**1**
2.1 Nuclear power plant and other facility design principles	**1**
2.2 Nuclear power plant/facility operational systems	**1**
2.6 Nuclear safety principles and analysis	**1**
2.7 Radiological safety and protection	**1**
2.8 Nuclear reactor physics and reactivity management	**1**
2.9 Nuclear fuel cycle technologies	**1**
3.17 Nuclear events and lessons learned	**1**
4.2 Ethics and values of a high standard	**1**

*Grosbois, J. de, F. Adachi, and H. Hirose. 2017. "International Nuclear Management Academy Master's Programmes in Nuclear Technology Management." IAEA.