MSc in Advanced Nuclear Engineering

2017 — 2018 Course Handbook

Director: Dr Ben Britton
Administrator: Mrs Raj Adcock

*Please read this booklet now and refer to it throughout the year*
1. Welcome from the Director

I’d like take a brief moment to warmly welcome you to the College, the Department and to our course in Advanced Nuclear Engineering. You are about to challenged, informed and intrigued by the world of Nuclear Engineering. This will reward you not only with a recognised and respected MSc degree, but also up to date insight and understanding of the complex world of Nuclear Engineering. At the end of this year you will have a firm grounding and be ready to launch yourself at the career of your dreams.

As this course is action packed and varied, you will only make the most of it by engaging with the programme and studying hard. It’s going to be a challenge, but at the other side you will have an experience that we hope you will treasure and value for years to come. To get you started we’ve prepared this handbook which I hope you’ll take the time to read through, and refer to throughout the course. The information in here has been collated to make your lives easier and make the course more enjoyable.

At Imperial College we are fascinated by all things Nuclear! We host the Centre for Nuclear Engineering which involves over 30 world leading academics bringing together a number of disciplines including mechanical, chemical and materials engineering, modelling and radio ecology to create one of the most comprehensive research and teaching groups dedicated to nuclear engineering and science. The College is also the only university in the UK to own a nuclear research reactor facility, originally designed by engineering faculty staff, located at the Silwood Park Campus in Surrey.

We actively engage the Nuclear Community in the UK and abroad, and as a student on this course you will see this first hand from our handpicked teaching staff and visiting lecturers. These lectures will give you a real world taste of life in industry, as well as enhancing your education and making sure that your course remains relevant to the ever changing political, economic and technical landscape.

An exciting and significant portion of your course is devoted to undertaking your own research project where you will explore the world around us with the level of scientific scrutiny demanded from the next generation of Nuclear Engineers. This is a fantastic opportunity where you will engage in real scientific problems, either within the Centre or with a world leading industrial collaborator. These projects have involved topics as diverse as reconciling French and Russian regulation requirements, to considering fluid flow within a running Nuclear reactor. While this project is certainly not a holiday, our students have managed to jet across the world to work with our collaborators in facilities in Australia and Sweden!

Right now I’m sure that you have many questions. The handbook is designed to inform and help you, please take the time now to have a read and families yourselves with its contents. It will act as your first point of call and had lots of really useful information in it. If you think we’ve missed something, please just ask and we’ll try to help you out.

I look forward to getting to know you all and I hope that you have an enjoyable and fulfilling year ahead.

With kindest regards,

[Signature]
2. People

Course Director

Dr Ben Britton
Room B303
020 7594 2624
b.britton@imperial.ac.uk

MSc Administrator

Mrs Raj Adcock
Room G.03a
020 7594 6728
raj.adcock@imperial.ac.uk

Other people in the Student Office (G03a) who can also assist you with any enquires:-

Mrs Fiona Thomson
Head of Student Administration
Tel: 020 7594 6726
E-mail: fiona.thomson@imperial.ac.uk

Miss Ela Calik
Student Office Administrator
Tel: 020 7594 6768
E-mail: e.calik@imperial.ac.uk

There are also a variety of other individuals you might need to contact within the Department of Materials:

- **Professor Eduardo Saiz Gutierrez**: Director of Postgraduate Studies: Office LM04.B
- **Professor Aron Walsh**: Postgraduate Tutor: Office 2.10
- **Dr Martyn McLachlan**: Director of Undergraduate Studies (DUGS): Office G03c
- **Dr Paul Franklyn**: Senior Undergraduate Tutor: Office G03c
3. Programme Specification

The course is full-time over 12 months and is both taught and research based. The overall course structure is divided into seven core modules, four compulsory short course modules and a research project.

The course will take a broad whole systems approach to the subject, covering all aspects from design and build, through operation to decommissioning and final disposal. [The ECTS assignment is given in brackets].

Core Modules:
(C1) Introduction to Nuclear Energy [6]

Options Modules (please note you will be assigned to all of the below and if you want to drop one then you will have to inform Mrs Raj Adcock):

(C2) Nuclear Chemical Engineering [6]
(C3) Nuclear Thermal Hydraulics [6]
(C4) Reactor Physics [6]
(C5) Nuclear Materials for Reactor Systems [6]
(C6) Nuclear Waste Management and Decommissioning [6]
(C7) Modelling for Nuclear Engineers [6]
(C8) Nuclear Safety Management [6]

In addition to the major core modules you will be expected to take four compulsory short course modules from below, typically these run over a period of one week and assessed at the end of that week by examination or coursework.

Core Short Courses:
(SC1) Radiation Protection [3]
(SC2) Fast Reactors and Nuclear Hydrogen Production [3]
(SC3) Nuclear Fusion [3]

Option Short Courses: (please note you will be assigned to both of the below and if you want to drop one then you will have to inform Mrs Raj Adcock):

(SC4) Nuclear Engineer in Industry [3]
(SC5) Nuclear Energy Policy [3]

Please note we advise ALL student to take 8 core modules and 5 short modules (this has proved to be in the students best interest in passing the degree overall).
Course Summary

Core lectures – 7/8 [42 ECTS; 41% of final grade]
Short courses – 4/5 [12 ECTS; 12% of final grade]
Other activities (journal club) [5 ECTS; 5% of final grade]
Project [31 ECTS; 42% of final grade]

MSc in Advanced Nuclear Engineering Total [90 ECTS]

A detailed description of the individual courses can be found towards the end of this handbook.

Term one:
In the first week you will all be given an induction, including a plagiarism awareness test, safety briefing and library training. The first week will also consist of the first core course: An Introduction to Nuclear Energy. From week two you will study the core subjects: Nuclear Materials for Reactor Systems, Modelling for Nuclear Engineers and Thermal Hydraulics. From week four you will study the short courses: Radiation Protection and Nuclear Fusion. Students will also take part in a journal club every two weeks to help them explore nuclear engineering and prepare for your research project, as well as developing transferable skills. You will also be presented with a wide variety of research project titles (November) and abstracts to consider. Towards the end of term in early December you may have the opportunity to visit a Reactor site.

Term Two:
In the second term you may take a short course in the first week which will be taught at Cambridge (extra costs may be required). From week two will an take the core subjects of Nuclear Waste Management and Decommissioning, Nuclear Safety Management, Reactor Physics and Nuclear Chemical Engineering. There are also two other short courses which are taught in this term and they are Engineer in Industry and Fast Reactors. As part of your research project, you will write a Literature Review in this term (more detail on page 26).

Term Three:
Examinations for the core modules will take place in the first two weeks of term. Thereafter the students will carry out their research project which finishes in beginning of September. Some research projects will be carried out in industry through an industrial placement. In this case the student will also be allocated an academic supervisor who will travel to meet the student at their place of work at several key stages of the project. At the end of the project students will be required to give a final presentation and produce a project thesis (more detail on page 26).

A table follows (on the next page) that gives an indication of your deadlines throughout the year. Coursework should always be handed in by 4pm into the coursework box (outside the office) or as stated in the deadline planner). Failure to hand in coursework on time will likely result in penalties for that component or element.
# Deadline Planner

<table>
<thead>
<tr>
<th>Term</th>
<th>Module</th>
<th>Assignment/Event</th>
<th>Due Date</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Autumn Term</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Introduction to Nuclear Engineering</td>
<td>Essay: Introduction (2500 words)</td>
<td>Mon 23 Oct 2017 4pm</td>
<td>On-line submission on Blackboard Learn</td>
</tr>
<tr>
<td></td>
<td>Modelling 1</td>
<td>Neutron Transport</td>
<td>Monday 13th Nov 2017 4pm</td>
<td>On-line submission on Blackboard Learn</td>
</tr>
<tr>
<td></td>
<td>Introduction to Nuclear Engineering</td>
<td>Test: 1.5 hrs</td>
<td>Thursday 16th Nov 2017 (10am, G05)</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Project</td>
<td>Choice of project</td>
<td>Tue 14th Nov 2017 4pm</td>
<td>On-line selection</td>
</tr>
<tr>
<td></td>
<td>Radiation Protection</td>
<td>Test</td>
<td>Tue 21st Nov 2017 2pm</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Modelling 2</td>
<td>Thermal Hydraulics</td>
<td>Monday 27th Nov 2017 4pm</td>
<td>On-line submission on Blackboard Learn</td>
</tr>
<tr>
<td></td>
<td>Modelling 3</td>
<td>Finite Element Modelling</td>
<td>Monday 11th Dec 2017 4pm</td>
<td>On-line submission on Blackboard Learn</td>
</tr>
<tr>
<td></td>
<td>Rector Centre Visit</td>
<td>Silwood Park</td>
<td>Wed 6th Dec 2017</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>MSc Cohort Christmas Party</td>
<td>In the department</td>
<td>Wed 13th Dec 2017 (G05)</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Spring Term</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Modelling 4</td>
<td>Radiation Hydraulics</td>
<td>Monday 15th Jan 2018 4pm</td>
<td>On-line submission on Blackboard Learn</td>
</tr>
<tr>
<td></td>
<td>Fusion</td>
<td>Tutorial Questions</td>
<td>Monday 15th Jan 2018 4pm</td>
<td>1 Hardcopy</td>
</tr>
<tr>
<td></td>
<td>Nuclear Energy Policy</td>
<td>Two Individual assignments</td>
<td>Thursday 8th Feb 2018 4pm</td>
<td>1 Hardcopy</td>
</tr>
<tr>
<td></td>
<td>Nuclear Engineer in Industry</td>
<td>Coursework (2500 words)</td>
<td>Thursday 22nd Feb 2018 4pm</td>
<td>1 Hardcopy</td>
</tr>
<tr>
<td></td>
<td>Project</td>
<td>Literature review report</td>
<td>Monday 5th March 2018 4pm</td>
<td>See Page 26 for more detail</td>
</tr>
<tr>
<td></td>
<td>Nuclear Safety Management</td>
<td>HAZOP coursework</td>
<td>Thursday 15th March 2018 4pm</td>
<td>1 Hardcopy</td>
</tr>
<tr>
<td>Term</td>
<td>Module</td>
<td>Assignment/Event</td>
<td>Due Date</td>
<td>Format</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------------------------------</td>
<td>------------------------------------</td>
<td>-------------------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td><strong>Summer</strong></td>
<td>Fast Reactors and Nuclear Hydrogen</td>
<td>Coursework – 1x Individual, 1x Group</td>
<td>Mon 30th April 2018 4pm</td>
<td>1 Hardcopy of each</td>
</tr>
<tr>
<td><strong>Term</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>EXAMS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nuclear Thermal Hydraulics</td>
<td></td>
<td>Thursday 3rd May 2018</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>MSE 414: Materials for Reactor Systems</td>
<td></td>
<td>Friday 4th May 2018</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Nuclear Reactor Physics</td>
<td></td>
<td>Thursday 10th May 2018</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Nuclear Chemical Engineering</td>
<td></td>
<td>Friday 11th May 2018</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>MSE 419: Nuclear Decommissioning and Waste Management</td>
<td></td>
<td>Tuesday 15th May 2018</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Nuclear Safety Management</td>
<td></td>
<td>Friday 18th May 2018</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Project (full time)</td>
<td></td>
<td>End of May-Mid Sept</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Project Thesis</td>
<td></td>
<td>Monday 3rd Sept 2018 4pm</td>
<td>See Page 26f or more detail</td>
</tr>
<tr>
<td></td>
<td>Project Final Presentation</td>
<td></td>
<td>Monday 17th Sept 2018 (All day)</td>
<td>Oral</td>
</tr>
<tr>
<td></td>
<td><strong>Exam Boards</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Internal Exam Board</td>
<td></td>
<td>Wed 26th Sept 2018</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>External Exam Board</td>
<td></td>
<td>Fri 28th Sept 2018</td>
<td>N/A</td>
</tr>
</tbody>
</table>
4. Start of the Year

4.1 Fresher’s week

The first week of term has a mixture of welcoming talks and for the MSc in Advanced Nuclear Engineering lectures also begin in this week. But you should have some free time in between lectures to join in with some of the events around the university.

4.2 Updating your contact information

Most times we will communicate with you using e-mail, but e-mail is not the perfect communication medium for all messages. It is therefore in your interest to keep us informed of alternative ways of contacting you.

If your phone number(s) and/or address change during the year, remember to update this information on your student e-service account as that is where we will look for your personal information.

4.3 Security passes

Student Cards

All students who need an ID card produced for them during Fresher’s week need to show a stamped registration document or a print out from registering online. ID office will then take a photo of you, and then you advised to either wait or collect it from us in the Student Office (during in the busy fresher’s week). Please note the ID card can take a few days to be produced. If you register online and upload a suitable photo, your IDs will be prepared in advance of you arriving. Student cards are automatically cancelled at the end of the course.

Security ID card office: Room 151 Sherfield Building
Opening hours: Monday to Friday:
08:30 to 10:30
12:00 to 14:00
15:45 to 16:45

4.4 Official documents

To avoid queues at the registry, you can request certificates from registry via on-line system (http://www3.imperial.ac.uk/studenthub/hubservices/documents). Please allow 3 working days for a council tax certificate and 5 working days for transcripts. Due to the extremely high volume of requests at registration time, they may take slightly longer. Registry cannot respond to every e-mail received, so if you do not receive a reply, this does not mean that they did not receive your request. All posted documents are sent out by second class post.

The following documents can be requested through the on-line system:

- Standard Statement
- Letters for Banks
- Council Tax Certificates
- Police Letter/Statement with Address
4.5 Effective communication in English

Being able to communicate effectively in English is crucial if you want to be successful at Imperial College. The emphasis in examinations and tests is on testing your mastery of the subject. However, expect to be marked down if you are not able to express yourself fluently in English. This is especially the case later in the MSc when more substantial written work such as the research thesis is assessed.

If you feel you would benefit from further lessons, there is a Centre for Academic English (CfAE) at Imperial which offers: “Free, dedicated support to international MSc students in science, engineering and medicine. Our aim is to help you with your language needs for your academic studies and to help you understand the expectations of postgraduate work. We offer:

- One-to-one tutorials with a dedicated tutor to support you with your course work and provide regular feedback
- Courses and workshops targeting specific academic language and skills”

If you wish to register for General Classes, Pronunciation Classes or Writing a Literature Review classes, you should contact the CfAE office to enquire at english@imperial.ac.uk or visit:

Centre for Academic English
Imperial College London
Room 309, Level 3, Sherfield Building

Classes start in mid-October and run until the end of the spring term, with some also running in the summer. Registration starts towards the end of the first week of term and more information on all these classes is available on MSc part of the CfAE website: http://www3.imperial.ac.uk/academic-english/msc

4.6 Widening your skills base: learning other languages

There are many excellent language courses in the College and below is a brief outline. More can be learnt from a visit to the Centre for Languages, Culture and Communication which is based on the third floor of the Sherfield Building or from http://www.imperial.ac.uk/centre-for-languages-culture-and-communication.

Students who would like to study a language can do so in their spare time if they wish. It is always useful to acquire fluency in another language and they are well taught here. The Centre for Languages, Culture and Communication is prepared to mark tests and exams in the normal way for 'non-credit' students so you could use the qualification on your CV if you wanted to. There is also a language laboratory where, once you have registered as a user, you may arrange to study in your spare time.
# 4.7 First Week Of Term Checklist

The first week can be a little daunting, so here’s a brief checklist to help you out:

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>College registration</td>
<td>If you have not yet registered on-line, you should do so as soon as possible at <a href="http://www.imperial.ac.uk/studenteservice">www.imperial.ac.uk/studenteservice</a>. It is not possible to issue you with your College ID card until you have registered.</td>
</tr>
<tr>
<td>Security/ ID Card</td>
<td>If you did not upload a photo of yourself before the first day of term when registering, you need to do this within the first week. You will then need to come into the Student Office on a daily basis to see if your card is ready for collection (during the first week only).</td>
</tr>
<tr>
<td>Start using your Imperial email account/ usernames and password</td>
<td>You should have been allocated a College username and password before arrival at the department. You can also find out your college email address on your Student e-service account. If you don’t yet have one, please come to the Student Office for further help.</td>
</tr>
<tr>
<td>Health &amp; Safety Guide</td>
<td>Read this document and familiarise yourself with the departments Health &amp; Safety procedures (<a href="http://www.imperial.ac.uk/engineering/departments/materials/hsdom">http://www.imperial.ac.uk/engineering/departments/materials/hsdom</a>). You will also be given a safety talk on your first day (details of which can be found in the fresher’s week timetable).</td>
</tr>
<tr>
<td>Imperial College Union Fresher’s Fair</td>
<td>Attend the Fair on Tuesday 3rd October between 11-4pm (when you haven’t got scheduled in the department). Stalls will be spread over the campus and a plan will be available on the Student Union website.</td>
</tr>
</tbody>
</table>
5. During the year

5.1 Timetable

The outline term timetable is available on **Blackboard Learn** (is may change throughout term). A week timetable is also posted on student notice boards in the department (on the lower ground floor) and also uploaded on to Blackboard Learn [https://bb.imperial.ac.uk/](https://bb.imperial.ac.uk/).

You will also be able to sign up to receive your own personalised timetable and you can find out more detail on how to set this up at [http://www.imperial.ac.uk/timetabling/](http://www.imperial.ac.uk/timetabling/).

5.2 Reading and responding to e-mails from the College

Please make sure you read your e-mail messages at least three times a week. If you receive an e-mail asking you to contact the Student Office or one of the lecturers, you should respond in a timely manner.

5.3 Attendance

The college has three terms: Autumn, Spring and Summer. You are expected to be available to attend activities in College during term time. Classes at Imperial College run between the hours of 9:00am and 6:00pm except on Wednesdays, when they finish at 12:00pm allowing students to take part in sports and other activities. It is essential that students attend College throughout the term. The term dates for this academic year:

<table>
<thead>
<tr>
<th>Term</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autumn Term</td>
<td>Monday 3rd October 2017 – Friday 15 December 2017</td>
</tr>
<tr>
<td>Spring Term</td>
<td>Monday 8th January 2018 – Friday 23rd March 2018</td>
</tr>
<tr>
<td>Summer Term</td>
<td>Monday 30th April 2018 - Friday 29th June 2018</td>
</tr>
</tbody>
</table>

(Please note as MSc students your summer term ends at the end of September)

You are expected to attend all lectures, tutorials and any practical classes; they are interdependent and together they form the basis for all the knowledge you will build on during your studies. We attach great importance to attendance by our students in the Department of Materials at your level of study. Therefore, if for any reason you are unable to come in to College, you must contact the Student Office at the start of the day by telephone or e-mail. You will also need to provide the Student Office with a medical certificate if you are away for more than seven consecutive days, or immediately if you are missing an in-course test or examination. **It is important to note that lectures are conducted on the last day of each term so you should not arrange travel until after that date and make sure to return for the start of term.**

5.4 Use of Departmental and College Facilities

For private study, students are allowed to be in the Department between the hours of 8:00am - 6:00pm only. If you need access out outside of these hours then you will have to request for permission and please note it is not normally given to students for safety reasons. You will need to use your swipe card to get in and out of the department outside the normal College hours, and will be asked to sign a book so that the security officer knows where you are in any emergency – if the fire brigade does not know you are in the building they will not come looking for you. Your swipe card is only effective at the RSM entrance and the Bessemer Building entrance. **No experimental work is allowed unless supervision arrangements for the student are agreed in advance.**
Computing rooms
You have access to the student computing room (G08 & G10), apart from the times when a class is being held there and can print your documents there. You should not misuse the departmental computers, nor use them to play games. Many students need the computers to complete coursework using software only available on these computers and selfish behaviour is not tolerated. You will find further computing facilities in the library. You can use lecture rooms as your study room when lectures/tutorials are not being given there but you must check with the Student Office first.

Post
Any post received for you, internal and external, will be placed in the pigeonholes which you can find in room G10 mezzanine floor and you should check as often as possible, and take anything addressed to you. The College address should only be used for course related post and not personal post. Please remember that there is not much room and accumulated post causes problems so it will only remain there for a limited time.

Photocopying and printing
Your swipe cards will have an amount of credit loaded on to it at the beginning of the term for use with the photocopiers in the computer rooms. You can use any printer/photocopier across the campus that is for student use with your swipe card. If you run out of credit then there is a top up machine in the central library. Please use the pre-loaded credit wisely as the department will not top it up for you.

The Library
The Imperial College Central Library and the Science Museum Library share a building at the heart of the South Kensington campus, near the Queen’s Lawn.

The Central Library has information on all subjects taught by the College, although it specialises in undergraduate, interdisciplinary and electronic material. There are a number of specialist collections, including a Core Text section, the Haldane Collection which contains humanities material, recreational reading, newspapers and magazines, and a music collection with tapes and CDs. The Science Museum Library specialises in the history of science and technology and the public understanding of science.

Access to the Central Library is 24hrs, except every Friday 20:00—Saturday 10:00 is closed. (please not this changes throughout term so you can find more detail at http://www.imperial.ac.uk/admin-services/library/use-the-library/our-libraries/central-library/)

5.5 Coursework
You will be asked to write various pieces of coursework marked by your project supervisor or lecturer/demonstrator. All coursework must be handed into the Student Office within a stipulated time. For all reports the deadline for submission of your work is 4pm of the stipulated deadline date.

Work submitted to the Student Office will be stamped with the date and time of receipt. Late receipt of work may be penalised. During ‘out of hours’ time, work can be ‘posted’ in the red letterbox (or the sliver slot below) outside door to G.03a and will be stamped as received on the following day. Where the deadline falls outside the term dates, it is replaced by the first Monday of the next term.

Please make sure that ALL coursework has the completed front cover sheet otherwise it cannot be accepted. This includes a declaration concerning plagiarism.

You may be given a specially prepared cover sheet by your supervisor or demonstrator but, if you are not, it is available on Blackboard Learn. You must adapt it in a manner appropriate to the particular piece of coursework concerned.
On this sheet please provide all of the information required in each section, with your full name in capitals, the subject title, the name of the person who will mark the work.

Late work:
Work submitted up to one (1) day after the assessment deadline (date and time) will be marked but capped at the pass mark. Work submitted more than one (1) day late will not be accepted as a valid attempt and mark of zero will be recorded.

<table>
<thead>
<tr>
<th>Days/Hours late</th>
<th>Penalty</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (up to 24 hours after the assessment deadline)</td>
<td>Capped at the pass mark (50%)</td>
</tr>
<tr>
<td>2 (more than 24 hours after the assessment deadline)</td>
<td>Mark of zero awarded</td>
</tr>
</tbody>
</table>

Marking:
Once the coursework has been marked and the mark recorded it will be returned to you via the Student Office. The actual mark is not indicated on the work but an indication of the mark is given by a grade according to the scheme set out below:

<table>
<thead>
<tr>
<th>A*</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;80%</td>
<td>84-70%</td>
<td>69-60%</td>
<td>59-50%</td>
<td>49-40%</td>
<td>39-0%</td>
</tr>
<tr>
<td>Distinction</td>
<td>Distinction</td>
<td>Merit</td>
<td>Pass</td>
<td>Fail</td>
<td>Fail</td>
</tr>
</tbody>
</table>

Please note that not handing coursework in on time and a lack of quality in your work are considered as strong indicators of a lack of academic progression (see below). Failure to complete coursework will seriously affect your chances of remaining on the course.

If due to illness or other serious circumstances you foresee that you will not be able to complete a piece of coursework by the deadline, you may be granted an extension provided you apply for it before the deadline. In case of illness, please discuss this when you contact the MSc administrator to inform them of your absence.

If you are experiencing other serious difficulties, you are advised to discuss this with the Course Director.

5.6 Plagiarism
You are reminded that all work submitted, as part of the requirements for an examination at Imperial College must be expressed in your own words and incorporate your own ideas and judgements.

Plagiarism, that is the presentation of the thoughts or words of another person as though they were your own, is not acceptable. Particular care should be taken in coursework, essays and reports written in your own time. Note that you are encouraged to read and criticise the work of others as much as possible. You are expected to incorporate this in your thinking and in your coursework and assessments but you must acknowledge and label your sources. Direct quotations from the published or unpublished work of others, from the Internet or any other source, must always be clearly identified as such. Remember that a series of short quotations from several different sources, if not clearly identified as such, constitutes plagiarism, as does an unacknowledged long quotation from a single source. Equally, if you summarise another person’s ideas, judgements, figures, diagrams or software, you must refer to that person in your text, and include the work referred to in your bibliography.
You should consult your Course Director if you are in any doubt about what is permissible. Direct and unacknowledged repetition of your own work, which has already been submitted for assessment, can constitute self-plagiarism.

You should be aware that you have a collective responsibility for the integrity of any group work submitted for assessment. The use of the work of another student, past or present, constitutes plagiarism. Where work is used without the consent of that student, it will normally be regarded as a major offence of plagiarism. **Failure to observe any of these rules may result in an allegation of cheating.**

Cases of suspected plagiarism will be dealt with under the College's Procedure for Dealing with Examination Offences and may result in a severe penalty being incurred by any student found guilty of plagiarism and could ultimately lead to you being told to leave the College.

We ask all markers to be attentive for plagiarism and randomly select coursework to process through a plagiarism detection website. Additionally some pieces of course work will be submitted through Blackboard Learn (TurnItIn) and this will automatically carry out a plagiarism check.

### 5.7 Satisfactory progression during the year

During the year the Course Director will receive information on your progress of completed course work or examination results at intervals throughout the year, and will discuss these with you (if necessary).

Students who are deemed not to progress satisfactorily can be excluded from examinations; a procedure of which any funding source would be kept informed. Ultimately, the student may be put on a six weeks’ notice, and if there is no improvement in performance this ultimately may result in withdrawal from the course.

### 5.8 Getting help

As a postgraduate university student you are deemed to be an adult capable of making your own decisions. The downside of this is that you are also responsible for your own decisions and that you will have to suffer the consequences for any poor choices you make.

Promising that you will work much harder next time round or pleading that you are a better student than the exam results show will not influence any decision by the Board of Examiners. However, part of being a mature student is recognising that sometimes you need help or advice. To help you make that transition towards being able to manage your own life a range of people are available for you to seek help or advice from.

The reason for seeking help sooner rather than later is quite simple, evidence of circumstances, which have affected your performance, are considered when making decisions about your progression. But with so many students with difficulties in their life who have gone before you and have performed exceptionally despite their difficulties, it is rare for a case to be strong enough to alter the decision.

You should therefore assume that as a rule, whatever your circumstances, once a test or exam has been taken, the result will stand. Before the test or examination we can advise you what the regulations allow us to do for you or where you can find the most effective help.

Nobody can monitor how well you are doing better than you. **If you are worried, seek help immediately.**
Your Course Director/Tutor

Your Course Director also acts as course tutor and your Course Director/tutor will remain the same person throughout your time here at the Department. Your Course Director will therefore get to know you better than most other members of staff and is best placed to advise you on study skills, progression, and professional development. You can talk to your Course Director in confidence on any matter that is affecting you and indeed it is not a good idea to pretend everything is going ok when it is not. Your Course Director can speak on your behalf at the meeting of the Examiners should that be required, but can only act on information you have made available.

In addition to support provided by the Course Director, you may wish to approach the Post Graduate Tutor. As courses, teaching and research are shared between the Post Graduate and Under Graduate areas of the Department, directions of the course are discussed both with the Director of Post Graduate Studies (DPS) and the Director of Undergraduate Studies (DUGS) as appropriate.

In addition of this you will also have two Class Representatives who you can raise any concerns to (more information on page 22).

The Materials Student Office team

Emails: queries etc.

Please note that when emailing the Student Office we aim to respond to your queries in a timely manner (within in 3 working days). However this is not always possible in busy periods of the term so it can take longer, please keep this in mind. **Do not resend emails or come into the office to ask us to respond to your email.** We will always try our best to respond to urgent queries as soon as possible and other emails when we can.

Letter request

Please note you need to give the MSc Administrator at least a weeks notice (more if possible). At busy times in the term it can take up to 2 weeks for request like this to be done. So ensure you keep this in mind and ensure you provide all the information you need in the letter by email.

If you require a reference Letter or a signature of the Course Director, please could you email and discuss this in advance of your need with them directly.

Student Office Hours

The Student Office is in G.03a and is open to students from:

Monday 8:45am-4:15pm
Tuesday 8:45am-4:15pm
Wednesday 8:45am-2:00pm
Thursday 8:45am-4:15pm
Friday 8:45am-4:15pm

There will almost always be someone there to help you if you need it and your first point of contact is the MSc Administrator, Mrs Raj Adcock (or the other staff when the MSc Administrator is not there). However there may be times when the office is not open during the term due to staff meetings etc. so please keep this in mind.
Support available through other hosting departments:-

Department: Mechanical Engineering
Module: Nuclear Reactor Physics and Nuclear Thermal Hydraulics

If you have selected the module Nuclear Reactor Physics or Nuclear Thermal Hydraulics the hosting department is Mechanical Engineering. They are in charge of all the matters to do with this module option e.g. module information, lectures, timetable etc.

For any issues or queries about these modules your first point of contact should be:

Senior UG Administrator:
Josie Ann Howard
UG Office, 553, 5th Floor, City and Guilds Building,
E-mail j.howard@imperial.ac.uk

Department: Chemical Engineering
Module: Nuclear Chemical Engineering

If you have selected the module Nuclear Chemical Engineering the hosting department is Chemical Engineering. They are in charge of all the matters to do with this module option e.g. module information, lectures, timetable etc.

For any issues or queries about these modules your first point of contact should be:

UG Administrator:
Margaret Gee
ACE Extension, 208, 2nd Floor, ACE Extension
margaret.gee@imperial.ac.uk

Support offered outside the Department

The College Tutors:
The college tutors can provide support on a range of issues both academic and pastoral care. Information can be found at:
http://www.imperial.ac.uk/student-space/here-for-you/college-tutors-and-departmental-support/

The Student Counselling Service:
Level 4, Sherfield Building , Room 449
Telephone: 0207594 9637 Email: counselling@imperial.ac.uk
http://www3.imperial.ac.uk/counselling

International Office:
Room 301, 3rd Floor, Sherfield Building,
Telephone: 020 7594 8040 Email: international@imperial.ac.uk
http://www.imperial.ac.uk/study/international-students/visas-and-immigration/
The Health Centre:
Imperial College Health Centre, 40 Princes Gardens, London SW7 1LY
Telephone number: 020 7584 6301 or 020 7594 9375/6
http://www.imperialcollegehealthcentre.co.uk/

National Health Dental Service:
Prince’s Garden, South Kensington Campus, Telephone: 020 7589 6623
New patients are welcome. You can register Monday to Friday 09:00—17:00.

Disabilities Office:
Level 5, Sherfield Building,
Telephone: 020 759 49755 Email: disabilities@imperial.ac.uk
Departmental Liaison: Dr Paul Franklyn

Imperial College Union Advice service:
The Advice Centre is located in the Union Offices in the Beit Building (telephone +44 20 7594 8060). They provide free and confidential advice on the following areas:
- Academic appeals
- Housing
- Employment
- International student issues
- Consumer rights
- Complaints and
- Personal safety

The Advice Service has a comprehensive range of free leaflets on a wide variety of issues and offers a referral system to organisations in the community that students may use. The Advice service operates on an appointment and drop-in basis. You can also e-mail advice@imperial.ac.uk or telephone between 09:30 – 17:00 hours, Monday to Friday.

College chaplains:
The Chaplaincy Centre, Beit Quadrangle http://www.imperial.ac.uk/chaplaincy
Tel: +44 (0)20 7594 9600 Email: chaplaincy@imperial.ac.uk

In an emergency you can call the Nightline, 020 7631 0101 for confidential listening and practical information, every night of term, from 6pm - 8am. It is also now possible to contact Nightline via e-mail: listening@london-nightline.org.uk

Imperial College Careers service:
The Careers Service provides professional, impartial and confidential advice to all Imperial College students in the areas of further study, employment and training. Appointments are available to book through the website http://www.imperial.ac.uk/careers/services/ or call +44 (0)20 7594 8024, appointments are subject to availability.

Careers advice is also available from your Departmental Careers Adviser, Dr Mark Wenman, m.wenman@imperial.ac.uk. Please note you will need to make an appointment or effectively you can talk to your Course director.
Careers website - An up to date site containing information on graduate recruitment events, vacancies, vacation work, library books, links to employers and professional associations www.imperial.ac.uk/careers/services/events/.

Vacancies - JobsLive is the Careers Service's online system for booking events and appointments, searching for jobs and employers.

Current Imperial students are automatically registered with JobsLive, just use your Imperial username/ password to login, https://imperial.targetconnect.net/home.html.

5.9 Making a technical presentation

A technical presentation, like report writing, is a 'personal transferable skill' and is required of all scientists and engineers. As with most activities it can be improved with practice, and by following a few simple guidelines.

- The aim of a presentation is that the speaker imparts knowledge to the audience.
- The objective is for the audience to acquire knowledge and information they have not previously possessed.

Success in reaching the objectives will only be achieved if the speaker gives some thought and careful preparation to the presentation. This applies equally to a presentation lasting for say 10 minutes and to one of half an hour or more. The following guidelines should help you to make your presentation a success.

1. Content of the talk

Structure

Decide on the main issues. No speaker should attempt to cover the whole subject area, but rather to enlighten the audience on those points or features of the investigation you regard as being of most significance, value or interest. This will require that you assess the information which you have available critically, selecting that which you feel is most appropriate, and presenting it in a logical and understandable way.

At the start of the presentation you should outline the structure of your talk (a slide or overhead is a simple way of doing this) so that your audience will know the scope of the presentation and how the talk has been organised.

Background

Few talks will be successful without setting the scene. This might include the reasons for doing the work, any underlying scientific principles involved and a summary of the previous work conducted in this field. Pitch the introduction of the talk at the general level of knowledge of the audience.

What have you done?

If the work has involved experimental or modelling activities then this is where you would give the details. These should be presented concisely, giving just enough detail for your audience to appreciate how the data has been obtained.
Results
Here you will be presenting the information you have acquired. The data needs to be critically assessed and presented one step at a time in a logical manner.

What does it all mean?
Having presented your findings you should now provide a discussion of the data. Highlight what you regard as the most significant findings, there may be previous work with which you can compare your results.

Conclusions and summary
This section allows you to summarise concisely what you consider to be the most important findings.

The future
Many investigations will continue or the problems remain unresolved. If you have ideas and plans for further work then this is where they should be summarised.

5.10 Security and safety

Security
We have been asked by the College Security to point out to all students the importance of looking after your own property. It is an unfortunate fact that the petty theft rate is relatively high in all Universities and Colleges and while we do our best to ensure that it is kept to a minimum it is up to you to make sure that you are constantly vigilant.

- Do not leave bags unattended in corridors or anywhere else.
- Do not bring valuable objects into College without good reason: if you must, then keep them safe, preferably by keeping them with you.
- If you have access to rooms, which are normally kept locked, then do lock the door when you leave.

Safety
Please familiarise yourself with the Departmental Safety Policy and important useful safety personnel in the department which you can find on our website: http://www.imperial.ac.uk/engineering/departments/materials/hsdom/.

Departmental Safety Officer:
Dr Peter Petrov
Room B333 (LCN Corridor)
Contact Tel: 48156 or 50321
Email: p.petrov@imperial.ac.uk
5.11 Tell us what you think

You should not be afraid to ask questions about the lectures or indeed to suggest ways in which the lectures could work better for you. However, keep in mind that what would be optimal for you might not be for your fellow students and that each lecturer will try to find a balance for the class which also suits their style of teaching.

PG POLE – You will be invited to take part in PG POLE (Post Graduate Student Online Evaluation) in both the autumn and spring terms. It is important to the course /department that you participate as this is our principal way of gathering feedback from you about the course and the teaching.

Year representatives and the staff-student committee

At the start of the academic year, you will elect two Class Representatives. They act as the focal point for Departmental – Student Cohort interactions, sitting on the Department’s Student Student-Staff Committee and the Post Graduate Committee and providing representation (together with other Class Representatives) across the college, typically via the Imperial College Student Union. The Departmental Teaching Committee is normally scheduled shortly after these meetings to ensure that we can discuss how, as a Department, we can best address any concerns raised.

Each cohort will select students to represent them on the committee. Help your representatives to be effective by telling them what you think so that they can report back to us what the year as a whole is thinking at the staff-student committee.

6. Examinations

6.1 Preparing yourself

Preparing for exams starts on the first day of the first term. The format of University exams is such that you are unlikely to achieve results which reflect your potential fully if you only start studying close to the exams. There is only limited time available for revision and you must make sure that you can use that time to re-visit the material to remind you of the understanding you have acquired during the year. You will need to do the following:

- You will need all the lecture notes, class-work and worked solutions.
- You have looked at past papers – papers for the last 2 years are available on Blackboard Learn (where possible).
- You know what is going to be covered in the exam and the format of the examination paper.
- You know when and where the exam will take place.
- You are familiar with the use of the examination calculator. In all college examinations you will have to use the standard calculators supplied by the Department because you will not be allowed to use your own calculator. If you want to get accustomed to using this calculator before the exams you can arrange to borrow one from the Student Office.
- If you are registered dyslexic you should inform the Student Office as soon after registration as possible. It is possible to receive certain concessions in examinations, e.g. extra time, use of a spellchecker, but this is only possible when a student has registered with the Disabilities Office.
6.2 Just before the start of the exam

- Be in plenty of time for the exam, allowing for public transport etc. if necessary. You will be allowed into the exam room about ten minutes before the start of the exam. All personal belongings should be left at the front of the classroom.

- Be absolutely sure you have NO revision notes on your person when you take your seat. You risk disqualification if you forget this. There will be a seating plan with your candidate number on a desk in the exam room: find it and sit down in the appropriate seat. Do not look at the exam paper until you are told to do so by the administrator/invigilator.

- If you are too unwell to sit an exam you must consult a doctor on the day of the exam and obtain a letter from him/her stating that you were not well enough to sit an exam. It is essential that you inform the Student Office immediately and before the start of the exam.

6.3 During the exam

- At the start of the exam there will be a number of members of staff present. You will be told when you can start the paper and when you must stop writing.

- Staff will act as invigilators and will supervise the exam and patrol the examination room from time to time. Several different members of staff may share the invigilation duties during the exam.

- Read the instructions for the exam carefully and make sure you are aware of what you are required to do. If any errors are found in the exam paper the invigilator will inform you and corrections will be written on the whiteboard at the front of the class.

- You may leave the exam permanently at any time from thirty minutes after the start of the exam. You may not leave the exam in the last thirty minutes of the allotted time as this may cause a disturbance to other candidates. Once you have left the exam room you will not be able to go back (but see below).

- On the front of every answer book write your candidate number clearly. Never write your name on your answer books.

- If you have a query or require extra answer books raise your hand and the invigilator will come to you. NEVER leave your seat without permission or being escorted.

- You may leave the lecture theatre under supervision to use the toilet. Again you should inform the invigilator by raising your hand and he/she will then escort you to the nearest toilet.

- If you have attempted more questions than is required, delete clearly the questions you do not wish to be marked. You should not hand in any rough work. On the front of the first answer booklet write the numbers of the questions that you have attempted.

- Do not leave your seat until you have been told that you may do so even after the exam has finished.

6.4 Good examination technique

- Always read the exam questions carefully - it is time very well spent. It is amazing how often the candidate provides an answer, which is not what the question requires. The most common reason is that the candidate starts reading the question and finds it similar to a class work problem previously attempted. The candidate then skims quickly over the rest of the question and starts providing the answer for the class work problem with which he/she is familiar, although the exam question requires a significantly different answer.
• Always attempt the full number of questions required. For example, if the exam requires you to answer three questions it is better to attempt three questions than to spend all your time attempting to answer two questions perfectly. This is because, in general, it is relatively easy to obtain the first 55-65% of the marks for a question but it becomes increasingly more difficult to obtain the remaining marks.

• The questions asked in an exam are straightforward - there are no tricks! Remember the questions are set so that a student should be able to gain full marks in the limited time available for each question in the exam. From the time available for each question you should be able to estimate the correct amount of time to spend on each part of that question. This in turn will guide you concerning the amount of detail expected in, for example, the answer to a descriptive part or a derivation.

• If you finish the questions in less than the time allocated, spend the remaining time checking your work. Check the arithmetic and, in the case of more qualitative questions, think about your lecture notes/lab class reports again - you might come up with more relevant facts, which escaped your memory during your first attempt at the question.

• If you make an error in the arithmetic/maths in your answer, don’t panic. You will lose a few marks for the error but most of the marks are given for the method.

6.5 After the exam

After the exam the exam scripts are marked by the examiners and then second marked by another member of staff. This process can take several weeks so you will not receive any feedback immediately. Exam results are not official until they have been considered by the External Examiners (a chosen academic from another university or suitably qualified person from a relevant industrial background) and there has been an examiners meeting (this takes place at the end of the course usually end of September.

This is also true for coursework. After this has taken place you can download all your marks from your Student E-service (exams and coursework) and until that time we are not able to disclose any marks to you. What we are able to do is to give an indication of performance - with coursework this is given by a grade (see earlier section on coursework) and with examination results by an equivalent degree classification (see earlier section on assessment).

In the unlikely event that you are unable to sit an exam through serious medical reasons you may be able to take the re-sit the exam (if this is agreed by the exam board). Please note for MSc courses this is the following summer, you are not permitted to sit the exam any other time.

Re-sits:

If you find out that you have to take some re-sits (after the exam board at the end of September) in order to pass the degree program. Please note the Departmental Policy on re-sitting exams is that they are ONLY allowed to be taken in the department we do not allow them to take place aboard. You have to re-sit your exams within two years of your study here, failure to do this will result in you being withdrawn from the course.

Marking Schemes for postgraduate taught programmes:

The pass mark for all postgraduate taught course modules is 50%. Students must pass all elements in order to be awarded a degree.
7. Departmental policy of failures

7.1 General policy
The Materials Department does not offer students the opportunity to repeat if you are deemed to have failed, unless medical or personal problems are known to have had a severely adverse effect on their studies during the relevant academic year. Before the examination period all students are invited to provide the Student Office with any relevant information concerning mitigating circumstances.

7.2 Marginal exam failures
Students who fail examinations by a small margin may be allowed to pass at the discretion of the exam board. No failures below 40% however, can be considered.

7.3 Other examination failures
Students who fail examinations by a significant margin are required to withdraw from the College, but with the right to return to take all the examinations again the following year, provided always that they have achieved a satisfactory mark in coursework (>50% when all coursework is considered together).

7.4 Coursework failures
There is a requirement that our students achieve a sufficiently high overall mark in coursework in order to pass the MSc. All students are made well aware of (i) the importance of coursework and the need to achieve an aggregate mark of 50% of the total coursework mark; and (ii) the individual marks carried by coursework in each subject. They are encouraged to monitor their own progress as each piece of graded work marks are uploaded on Blackboard Learn.

There are deadlines for the submission of each piece of coursework, with penalties for late submission as stated before, but if any student cannot carry out practical work at a scheduled time or submit a report by a particular deadline because of a medical or personal problem, then alternative arrangements can be made if the Student Office is informed.

Given the above, and in the absence of any convincing extenuating circumstances, the Materials Department does not offer students who have failed coursework to resubmit. They are required to withdraw from the College permanently.

7.5 Overall performance
In addition to these criteria, students also have to achieve a sufficiently high overall mark for the year to pass (combined exams, coursework and project). These three components are known as the elements of the MSc. For any Masters course you must achieve at least 50% in each element of the MSc. Likewise to achieve a Merit you must achieve 60% in each element and for a Distinction a mark of 70% for each element.
8. Research Project

It is also your responsibility to try to find a placement for your project should you wish to do this in industry. **Miss Emma Warriss (Nuclear placement co-ordinator room B303)** can help you contact people in industry but it is ultimately up to you to help yourself.

After the summer exams students will start their research projects full time either here at Imperial College or in industry or a combination of both. If you are studying outside of the College it is your responsibility to find accommodation and arrange travel to your place of work. You should usually be paid by your employer a reasonable salary to allow you to do this.

The project nominally starts around the beginning of January. At this time you will start a literature report, whilst still at College, to prepare you for your project work in the summer. Therefore ideally you need to have found a placement by this time. The project is assessed by an initial by your producing a Literature Review report (on the research and data you have found ) and then by a written Thesis (Research Project) of a maximum of 12,500 words, which is usually handed at the start of September. A final presentation will then take place usually in the last week of September.

**Literature Review**

As part of their research project, you will write a Literature Review in advance of the project starting. The Literature Review will be a maximum of 5,000 words. You will need to outline the motivation for your project and outline the most important prior research in the field to date. This will be assessed by your project supervisor and a second assessor. For the Literature Review you will be required to submit one copy through Blackboard Learn for marking (plus additional electronic copy submitted through TurnItIn for a Plagiarism check). Both copies must include a signed coversheet (which you can find on Blackboard Learn) and submitted by 4pm on Monday 5th March 2018.

It will constitute 20% of the research project (75% for the final thesis, 5% for the final presentation – in total this is 41% of the degree). The final thesis may contain a brief updated literature review if appropriate, and the original literature review shall be appended as an appendix. If you choose to undertake a project abroad or at a company (e.g. ANSTO) you should to discuss writing an appropriate Literature Review with the Course Director and you will have to factor this in writing up the final thesis.

**Thesis (Research Project)**

The thesis should of course answer some form of research question and should not simply be a record of your time at the workplace where it was carried out. It should ideally contain a literature review and background information on the area of study to give the reader an overview of the field of research and a review of what has been done before. The introduction should finish by stating what needs to be done and how you plan to do that through your research project. This should be followed by a methods/experimental procedure section. This section should detail the methods you have used to collect the data and any methods you have used to analyse it e.g. a brief explanation of a statistical method. The idea of this section is to allow a reader to recreate your work if they wished to do so. It should be kept as brief as possible however, it is acceptable to simply refer to a standard for the procedure, if one were to exist.

Next should come the results or if appropriate the results and discussion combined. If it is a results only section this should describe the Tables and Figures presented in the work factually i.e. the discussion section is where you should comment on the results and try to interpret them.
The discussion section allows you to freely make comments on what you think is happening and why but should be backed up by reference to your results.

The final main section is the conclusions and these should be factual statements about what the main findings of the work were. Some people even list these as bullet points. The last section should be a future work section. This section should state the direction in which you believe further work needs to be conducted to improve upon the understanding gained in your work.

After the future work section should come a list of the references that you have used. Again a standard referencing format should be chosen and adhered to. The most common system is called the Vancouver system or author-number system. The other common referencing system is the Harvard system or author-date system. Information on how to use them properly can easily be obtained using internet searches for the names of the systems. There is also some brief help in section 4.5 of this document. Typically an MSc thesis may contain between 40-80 references but there are no hard and fast rules on this and it depends largely on the content of the work. The thesis should be submitted in both a bound printed volume and electronically so it can pass through a plagiarism checker.

Please ensure you allow enough time to print and bind your thesis. Many students do this on the deadline day only to find that the printer has no ink, there is not enough paper or they cannot get it bound in time. None of these will be considered as valid mitigating circumstances for a late submittal. Extra information, detailed methods, extended data (which is not needed for the reader to understand the work but you wish to include for completeness) can all be attached as an appendix.

Few other things to remember when submitting your thesis:-

- Need 1 hard copy (bound)
- Electronic copy submitted through TurnItIn (Plagiarism Check)
- Electronic copy submitted through Blackboard Learn (for marking)
- Thesis Declaration (find this on Blackboard Learn) for your plagiarism declaration
- Normal 12 size font
- Style of font is Calibri or Arial (or similar)
- Should have a word count on the front of the report
- Word count up to 12,500 (a good thesis is concise)
- A4 size

Deadline for your Thesis is Monday 3rd September 2018 4pm.

*The updated literature review will not be marked as it is part of the assessment in the Spring term. Make any necessary changes to ensure that it is relevant to your results - it is entirely possible that your research plan has evolved over the time of your project.

However please include it in the report appendix, (as it is a requirement, even if you have not updated it).
9. Graduate School

The Imperial College Graduate School is in-place to support the learning experience of postgraduate studies on taught and research degrees. As soon as you begin your postgraduate studies at Imperial College you automatically become a member of the Graduate School. Membership means you become part of a wider community, broadening and enriching your academic experience. Their remit includes both quality assurance and the provision of the award-winning and internationally renowned programme of transferable skills training.

As part of the Graduate School, the Postgraduate Development Unit (PDU) ensures that the transferable skills programme is educationally relevant, develops new initiatives and ensures its quality and relevance. All activity undertaken by the PDU is underpinned by an educational research programme, specifically focused on the postgraduate student experience.

The Graduate School is also responsible for the regular review of Master's Level Courses and Research programmes, ensuring best practice across the College.

They also organise a number of special events throughout the year which are designed to bring all postgraduate students together in an informal setting and to foster interdisciplinary discussion – as an MSc student we encourage you to participate in such events and to make use of the many opportunities Graduate School membership offers.

Full information is at: [http://www3.imperial.ac.uk/graduateschools](http://www3.imperial.ac.uk/graduateschools) (please see Appendix B for a welcome letter form the Graduate School)

9.1 MasterClass Programme

Students on Master's level programmes are encouraged to develop transferable skills as an important part of their postgraduate education here at Imperial, and most Master's students will receive transferable skills training as an integral part of their Master's programme.

The Graduate School has developed a MasterClass programme specifically for Master's level students. [http://www.imperial.ac.uk/study/pg/graduate-school/professional-skills/](http://www.imperial.ac.uk/study/pg/graduate-school/professional-skills/)

These sessions have been designed particularly to give you an introduction to each of the topics.

- Academic Writing
- Developing your career through Networking
- Informational Posters - Layout & Design
- Interpersonal Skills
- Interview Skills
- Job search with a difference
- Negotiating Skills
- Note Taking and Efficient Reading
- Preparing and writing a literature review
- Research Skills and Reference Management
- Stress Management
9.2 Plagiarism Awareness

http://www.imperial.ac.uk/study/pg/graduate-school/professional-skills/masters/online/

The College has developed a new online course entitled Plagiarism Awareness. The course is designed to provide you with guidance and information about proper citation and attribution in writing. After completing the course you should be able to explain what plagiarism is, be familiar with the concept of academic integrity, be able to explain how to avoid plagiarism and learn what the College’s policy concerning plagiarism is.

There is no limit to the amount of times you can take the course – it can be accessed anytime, so there will always be an opportunity to refresh your understanding. If at the end of the course, you feel that you might require additional guidance, directions will be given to alternative sources of information and advice.

All Master’s students will be required to complete a Master's version of the online plagiarism awareness course. Master's programme organisers should decide the most appropriate time for their students to complete the course. Master’s students who progress to a doctorate at the College will not be expected to take the doctoral version of the course but will be reminded about the course 6 months prior to submission of their thesis.

All students can self-enrol onto the appropriate course, by logging in to Blackboard in the usual way and following these instructions from the ‘Masters Self-Enrolment Guide’ (at the bottom of the website) http://www.imperial.ac.uk/study/pg/graduate-school/professional-skills/masters/online/
Appendix A – Course Syllabi

Core Modules:
(C1) Introduction to Nuclear Energy [6]

Options Modules
(C2) Nuclear Chemical Engineering [6]
(C3) Nuclear Thermal Hydraulics [6]
(C4) Reactor Physics [6]
(C5) Nuclear Materials for Reactor Systems [6]
(C6) Nuclear Waste Management and Decommissioning [6]
(C7) Modelling for Nuclear Engineers [6]
(C8) Nuclear Safety Management [6]

Core Short Courses:
(SC1) Radiation Protection [3]
(SC2) Fast Reactors and Nuclear Hydrogen Production [3]
(SC3) Nuclear Fusion [3]

Option Short Courses:
(SC4) Nuclear Engineer in Industry [3]
(SC5) Nuclear Energy Policy [3]

Please note we advise ALL student to take 8 core modules and 5 short modules (this has proved to be in the students best interest in passing the degree overall).
C1—Introduction to Nuclear Energy

Course Co-ordinator: Dr Mark Wenman
Status: MSc Nuclear compulsory option
Prerequisites: None

Aims
The course is aimed at giving students the basic background knowledge, understanding and vocabulary to understand later lectures on the MSc in Nuclear Engineering course and to show what differentiates nuclear engineering from other disciplines.

Learning outcomes
Discuss and explain technical, social, economic and environmental issues related to nuclear energy.

Syllabus

Units and nomenclature. Radiation, radioactivity, particles and their interactions. Radioactive decay.

Nuclear fission. Binding energy, liquid drop model, fission process and energy release, fission and actinide yields.


Historical context of nuclear power. Discovery of radioactivity, splitting atoms, artificial radioactivity and the possibility of fission as an energy source. The first reactors – Chicago Pile reactor, EBR 1, Caldewr Hall and Shipping port. Timeline and definition of Gen I-IV reactors.

Radiation effects on matter. Basics of penetration depth of different radiation types: alpha, beta, gamma and neutrons. Defects in material, origin of swelling and the concept of material degradation mechanisms.

Reactor engineering. Laminar versus turbulent flow, nucleate boiling, departure from nucleate boiling, heating along a fuel channel, hot channel factor and reactor design.

Fuel cycle and fabrication. Uranium ore resources, mining and yellow cake, uranium enrichment, fuel pellet production. Typical fuel pin design, fuel burn-up, fission products, gas swelling, fuel microstructures. Use of U and Pu in fuel. Closed cycle and recovery, MOX fuel. Defects in material, origin of swelling and the concept of material degradation mechanisms.


Nuclear reactor safety/ Nuclear safety culture. General intro to nuclear safety management, concept of risk, consequences, ALARP. Probabilistic and deterministic risk assessment, defence in depth, redundancy and diversity. Role of the regulator.

Reactor accidents. Windscale (Wigner energy), TMI (loss of coolant, decay heat + training versus education), Chernobyl (xenon poisoning), Fukushima and the Davis-Besse incident.
UK nuclear policy and socio-economic aspects of nuclear power. Introduction to UK energy policy – Electricity in the UK - a brief history. The “energy policy triangle” (including energy security, UK climate change Act). Nuclear New Build – a British policy perspective including UK electricity market reform.

Future reactor designs. AP1000, EPR, Pebble bed, small reactors and Gen IV reactors.

Recommended textbooks A = required, B = recommended but not essential, C = background reading.

B Lamarsh and Barrata. Introduction to Nuclear Engineering. Prentice Hall.
B HSE website – General Design Assessments.
B Stacey – Nuclear Reactor Physics. Wiley-VCH.
B David Mackay. Sustainable Energy - Without the Hot Air.
B Dieter Helm. The Carbon Crunch.

Structure, teaching and learning methods

20 lectures: Autumn term (weeks 1 to 2)

Assessment

Coursework: Write a 2500 word essay on a topic given to you.

Test: 1 hour and 30 min. 20 multiple choice questions + 50 minutes of short answer questions worth 35 marks.

Staffing

<table>
<thead>
<tr>
<th></th>
<th>Lectures</th>
<th>Tutorials</th>
<th>Lab sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Mark Wenman</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr Michael Ruston</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prof Bill Nuttall (Open University)</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Course Material

<table>
<thead>
<tr>
<th></th>
<th>PowerPoint Lectures</th>
<th>Lecture Hand-outs</th>
<th>Tutorial Sheets</th>
<th>Lab Scripts</th>
<th>WebCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Mark Wenman</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Dr Michael Rushton</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Prof Bill Nuttall (Open University)</td>
<td>2</td>
<td></td>
<td></td>
<td>Y</td>
<td></td>
</tr>
</tbody>
</table>
C2—Nuclear Chemical Engineering (Chem Eng)

Course Co-ordinator: Dr Bradley P. Ladewig
Status: MEng and BEng Third Year option and MSc Nuclear MSE option
Prerequisites: This course is designed to accommodate students from Materials and Chemical and Mechanical Engineering. No previous basic knowledge of the topics covered is assumed.

Aims

This is one of 5 elective courses being offered in the nuclear power area as part of a collaborative activity between the Departments of Mechanical Engineering, Chemical Engineering and Materials. Starting in the third year, students can take all 5 electives as part of qualification for a combined degree in Mechanical and Nuclear Engineering, or Chemical and Nuclear Engineering or Materials and Nuclear Engineering. Information on these degree courses is given in a separate brochure (http://www3.imperial.ac.uk/chemicalengineering/courses/undergraduate/coursedetails/nuclearengineering).

Each of the courses is offered as a stand-alone elective and one or more of the electives can be taken without proceeding to the full set of options for the combined degrees.

The overall aim of the Introduction to Nuclear Chemical Engineering course is to give students a wide knowledge of the chemical and chemical engineering processes associated with the production of nuclear fuel, the operation of nuclear reactors and the processing of nuclear waste.

Learning outcomes

By the end of the course, the student should be able:

- To understand the basics of the main chemical engineering processes associated with nuclear energy and particularly liquid-liquid extraction and ion exchange.
- To have a knowledge of the bases and applications of radiation chemistry.
- To have an overall appreciation of chemical engineering aspects of the nuclear fuel cycle and of the options available for dealing with spent fuel.
- To understand the bases of the processes involved in fuel production (uranium hydrometallurgy, fuel fabrication and production.
- To understand the principles of nuclear fuel reprocessing and the application of these principles in reprocessing plant such as THORP.
- To appreciate the challenges and processes involved in the long term disposal of nuclear waste and of decommissioning nuclear plant.
- To understand the chemical behavior of coolants in nuclear reactors and the chemical engineering processes associated with controlling this behavior.

Lectures:

Introduction to Nuclear Chemical Engineering (1 lecture)

- The nuclear fuel cycle.
- Fuel manufacture.
- Reprocessing.
- Storage and disposal.
- Thermal aspects.
Ion exchange (3 lectures)
- Introduction and materials.
- Theory.
- Equipment design.
- Applications in nuclear systems.

Radiation Chemistry (2 lectures)
- Basic principles, dosimetry and experimental methods.
- Radiation Chemistry in the Nuclear Fuel Cycle: Examples from power generation and reprocessing through to repository.

Uranium Production Technology (2 lectures)
- Uranium resources and demand.
- Uranium hydrometallurgy.

Isotope Separation and Enrichment (2 lectures)
- Principles of isotope separation.
- Uranium enrichment.

Fuel Production and Utilisation (2 lectures)
- Fuel fabrication and construction.
- Fuel utilisation in reactors.

Reactor Chemistry (2 lectures)
- Water reactor coolant chemistry.
- Gas cooled reactor coolant chemistry.

Fuel Reprocessing: Liquid-Liquid Extraction (4 lectures)
- Bases of liquid-liquid extraction
- Single Stage Systems.
- Crosscurrent and Counter current liquid-liquid extraction systems.
- Design Examples.

Fuel Reprocessing and the PUREX Process (2 lectures)
- Fuel reprocessing strategies.

Waste Management/Decommissioning (3 lectures)
- Introduction to nuclear waste management
- Decommissioning.
The Future of Nuclear Energy (2 lectures)

A three-hour revision lecture takes place on the last day of the spring term to aid exam preparation.

Recommended textbooks
A = required, B = recommended but not essential, C = background reading.


Structure, teaching and learning methods
30 hours of lectures: Autumn term (weeks 2 to 11)

Assessment
Coursework: - Eight homework sheets
Examination:- In the summer term

<table>
<thead>
<tr>
<th>Staffing</th>
<th>Lectures</th>
<th>Tutorials</th>
<th>Lab sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Bradley P. Ladewig</td>
<td>All</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Material</th>
<th>PowerPoint Lectures</th>
<th>Lecture Hand-outs</th>
<th>Tutorial Sheets</th>
<th>Lab Scripts</th>
<th>WebCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Bradley P. Ladewig</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
</tbody>
</table>

Weighting
Coursework: 20%
Exam: 80%
The pass mark for the module is 50% for the MSc Nuclear Students

Contact Details
Dr Bradley P. Ladewig Email: b.ladewig@imperial.ac.uk Office: 412 ACE Extension
C3—Nuclear Thermal Hydraulics (Mech Eng)

Course Co-ordinator: Dr Simon Walker (Mech Eng)
Status: MEng and BEng Third Year option and MSc Nuclear MSE option
Prerequisites: Introduction to Nuclear Energy

Aims
This course aims to give a more detailed appreciation of the thermal hydraulics (i.e. the heat transfer and fluid flow) in reactor systems and starts with basic material on single phase and boiling heat transfer, critical heat flux etc. The prediction of thermal hydraulic behaviour using nuclear systems codes such as TRACE and generic CFD codes such as STARCD will be described.

Session I: Bases A. Single phase fluid flow
- Introduction to the course
- Pressure drop in straight channels; friction factor, equivalent diameter, friction relationships. Pressure drop in singularities; bends, changes in cross section, fuel element grids
- Critical flow.

Session II: Bases B: Single phase heat transfer
- Regimes of heat transfer; natural convection, forced convection, mixed convention. Laminar, turbulent.
- Relationships for prediction of heat transfer in smooth and rough tubes.

Session III: Bases C: Two phase flow
- Regimes of flow in simple channels and fuel bundles,
- Models for multiphase flow; empirical, phenomenological, multifluid.
- Prediction of pressure drop in channels and singularities.

Session IV: Two-phase heat transfer
- Regimes of boiling; pre-dryout heat transfer.
- Critical heat flux.
- Post-dryout heat transfer, reflood/rewet.

Session V: Heat transfer within and from fuel
- Heat transfer inside fuel pins. Within-pin temperature distribution, cladding temperature drop, gap temperature drop, significance of pellet central hole.
- Heat transfer from fuel pin surface to fuel. Axial variation of fuel centre temperature, determination of magnitude and location of peak cladding temperature
Session VI: Aspects of fuel behaviour
- Fuel elements design and CHF prediction.
- Crud formation and its effects.

Session VII: Systems codes for safety analysis
- General description of system codes.
- Introduction to the TRACE code.

Session VIII: System code application exercise
- Introduction to exercise. Containment materials.
- Tutored class work on exercise.

Session IX: Application of Computational Fluid Dynamics (CFD)
- Introduction to CFD.
- Applications of CFD to nuclear reactor systems.
- Closing tutorial. Scope of examinations.

Assessment
Written examination in April/May

Weighting
Exam: 100%

The pass mark for the module is 50% for the MSc Nuclear Students
C4—Nuclear Reactor Physics (Mech Eng)

Course Co-ordinator: Dr Simon Walker (Mech Eng)
Status: MEng and BEng Third Year option and MSc Nuclear MSE option
Prerequisites: Introduction to Nuclear Energy

Aims
To provide an introduction to the reactor physics of nuclear reactors.

Learning outcomes

Knowledge and understanding
On successfully completing this course unit, students will be able to:
- Discuss aspects of reactor physics relevant to nuclear power;
- Understand the concept of criticality, and its estimation in various idealised geometries
- Understand basic point kinetics concepts, and prompt and delayed criticality
- Appreciate the main reactivity feedback mechanisms and their significance

Skills and other attributes
On successfully completing this course unit, students will be able to:

Intellectual skills
- Calculate basic parameters of reactor physics, e.g. multiplication factors, critical sizes
- Perform point-kinetics reactor transient analyses, appreciating the importance of prompt criticality and neutron lifetime
- Perform analyses on simple reactor geometries.

Course syllabus

Overview of nuclear reactor physics; basic concepts. The diffusion equation. Diffusion, neutron current, neutron flux, the diffusion approximation, the diffusion equation. Example solution for a source free region.


Reactor physics of thermal reactors. Thermal reactor analysis, the four-factor formula, resonance escape, fast fission. Neutron life cycle in a thermal reactor.


Fast reactors. Reactor physics of fast reactors; breeding.

Reactor kinetics. Doubling times, prompt criticality; reactivity feedback mechanisms, positive and negative feedback, power and temperature coefficients. Xenon poisoning.
### Teaching methods

- **Duration**: Spring Term (11 weeks)
- **Lectures**: 2hrs per week.
- **Tutorials**: 1hr per week.
- **Laboratory exercises**: details where possible.
- **Projects**: details where possible.
- **Item**: any other learning activity required by the course.

### Summary of student timetabled hours

<table>
<thead>
<tr>
<th></th>
<th>Autumn</th>
<th>Spring</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lectures</td>
<td>---</td>
<td>22</td>
<td>—</td>
</tr>
<tr>
<td>Tutorials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>32 (if 10 tutorials attended)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected private study time</td>
<td>3-4 h per week plus exam revision</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Assessments

**Written examinations**: title, duration and rubric

<table>
<thead>
<tr>
<th></th>
<th>Date (approx.)</th>
<th>Max. mark</th>
<th>Pass mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear Reactor Physics (3h)</td>
<td>April/ May</td>
<td>200</td>
<td>n/a</td>
</tr>
</tbody>
</table>

*This paper contains FOUR questions.*  
*Attempt ALL questions.*  
*All questions carry equal marks. The numbers shown by each question are for your guidance; they indicate approximately how the examiners intend to distribute the marks for this paper.*  
*A Data and Formula book and ‘NRT Data and Formulae’ are provided.*  
*This is a CLOSED BOOK Examination.*  

### Weighting

Exam: 100%

*The pass mark for the module is 50% for the MSc Nuclear Students*
Course Co-ordinator: Dr Mark Wenman  

Status: Fourth Year option/MSc Nuclear engineering/MRes Core course  

Prerequisites: None  

Introduction to Nuclear Energy 3rd year Mech Eng course very useful; knowledge of basic materials defects and the concept of microstructure very useful.

Aims    

The course will assume students have at least a basic understanding of a reactor system. The aim is then to develop an appreciation of materials issues associated with nuclear reactor technology and how this information is used when designing reactor systems. A mechanistic description of materials selection for intense radiation fields and the associated degradation mechanisms will be covered for different classes of material with a focus on the specific advantages and disadvantages. The course will then cover specific cases where materials issues have been crucial to systems performance and a variety of degradation and failure mechanisms as well as the radiation damage processes that brought about these failures. NB: Although not solely focused on water reactor systems (especially PWR) the course will be aimed at this system.

Learning outcomes  

Prof Robin Grimes  

- Review radiation types, radioactive decay and dose units.
- Discuss the mechanisms of radiation damage of nuclear materials, the units used to measure damage and the models behind them.
- Use the Kinchin-Pease Model to predict damage accumulation and its part in general chemical rate theory of radiation damage.
- Recall the types of fuel and components for the Nuclear Fuel Assembly.
- Discuss the fuel cycle and fuel fabrication.

Dr Mark Wenman  

- Explain the use of different materials (stainless steels, Ni alloys) used in a PWR primary circuit and the problems and mitigation strategies associated with them.
- Understand the microstructure and mechanical properties of ferritic steels used for reactor pressure vessels (including welded structures) and the degradation of the steels due to neutron irradiation.
- Define and explain the terms residual stress, primary stress and secondary stress and how they affect structural integrity assessments of nuclear plant.
- Use the FAD and Weibull analysis methods to predict failure in nuclear components.
- Describe the phenomenon of pellet-clad mechanical interactions (PCMI) in PWR and AGR systems, the pellet-clad gap, its closure, heat transfer mechanisms and their roles in PCMI.

Dr T B Britton  

- Outline the motivation for zirconium as a cladding in PWR environments.
- Discuss alloying of zirconium for cladding materials, including the presence of microstructure in single phase and dual phase alloys and secondary phase particles (SPPs).
- Introduce deformation modes in zirconium systems and their impact on crystallographic texture evolution, including crystallographic slip and twinning.
- Discuss crystallographic texture and its importance in highly engineered systems, including how to measure texture and describe it using pole figures & Kearn’s factors.
- Introduce ageing and corrosion of zirconium in power plant systems, with a focus on hydrides, oxidation, radiation creep and growth.
- Discuss engineering decisions for tube fabrication, as well as a simple overview of the benefits and disadvantages of different joining technologies.

**Recommended textbooks**

A = required, B = recommended but not essential, C = background reading.

C  P D Wilson (Editor) “The Nuclear Fuel Cycle: From Ore to Waste” (0198565402W)
B  G S Was “Fundamentals of Radiation Materials Science” Springer (978-3-540-49471-3)

**Structure, teaching and learning methods**

24 lectures: Autumn term

**Assessment**

*Examination:* The course is examined in the summer term. Exam format answer any three from 5 questions.

<table>
<thead>
<tr>
<th>Staffing</th>
<th>Lectures</th>
<th>Tutorials</th>
<th>Lab sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professor R W Grimes</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr T B Britton</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr M R Wenman</td>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Course Material**

<table>
<thead>
<tr>
<th></th>
<th>Power-Point Lectures</th>
<th>Lecture Handouts</th>
<th>Tutorial Sheets</th>
<th>Lab Scripts</th>
<th>WebCT</th>
<th>Panopto</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professor Grimes</td>
<td>8</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr T B Britton</td>
<td>8</td>
<td>1</td>
<td></td>
<td></td>
<td>y</td>
<td>y</td>
</tr>
<tr>
<td>Dr M Wenman</td>
<td>8</td>
<td></td>
<td>y</td>
<td>y</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Weighting**

Exam: 100%

The pass mark for the module is 50% for the MSc Nuclear Students
C6— Decommissioning, Waste Management and Geological Disposal (Materials, MSE 419)

Course Co-ordinator: Professor Laurence Williams

Status: Fourth Year MEng and MSc Option

Prerequisites: MSE 414 Materials for Reactor Systems

Aims

This course will begin by providing the student with an understanding of the regulatory and technical issues associated with decommissioning nuclear facilities at end of life. The aim is then to develop a more detailed technical understanding of the engineering processes and chemistry and physics of immobilising radionuclides in ceramic, glass and cement hosts so they are safe and durable. Issues associated with storage of radwastes prior to their eventual disposal will be covered. Finally, we aim to make students aware of the complexity of design, engineering and technical problems associated with permanently disposing of ILW and HLW in a geological repository.

Learning outcomes

At the end of the course you will be able to:-

- Understand the organisational and regulatory environment in which decommissioning takes place under the umbrella of Government policies. Contrast key aspects of UK decommissioning policy and strategy with the situation in other countries.
- Describe modern techniques for characterisation, decontamination, dismantling and demolition in nuclear decommissioning and appreciate how these are applied in decommissioning various types of nuclear facilities.
- Understand how options for carrying out decommissioning work are identified and assessed, including methods for financial appraisals and making business cases.
- Appreciate the progress being made in decommissioning nuclear power stations and fuel cycle facilities worldwide, including those closed following accidents.
- Comment on the politics of UK radioactive waste management, e.g. waste as an issue against use of nuclear power. Understand waste types, sources and locations. Summarise the work of the Department of Energy and Climate Change, the Committee on Radioactive Waste Management and the Nuclear Decommissioning Authority.
- Describe short-lived and long-lived radionuclide containing wastes and difficult wastes. (Short-Lived radionuclides: tritium, $^{90}$Sr, $^{137}$Cs. Long-lived radionuclides: $^{14}$C, $^{99}$Tc, $^{129}$I, $^{239}$Pu.)
- Understand how low level radioactive wastes are managed, including application of the Waste Hierarchy, opportunities for reuse and recycling, and principal features of safety cases for near-surface disposal (in dedicated facilities and in landfills).
- Explain the steps in the management of higher activity wastes and describe the types of encapsulation, immobilisation and packaging methods for intermediate level wastes, high level wastes and spent fuels.
- Discuss ILW cementation, including cementation technology and the behaviour of cement waste forms during storage and disposal.
- Discuss vitrification, covering natural analogues, vitrification technology, glass selection & HLW compositions, benefits & difficulties of glasses.
- Comment on the use of ceramic and glass composite material wasteforms, potential wasteforms for difficult wastes, ceramic densification processes, glass ceramic processing & crystallization, the Synroc process.
• Understand why wastes are stored, store designs and issues of wasteform degradation in store.
• Appreciate geological repository concepts and designs, and their limitations. Describe the key functions of the natural and engineered barriers in a repository. Summarise worldwide experience of geological disposal and identify potential repository problems.
• Discuss alternatives to geological disposal of higher activity wastes in a mined repository (e.g. deep bore-hole disposal of spent fuels, near-surface disposal of short-lived ILW).

**Recommended textbooks** A = required, B = recommended but not essential, C = background reading.


**Structure, teaching and learning methods**

24 lectures: Spring term

**Assessment**

*Examination:* The course is examined in the summer term. The exam paper consists of 5 questions from which the students must answer 3 and is 2½ hours in duration.

<table>
<thead>
<tr>
<th>Staffing</th>
<th>Lectures</th>
<th>Tutorials</th>
<th>Lab sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof Laurence Williams</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ms M Hill</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prof C Tweed</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Material</th>
<th>Powerpoint Lectures</th>
<th>Lecture Handouts</th>
<th>Tutorial Sheets</th>
<th>WebCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof Laurence Williams</td>
<td>10</td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Ms M Hill</td>
<td>10</td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Prof C Tweed</td>
<td>4</td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Weighting**

Exam: 100%

The pass mark for the module is 50% for the MSc Nuclear Students
**C7—Modelling for Nuclear Engineers (Materials)**

**Course Co-ordinator:** Dr Michael Rushton  
**Status:** MSc Nuclear Engineering Core Module  
**Prerequisites:** Basic knowledge of Nuclear Engineering.

Aims

The aim of the course is to introduce students to modelling and simulation methods that are directly relevant to nuclear engineering. A number of techniques are introduced spanning a wide range of length scales; from the atomic scale to the continuum. The following methods will be covered during the course (relevant simulation codes are given in brackets):

- **Atomistic simulation, effective pair potentials:**  
  Molecular dynamics (DL_POLY)
- **Binary collision models:**  
  SRIM/TRIM
- **Continuum modelling using finite element methods:**  
  Stress analysis and heat transfer (FENICS)  
  Thermal hydraulics (OpenFoam)
- **Neutron Transport:**  
  Deterministic methods  
  Probabilistic Monte-Carlo methods (MONK)

These methods are split between four themes within the modelling course namely:

- **Radiation damage at the atomic scale** (Dr. Michael J.D. Rushton): molecular dynamics and SRIM/TRIM,
- **Thermal Hydraulics** (Dr. Mike Bluck): OpenFoam,
- **Neutron Transport** (Dr. Andrew Buchan): MONK,
- **Stress and heat transfer analysis using finite element methods** (Dr. Andrew Buchan): FENICS.

Each comprises two parts: a taught lecture/tutorial and a practical classwork. The taught component provides the theoretical basis underlying each simulation technique, these lead into the computer based workshop sessions that allow students to apply industry standard simulation packages to solve practical problems in nuclear engineering.

Students are expected to produce a technical report, to be handed in two weeks after each classwork which will allow them to demonstrate their understanding of how each simulation method can be applied and its strengths and limitations.

The computational methods hub will provide an introduction to working in a Linux/UNIX high performance computing environment which, this will be conducted as a practical computing session at the beginning of the first classwork session.
Learning outcomes

Introduction to High Performance Computing (Computational methods hub)

Several of the practical computing sessions will be performed, using a command line interface, to the Linux operating system. It is recognised that not all students will be familiar with Linux and as a result, a basic introduction will be provided to support the subsequent practical sessions. This will take the form of an interactive tutorial that will be performed, in the computing lab, at the start of the first practical session. There will be no specific assessment for the computing tutorial, however, as the skills covered are required for the remainder of the course, attendance is compulsory.

Linux/UNIX:

Learning outcomes. Students should be able to:

- Use the PuTTY software to log in to a remote Linux machine.
- Understand the basic layout of the Linux file structure.
- Navigate around the Linux file system using the cd command (making use of TAB completion) recognizing the difference between relative and absolute paths.
- Perform basic file manipulation operations: cp, mkdir, ls, rm, mv.
- View, edit and search text files using tools such as: less, pico, grep and wc.
- Use --help command line option and man to get information on commands.
- Interact with batch queuing system using: qstat and qdel.
- Transfer files between Windows and Linux machines using client software such as WinSCP or Filezilla.

Radiation damage at the atomic scale (Dr. Michael J.D. Rushton)

Within this module atomistic simulation techniques will be used to consider radiation damage in nuclear materials. This section of the course is split into two distinct but complementary parts:

- Binary Collision Methods (SRIM/TRIM).
- Molecular Dynamics (MD).

Both methods attempt to model the damage caused when a material experiences a collision cascade due to an energetic particle. One lecture will be given on each and these will be supported by a computing session on each method. As MD and SRIM/TRIM simulate similar effects, students will be expected to produce a single report describing both approaches. As well as giving a brief description of the two methods, students are expected to discuss the advantages and limitations of each in the context of their results.

Molecular Dynamics: Molecular dynamics will be performed using the DL_POLY simulation code in conjunction with effective pair potentials to model displacive radiation events (using the primary knock-on atom method) within UO2. Students should be able to:

- Describe molecular dynamics as a classical theory which is based on Newton’s Second Law of Motion.
- Assess the suitability of molecular dynamics simulations for a given material, length scale and time scale and then judge the limitations of such an approach.
- Summarise concepts commonly used within molecular dynamics simulations such as periodic boundary conditions, potential cut-offs, numerical algorithms for integrating the equations of motion, the process of equilibration and ensembles.
- Perform molecular dynamics simulations using the DL_POLY program by editing input files, executing the program and finally handling and presenting the data output in an appropriate way.
• Quote the conservation of momentum theory and illustrate it in terms of simulation results.
• Recognise the different energy contributions to the total energy in a simulation and identify the energy exchange between contributions in the context of the NVE, NVT and NPT ensembles.
• Investigate, analyse and assess the length of a suitable time step for a molecular dynamics simulation.
• Perform a series of molecular dynamics simulations in order to determine the threshold displacement energy for a uranium PKA in uranium dioxide for a given crystallographic direction.
• Visualise simulation results using 3D molecular visualisation programmes (VMD).
• Use the calculated threshold displacement energies to predict defect populations following radiation damage using the Kinchin-Pease method.

SRIM/TRIM:
• Describe the SRIM/TRIM algorithm.
• Perform SRIM/TRIM calculations to predict penetration depth and the size of the damaged region within UO2 for incident particles with a range of energies.
• Students should be able to compare the results of molecular dynamics damage cascades with similar results obtained using SRIM/TRIM.
• They should understand the limitations of each technique and which physical effects can and cannot be predicted with each method.
• Be able to understand when it is appropriate to use binary collision models or when to use molecular dynamics to study radiation damage.

Finite Element Modelling (Dr. Andrew Buchan)
Learning outcomes. Students should be able to:
• Derive the partial differential equations that form the basis of our mathematical understanding of nuclear engineering problems.
• Introduce finite element basis functions and show how they are used to represent solution of equations.
• Introduce the strong and weak form of PDEs.
• Develop the discretised PDEs using the weighted residual method and form the linear equations that are to be solved in order to obtain the finite element solution.
• Short discussion on linear solver technologies.
• Demonstrate convergence of finite element solutions with respect to resolution.
• Construct and solve a nuclear engineering problem using a finite element code.

Thermal Hydraulics (Dr. Mike Bluck)
Learning outcomes. Students should be able to:
• Understand the mathematical description of fluid flow (momentum and energy). Demonstrate an awareness of the terms in the Navier-Stokes equations and their relative magnitudes in terms of Reynolds & Prandtl numbers.
• Understand hydrodynamic and thermal boundary conditions and the modes of heat transfer
• Demonstrate an understanding of flow regimes; laminar, turbulent, forced convection, and natural circulation and their role in nuclear engineering
• Understand the meaning of compressible and incompressible flows
- Appreciate the fundamental issues of multiphase flow, boiling and critical heat flux.
- Explain the basic concepts underlying the finite volume methods in CFD.
- Demonstrate an appreciation of methods for the modelling of turbulence in CFD.
- Understand the principles of the implementation of CFD solution schemes in openFoam.
- Construct simple flow models in openFoam, including basic meshing, application of boundary conditions and subsequent solution.
- Demonstrate the use of Paraview for pre & post processing CFD results in openFoam.

**Neutron Transport (Dr. Andrew Buchan)**

Learning outcomes. Students should be able to:

- Understand the importance of neutron transport in reactor physics and nuclear engineering applications.
- Know the underlying principals and assumptions that affect the movement of neutrons
- Understand the fundamental concepts of scalar flux, angular flux and current.
- Understand the origin of nuclear cross sections and the expression for reaction rates.
- Be able to recognise and describe the physical meaning of each term within the Boltzmann transport equation.
- Be able to derive the transport equation and its associated boundary conditions.
- Understand the importance of delayed neutrons, where they come from, and how to include them in the transport equation and derive the kinetic equations.
- Understand the physical meaning of the neutron multiplication factor, k-effective, and the relation to criticality.
- Know the most well-used methods for solving the Boltzmann transport equation.
- Have gained practical experience using two radiation transport codes well-used within industry.
- Understand some important reactor physics concepts that affect reactivity, such as temperature effects, control rod insertion and fuel to moderator (* H:U) ratio.

**Recommended textbooks** A = required, B = recommended but not essential, C = background reading.


**Structure, teaching and learning methods**

Autumn term (weeks 2 to 11). Each simulation courses (MD/SRIM, FE, Thermal Hydraulics and Neutron Transport) will be conducted as a 3 hr lecture and a 3 hr computing lab. The first computing session will include
an introduction to the Linux computing environment. It is expected that each module will require another ~3hrs of independent work following the lab session in order to complete work required for each report.

Assessment

Coursework:-
Assessment will take the form of a technical report describing the work performed within the computing workshop associated with each method. One report will be produced per module (one each for Neutron Transport, Finite Element Methods, Thermal Hydraulics and MD/SRIM). A typical report would be expected to have an abstract, introduction, a brief methodology, results, discussion and conclusions. It should show how each simulation method has been applied to the problem at hand with special attention being given to the reliability and limitations of each simulation method. Appropriate graphs, tables and figures are expected and relevant references should be cited extensively.

<table>
<thead>
<tr>
<th>Staffing</th>
<th>Lectures</th>
<th>Tutorials</th>
<th>Lab sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr M.J.D. Rushton</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr M. Bluck</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr A. Buchan</td>
<td>12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Material</th>
<th>PowerPoint Lectures</th>
<th>Lecture Handouts</th>
<th>Tutorial Sheets</th>
<th>Lab Scripts</th>
<th>WebCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr M.J.D. Rushton</td>
<td>Y</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Dr M. Bluck</td>
<td>Y</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Dr A. Buchan</td>
<td>Y</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
</tbody>
</table>

Weighting

Coursework: 100%

The pass mark for the module is 50% for the MSc Nuclear Students

Contact Details

Dr Michael Rushton  Email: m.rushton@imperial.ac.uk  Office: B303, Bessemer Building
Dr Mike Bluck       Email: m.bluck@imperial.ac.uk
Dr Andrew Buchan    Email: Contact Mrs Raj Adcock for details
C8— Nuclear Safety Management

Course Co-ordinator: Dr Trevor Chambers (Reactor Centre)
Status: MSc Nuclear MSE option
Prerequisites: Introduction to Nuclear Engineering

Aims
Students should become familiar with IAEA and UK guidance for the safe management of nuclear licensed sites. This will include safety case methodology, engineered systems used to ensure safety, risk assessment, shielding calculations and emergency arrangements. At completion of the course students should have acquired an overview of the management of nuclear plant and nuclear sites, and have the ability to produce simple safety case arguments, carry out risk assessments, carry out role play for emergency exercises, calculate operator doses and fault frequencies, and be able to compare calculated radiological risk with regulatory acceptance criteria.

Learning outcomes

Lecture 1. Overarching Legislation
Learning outcomes. Students should be able to:
- Describe the function of the IAEA Guidance Documents with relevance to individual member states
- Explain the key HSE Legislation covering conventional and radiological safety with respect to the operation of nuclear plant
Describe the concept of a Nuclear Site Licence and how aspects of operations on a Nuclear Licensed Site (NLS) are further controlled by means of Site Licence Conditions

Lecture 2. Safety Cases
Learning outcomes. Students should be able to:
- Understand the requirements for safety cases with respect to operations on a NLS
- Describe the main sections of a safety case
- Understand the categorisation methodology of a safety case
- Understand the safety arguments
Explain the approval process including peer review and Nuclear Safety Committee requirements

Lecture 3. Hazard Assessments
Learning outcomes. Students should be able to:
- Describe Hazard Assessment methodology
- Explain the concept of BSO and BSL
Explain the concept of ALARP

Lecture 4. HAZOP Studies
Learning outcomes. Students should be able to:
- Understand the function of HAZOP studies
- Describe the methodology and the key areas for assessment
Summarize the requirements for management and engineering controls

**Lecture 5. HAZOP Exercise**

Learning outcomes. Students should be able to:

- Identify the key areas for assessment
- Identify the groups or individuals at risk
- Identify the management and engineering controls

Evaluate the potential for further controls

**Lecture 6. Dose Uptake Calculations**

Learning outcomes. Students should be able to:

- Understand the different types of radiation and the potential for harm for each type
- Understand the uptake routes for internal doses and potential mitigation
- Understand the methodology for internal dose assessment

Understand the methodology for external dose assessment

**Lecture 7. Dose Uptake Calculation Exercise**

Learning outcomes. Students should be able to:

- Calculate internal dose uptake
- Calculate external dose uptake

Compare derived doses with dose limits and discuss potential for dose reduction

**Lecture 8. Radiological Risk Assessment**

Learning outcomes. Students should be able to:

- Understand the methodology for radiological risk calculation
- Understand the derivation of fault frequencies by Fault Tree Analysis
- Undertake radiological risk calculations
- Understand the requirement to compare assessed numerical risk with ONR acceptance criteria

**Lecture 9. Engineering Safeguards/Engineering Substantiation and Human Factors**

Learning outcomes. Students should be able to:

- Explain the safety functions of a variety of typical engineering safeguards including ventilation, shielding, containment, remote techniques, transport packages, posting systems and interlock arrangements
- Understand the engineering arguments supporting a sound substantiation
- Evaluate the relative merits of the engineering argument to assess ALARP
- Understand the importance of Human Factors in safe operations

Assess the Human Factors associated with a given task and propose measures to reduce risks to ALARP
Lecture 10. Shielding
Learning outcomes. Students should be able to:
- Understand shielding properties for various shield materials with respect to $\alpha$, $\beta$, $\gamma$ and neutron radiation
- Understand shielding calculation methodologies

Lecture 11. Shielding Calculations Exercise
- Learning outcomes. Students should be able to:
  - Select appropriate shield materials and calculate the required shielding thickness, to adequately reduce the doserate from a variety of specified isotopes

Lecture 12. Risk Assessments
Learning outcomes. Students should be able to:
- Describe Risk Assessment methodology
- Understand techniques for risk reduction
- Apply ALARP concepts to risk reduction

Lecture 13. Risk Assessment Exercise
Learning outcomes. Students should be able to:
- Evaluate the risks associated with various hazards
- Evaluate the potential for risk reduction
- Demonstrate risks are ALARP

Lecture 14. Modifications to Safety Cases
Learning outcomes. Students should be able to:
- Understand the requirements for change control
- Explain the implementation methodology and documentation
- Understand the arrangements for Management of Change

Lecture 15. Safe Operation of Plant
Learning outcomes. Students should be able to:
- Explain the requirements for Operating Rules, Authorities to Operate, Operating Instructions
- Understand the requirement for DAPs and SQEPs
- Understand the requirements for maintenance
- Derive Operating Rules for a specified plant
Lecture 16. Incidents

Learning outcomes. Students should be able to:

- Understand and explain incident reporting categories
- Describe in overview incident investigation techniques
- Understand the failure sequences in historical radiological accidents

Lecture 17. Emergency Arrangements

Learning outcomes. Students should be able to:

- Understand the legal requirements for Emergency preparedness
- Describe arrangements for on-site and off-site emergency plans
- Understand Command and Control techniques

Lecture 18. Emergency Arrangements Exercise

Learning outcomes. Students should be able to:

- Role play in a table top exercise

Recommended textbooks A = required, B = recommended but not essential, C = background reading.

C Health and Safety Executive website at www.hse.gov.uk – Risk assessment, Managing for Health and Safety HSG65
C Office for Nuclear Regulation website at www.onr.org.uk - A guide to nuclear regulation in the UK, License Conditions Handbook

Structure, teaching and learning methods

24 hours of lectures: Spring term (weeks 17 to 24)

Assessment

Coursework: - 1000 word HAZOP essay on a topic given.
Examination: - 2.5hr exam in Summer term
Weighting
Coursework: 25%
Exam: 75%

The pass mark for the module is 50% for the MSc Nuclear Students

Contact Details
Dr Trevor Chambers  Email: t.chambers@imperial.ac.uk  Office: Reactor Centre, Silwood Park
Dr Heather Phillips  Email: h.phillips@imperial.ac.uk  Office: 2.18, Reactor Centre, Silwood Park
Dr Helen Day  Email: h.day@imperial.ac.uk  Office: 3.15, EAS Building, Silwood Park
SC1— Radiation Protection

**Course Co-ordinator:** Dr Helen Day (Reactor Centre)

**Status:** MSc Nuclear MSE option

**Aims**
To provide an understanding of radiation protection concepts

**Learning outcomes**

**Day 1**
- Describe early evidence for the detrimental effects of exposure to ionising radiation. In the context of deterministic effects.
- Describe the nature of the dose/response relationship.
- Describe the physical effects and symptoms at various levels of dose.
- In the context of stochastic effects:
  - Identify the major sources of information on the cancer risks associated with radiation exposure.
  - Distinguish between the deterministic and stochastic effects of radiation exposure.
  - Describe the form of the dose/response relationship.
  - Criticality

**Day 2**
- State the aims of radiological protection.
- Explain the ICRP system of radiological protection - Justification, Optimisation and Dose Limitation.
- List UK legislation relevant to radiation protection, IRR ’99, REPPIR, NIA ’63 and briefly describe the purpose of each Act/Regulation.
- Define and explain the terms Absorbed Dose, Equivalent Dose, Effective Dose, Collective Effective Dose and define the appropriate dose units in each case.
- Describe the relationship between the gray and the sievert and the significance of this relationship in terms of biological damage.
- Specify values of risk coefficients as defined in ICRP Publication 60
- Natural and artificial radioactivity, including radon and medical exposures
- Shielding principles
- Undertake simple dose calculations

**Day 3**
- Outline the practice of radiation monitoring and personal dosimetry and typical equipment.
- State the requirements for undertaking risk assessments in IRR ’99 and describe the concepts of ALARP, Basic Safety Limit (BSL) and Basic Safety Objective (BSO) as set down by the HSE in the tolerability of risk.
- Outline the sources of external radiation generated by a PWR
- Radiography arrangements
- Personal protective equipment
- Change room arrangements
Day 4 -
• State the current statutory dose limits (IRR 99) for workers and the general public.
• Describe why radioactive material is accumulated on-site and state the requirements for storage facilities.
• Describe the regulatory framework for controlling radioactive discharges
• Explain the UK policy for classification and disposal of radioactive wastes
• Discuss how members of the public can be exposed to aqueous and atmospheric radioactive waste discharges
• IRR 99
  • REPPR01
• Discuss the on-site arrangements for accident and emergency response.

Recommended textbooks A = required, B = recommended but not essential, C = background reading.
C  An Introduction to Health Physics: A Martin, S Harbison, K Beach, P Cole

Structure, teaching and learning methods
12 hours of lectures: Autumn term

Assessment
Test:  1 hr test answer 2 questions from 2.

<table>
<thead>
<tr>
<th>Staffing</th>
<th>Lectures</th>
<th>Tutorials</th>
<th>Lab sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miss Helen Day</td>
<td>12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Course Material

<table>
<thead>
<tr>
<th>Power-Point Lectures</th>
<th>Lecture Hand-outs</th>
<th>Tutorial Sheets</th>
<th>Lab Scripts</th>
<th>WebCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miss Helen Day</td>
<td>12</td>
<td></td>
<td></td>
<td>Y</td>
</tr>
</tbody>
</table>

Weighting:
Test—100%
The pass mark for the module is 50% for the MSc Nuclear Students

Contact Details:
Miss Helen Day Email:  h.day@imperial.ac.uk  Office: 3.15, EAS Building, Silwood Park
SC2— Fast Reactors and Nuclear Hydrogen Production

Course Co-ordinator: Dr Anthony Judd

Status: MSc Nuclear MSE option

Aims
The aim of the course is to provide an introduction to the technology of fast reactors based on past experience, and to examine the role fast reactors will play in the future nuclear industry. It covers fast reactor physics, the behaviour of fast reactor fuel at high burnup, fast reactor systems including sodium technology, and fast reactor safety.

Learning outcomes

Dr Tony Judd

Lecture 1  Fast reactor physics 1

- Fast and thermal reactors
- Neutron economy
- Characteristics of fast reactors
- Multigroup diffusion theory and the fundamental mode approximation
- Neutron flux and importance in fast reactors
- Reactivity coefficients – Doppler; sodium density

Learning outcomes: The student should be able to:-

- Understand the essential features of fast reactors,
- Perform simple fundamental mode calculations,
- Determine the effects of different coolants, fuel material, etc., on reactor performance, and
- Understand what influences the main reactivity coefficients.

Lecture 2  Fast reactor physics 2

- Breeding and consumption of plutonium
- The economic importance of breeding
- Transmutation of high-level waste
- Accelerator-driven systems
- The thorium cycle

Learning outcomes: The student should be able to:-

- Understand the potential effect of fast reactors on world energy resources
- Analyse the place of fast reactors in the plutonium and thorium cycles,
- Understand the use of fast reactors to consume radioactive waste, and
- Discuss the advantages and disadvantages of accelerator-driven subcritical reactors.
Lecture 3  Fast reactor cores
The performance of oxide fuel at high burnup in a fast reactor
Metal fuel and other fuel materials
The structure of a fast reactor core
Cladding and structural materials

Learning outcomes: The student should be able to:-
Understand the complex behaviour of high-burnup oxide and metal fuel,
Appreciate the different behaviour of other fuel materials,
Understand how the design of a fast reactor core is determined, and
Discuss the choice of core structural materials.

Lecture 4  Fast reactor power plant
Coolants – sodium, lead-bismuth, gas
Sodium coolant circuits – layout, components
Sodium-heated steam generators
High-cycle fatigue
Fuel handling systems
Steam plant

Learning outcomes: The student should be able to:-
Compare the relative merits of different coolant materials and plant layouts,
Understand the design and operation of sodium-heated steam generators, and
Explain the effect of sodium heat-transfer on component integrity.

Lecture 5  Fast reactor safety
Operational safety
Decay-heat rejection
Sodium fires
Steam-generator leaks
Inherent safety
Core-disruptive accidents

Learning outcomes: The student should be able to:-
Understand the basic safety features of fast reactors,
Perform quasi-static calculations to examine the inherent safety of fast reactors,
Discuss the standard scenarios for core-disruptive accidents, and
Understand transition-phase calculations and the risks of vapour explosions and recriticality.
Lecture 6  Fast reactors, past and future

The development of fast reactors from the 1940s to the present
Current fast reactors in operation and under construction
Plans and proposals for the deployment of fast reactors in Europe and Asia

Learning outcomes: The student should be able to:-
Understand the history of fast reactors and the extent of experience worldwide,
Criticise current fast reactor of design proposals, and
Discuss the place of fast reactors in the nuclear industry of the future.

Prof Alexander Chroneos

Lecture 7  Nuclear hydrogen production 1

Background and motivation of the hydrogen economy
Challenges of hydrogen technologies
Hydrogen economy and the environment
Hydrogen production and storage

Learning outcomes: The student should be able to:-
Compare the relative merits of different hydrogen production methods,
Understand the challenges of hydrogen storage,
Understand the benefit of nuclear hydrogen production.

Lecture 8  Nuclear hydrogen production 2

Fuel cells
Solid oxide fuel cells (SOFC) and solid oxide electrolyte cells (SOEC)
Safety issues

Learning outcomes: The student should be able to:-
Understand the basic safety features of the hydrogen technology,
Gain a basic understanding of SOEC and SOFC,
Understand how electricity can be produced with SOEC and nuclear energy.

Lecture 9  Nuclear hydrogen production 3

Nuclear reactors and hydrogen production
Reactor options
Summary and future challenges
Learning outcomes: The student should be able to:-

- Understand hydrogen production from nuclear heat,
- Understand the benefits of different reactor options,
- Discuss the challenges for nuclear hydrogen production.

Recommended textbooks A = required, B = recommended but not essential, C = background reading.

B IWGFR "Status of Fast Reactor Research and Technology Development, TECDOC 1691", IAEA, Vienna 2013

Structure, teaching and learning methods

9 hours of lectures: Spring term

Assessment

Coursework: - 2500 essay based on questions provided by the lecturers (one will be an individual project and other group project).

<table>
<thead>
<tr>
<th>Staffing</th>
<th>Lectures</th>
<th>Tutorials</th>
<th>Lab sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Anthony Judd</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prof Alexander Chroneos</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Material</th>
<th>Power-Point Lectures</th>
<th>Lecture Handouts</th>
<th>Tutorial Sheets</th>
<th>Lab Scripts</th>
<th>WebCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Anthony Judd</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Y</td>
</tr>
<tr>
<td>Prof Alexander Chroneos</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Y</td>
</tr>
</tbody>
</table>

Weighting:

Coursework: 100%

The pass mark for the module is 50% for the MSc Nuclear Students

Contact Details

Dr Anthony Judd Email: tony.judd@btinternet.com
Prof Alexander Chroneos Email: alexander.chroneos@imperial.ac.uk
SC3— Nuclear Fusion

Course Co-ordinator: Chris Ham
Status: MSc Nuclear MSE option
Prerequisites: General understanding of nuclear physics, nuclear energy and global energy problems.

Aims
Understand what drives the need for completely new energy sources, such as fusion; clarify the underlying science and technology challenges including the role of materials development; understand the progress to date and how this is expected to impact on the potential for fusion power as an energy system.

Learning outcomes

Chris Ham

Lecture: Fusion reactions: cross sections and reactivity.
Learning outcomes. Students should be able to:
- Understand the origin of fusion energy in terms of the nuclear forces and be able to estimate the energy yield from a given fusion reaction.
- Explain the requirements for fusion reactors.
- Summarise the main features of the Fusion cross-sections and reactivity for the most promising fusion reactions i.e. DT, DD, DHe3 and pB.
- Compare the pros and cons of the Magnetic and inertial approaches to fusion.
- Determine the correct application of the nTt formula.
- Derive the fusion triple product and link to energy gain.

Lecture: Magnetic confinement systems.
Learning outcomes. Students should be able to:
- Understand particle motion in electromagnetic fields and drifts in tokamak plasmas.
- Describe the magnetic configuration required for confinement
- Describe the concept of stationary equilibrium.
- Compare different heating mechanisms
- Describe different modes of plasma operation

Lecture: Physics and reactor systems.
Learning outcomes. Students should be able to:
- Explain the concept of instability
- Linearise MHD equations and perform simple stability calculations.
- Discuss and estimate confinement time, specifically classical and turbulent confinement.
- Describe common plasma diagnostics
- Explain the main challenges for ITER.

Problem Session: (1.) Estimate energy yield from fusion. (2) Estimate confinement time, nTtau. (3) Linearise the MHD equations. (4) Calculate the gradient of B particle drift.
**Dr Hanni Lux**

**Lecture: Reactor needs.**
Learning outcomes. Students should be able to:
- Explain how high temperatures are achieved.
- Illustrate the generic layout of a fusion power plant.
- Describe common features of magnetic and inertial fusion plants.
- Analyse the factors that determine the size of a power plant.
- Determine fuel use and resources.
- Compare and contrast the range of technology options.
- Analyse the gain needed in a power plant.

**Lecture: Reactor Performance.**
Learning outcomes. Students should be able to:
- Understand the issues affecting safety of fusion power plants.
- Explain the waste products of a fusion reactor and the measures to ensure minimal environmental impact.
- Discuss the radiological hazards including tritium in context.
- Differentiate the factors affecting cost e.g. capital, cost of replacement components, Operation and Maintenance and understand the impact of volatile markets and external costs

**Problem Session:** (1) Estimate cost of electricity from a fusion power plant including unit size, technological learning etc. (2) Determine the impact of materials on economics.

**Lecture: Fusion in the Market.**
Learning outcomes. Students should be able to:
- Explain expected global future energy demand.
- Discuss the international nature of the energy challenge and approaches to its solution
- Evaluate options for a low carbon future.
- Elucidate the role for fusion alongside fission and renewables.
- Outline the issues that determine the timescale to fusion.

Problem Session: (1) Calculate the energy content of a litre of sea water.
(2) Estimate total potential energy supply from fusion based on concentration of D and lithium on Earth.

**Prof Sergei Dudarev**

**Lecture: Materials for Fusion I.**
Learning outcomes. Students should be able to:
- Discuss the issues critical for the choice of fusion materials. Compare fusion and fission needs, and identify the key differences.
- Explain the role of transmutation effects, the notion of low activation materials, and technological constraints associated with fusion irradiation environment.
Lecture: Materials for Fusion II.

Learning outcomes. Students should be able to:

- Understand the different roles of structural, plasma-facing, and functional materials.
- Assess factors influencing the choice of materials for fusion applications, and implications for power plant design and economics
- Rationalize and assess the current status of fusion materials development and identify its future objectives

Problem Session: (1) Simple estimates of damage from fusion neutrons. (2) Evaluation of factors determining temperature operating windows for various fusion materials

Recommended textbooks A = required, B = recommended but not essential, C = background reading.

B ‘Physics of Plasmas’ by Boyd and Sanderson CUP
C Fusion, the Energy of the Universe, McCracken, Stott, Academic Press.
C Tokamaks, Wesson, OUP.

Structure, teaching and learning methods

8 hours of lectures, 4 hours of tutorials

Assessment:

Coursework: - Tutorial sheet of questions from each lecturer.

<table>
<thead>
<tr>
<th>Staffing</th>
<th>Lectures</th>
<th>Tutorials</th>
<th>Lab sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Hanni Lux</td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Dr Christopher Ham</td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Prof Sergei Dudarev</td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Material</th>
<th>PowerPoint Lectures</th>
<th>Lecture Handouts</th>
<th>Tutorial Sheets</th>
<th>Lab Scripts</th>
<th>WebCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Hanni Lux</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Dr Christopher Ham</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Prof Sergei Dudarev</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
</tbody>
</table>

Weighting

Coursework: 100%

The pass mark for the module is 50% for the MSc Nuclear Students

Contact Details

Dr Hanni Lux Email: Hanni.Lux@ukaea.uk
Dr Christopher Ham Email: Christopher.Ham@ukaea.uk
Prof Sergei Dudarev Email: sergei.dudarev@ukaea.uk
SC4— Nuclear Engineer in Industry

Course Co-ordinator: Professor Steve Garwood
Status: MSc Nuclear MSE option

Aims:
To introduce students to the history of nuclear power in the UK and abroad and provide an insight into working as an engineer in the industry.

Learning outcomes:

Dame Sue Ion:-

Lecture 1. Early days of Nuclear Power in the UK: 1940’s- early 1970’s
Students should be able to understand:
- The importance of international politics in early decisions for the UK to ‘go it alone’
- Rivalry within Government and the organisations within the sector and how this impacted on decisions
- How Magnox technology came to be chosen and the consequences of lack of standardisation of design
- The pursuit of the AGR and the emergence of the Private Sector
- The race for Fast Reactor technology

Lecture 2. Nuclear Power in the UK: 1970’s to the present day
Students should be able to understand:
- Why the Fast Reactor was never deployed commercially
- The problems experienced with the AGR’s
- The politics and policies which led to the decision to import US LWR technology
- The privatisation and break-up of the Central Electricity Generation Board (CEGB) and the United Kingdom Atomic Energy Authority (UKAEA) and the consequences for the role of nuclear energy and supporting R+D in the UK.
- The re-emergence of nuclear energy and the consequences of little indigenous industry

Lecture 3. The UK’s Nuclear Legacy: Consequences of early decisions on the fuel cycle which supported the early reactors and waste management as an afterthought
Students should be able to have a particular understanding of this important issue:
- The legacy left by the early, military driven programme
- The long term consequences of a closed fuel cycle
- British Nuclear Fuels Ltd (BNFL) early promise and international aspirations
- The break-up of BNFL and the creation of the NDA
- The massive challenge of cleaning up the past: organisational, financial and logistic issues
Prof Mamdouh El-Shanawany:

Lecture 1. International Atomic Energy Agency History and Mandate
Students should be able to appreciate:
- Why the IAEA was established in 1957,
- IAEA mandate in the developments and applications of “Safety Standards”,
- Relationship between Safety and Security.

Lecture 2. Nuclear Safety: The principle of “Defence in Depth” (DiD)
Students should be able to appreciate:
- The three fundamental “Safety Functions”,
- The principle of DiD
- The applications of DiD in the design process and operation of nuclear facilities,
- Wider application of DiD: Management for Safety.

Lecture 3. Fukushima Events and Lessons Learned
Students should be able to appreciate:
- Sequence of events during the Nuclear power plant equipment classification,
- Lessons learned,
- Objectives of European Council/ European Nuclear Safety Regulatory Group (ENSREG) “Stress Test”.

Prof Stephen Garwood:

Lecture 1. Engineering skill development and R&D support to Naval Reactor Plant Development
Students should be able to understand:
- Why Nuclear power was developed for Submarine Propulsion
- The relationship between the UK’s defence and civil Nuclear power programmes
- The range of Engineering support skills required to support the ‘Design to Decommission’ lifecycle of a Nuclear propulsion plant.
- The mechanisms employed to develop and maintain Nuclear Suitably Qualified and Experienced Personnel
- How to develop the required technical abilities and demographics in the design and manufacturing teams
- The underpinning R&D programmes required to maintain ‘spiral’ developments in long cycle product development programmes

Lecture 2. The Background to the UK Submarines Nuclear Steam Raising Plant
Guest lecturer: Jack Adams – Rolls-Royce-Submarines
Students should be able to understand:
- The origins of the UK development & construction programme for Naval PWRs
- The development of the Submarine Enterprise and the organisations and facilities involved
Future requirements for Naval Nuclear power.

**Lecture 3. Technical career development for ‘Nuclear’ Engineers in a large (FTSE100) Engineering company**

Students should be able to understand:

- The roles and career paths of project engineers, chief engineers and technical specialists
- How to develop and lead teams of Engineers
- How to network across functions and influence and manage project and functional groups in medium and large Engineering companies.
- How to understand complex Organisations and team structures and develop an Engineering career to Director level.

**Prof Laurence Williams:**

**Lecture 1. ‘The UK Nuclear Regulatory Environment’**

Students should be able to understand:

- The important role played by the nuclear regulator
- The concept of the "triple lock" and the role of the licensee as the "controlling mind" and the "intelligent customer.
- The UK nuclear licensing system and the development and use of standards set of licence conditions.
- The reasoning behind the introduction of licence condition 36.

**Mr Francois Perchet:**

**Lecture 1. French Nuclear History: a one of a kind example for other countries?**

Students should be able to:

- Have an understanding of the share of Nuclear energy in the Electricity Generation in France,
- How this happened, and what was the situation that allowed the program to develop when in other countries like the US, the 1973 Oil crisis initiated a shortage of investments that stopped the development of new nuclear plants, together with later on, fear of Nuclear accidents following TMI.
- Reflect by themselves on how this example is relevant or not to current nuclear renaissance in other countries.

**Lecture 2. Nuclear Operation: what is it to be an Engineer in a Working Nuclear Power Plant and positions to be filled in. Other opportunities in Design or Safety Organisations.**

Students should be able to:

- Get an understanding on how most plants in the world are organized and managed,
- What are positions that can be taken by young Engineers in a power plant,
- What are EPC companies - engineering, procurement and construction - and what are the associated jobs behind Design, Construction, and commissioning.
- Some other positions are uniquely related to Safety in Regulatory bodies for example.
- “Why” some specializes as Expert Engineers, others in Management, and why both careers could fulfill anyone life aspirations.
Lecture 3. New Build in the world and new countries willing to acquire nuclear energy

Students should be able to:
- Better know where New build is happening in the world, and could happen next,
- How established countries or industry leaders are involved with new countries.
- Have a preliminary view of what it takes for a new comer country to decide and embark in a nuclear power program, with some elements of a feasibility study.

**Recommended textbooks/Web sites** A = required, B = recommended but not essential, C = background reading.

**Dame Sue Ion:**
B [www.world-nuclear.org/](http://www.world-nuclear.org/) look in the Country profile section for an up to date summary of the UK
B [www.iaea.org/](http://www.iaea.org/) for general info on nuclear energy

**Prof Mamdouh El-Shanawany:**
B IAEA’s web site ([www.iaea.org/](http://www.iaea.org/))

**Mr Francois Perchet:**
B [www.world-nuclear.org/](http://www.world-nuclear.org/) look in the Country profile section for an up to date summary of the UK
B [www.iaea.org/](http://www.iaea.org/) for general info on nuclear energy

<table>
<thead>
<tr>
<th>Staffing</th>
<th>Lectures</th>
<th>Tutorials</th>
<th>Lab sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dame Sue Ion</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prof Mamdouh El-Shanawany</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prof Stephen Garwood</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prof Laurence Williams</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mr Francois Perchet</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Material</th>
<th>PowerPoint Lectures</th>
<th>Lecture Handouts</th>
<th>Tutorial Sheets</th>
<th>Lab Scripts</th>
<th>WebCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dame Sue Ion</td>
<td>3</td>
<td>0</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Prof Mamdouh El-Shanawany</td>
<td>3</td>
<td>0</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Prof Laurence Williams</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prof Stephen Garwood</td>
<td>3</td>
<td>0</td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Mr Francois Perchet</td>
<td>3</td>
<td>0</td>
<td></td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
Weighting:
Coursework: 100%

The pass mark for the module is 50% for the MSc Nuclear Students

Contact Details

Dame Sue Ion  Email:  Contact Miss Raj Gill for details
Prof Mamdouh El-Shanawany  Email:  Contact Miss Raj Gill for details
Prof Stephen Garwood  Email: s.garwood@imperial.ac.uk
Mr Francois Perchet  Email: fperchet@yahoo.com
Prof Laurence Williams  Email: laurence.williams@imperial.ac.uk
SC5— Nuclear Energy Policy

Course Leader: Professor William J Nuttall (Open University)
Status: MSc Option Course
Prerequisites: None

Aims
This module is intended to introduce and explore issues of public policy relating to commercial nuclear energy and the civil nuclear fuel cycle. The module content also forms part of the core of the University of Cambridge MPhil in Nuclear Energy, therefore basic understanding of reactor physics and nuclear engineering is assumed. The module is delivered jointly to Imperial College London, Cambridge University students and possibly students drawn from other programmes with which the OU has doctoral training links.

Learning outcomes
It is an aim of this module to expose the students to the messy realities of public policy. Such realities involve trade-offs, complex socio-economic and political factors and high levels of uncertainty. As such it is generally the case that there is no single ‘right answer’.

An objective of the course is to allow the students to appreciate the attributes of nuclear power as seen from the perspectives of stakeholders in a modern electricity market. By the end of the module the students should have a good introductory overview of current issues in electricity policy and the position of civil nuclear power in that landscape. Emphasis is given to the British context, as a leading nuclear renaissance nation.

Programme content:
1. Introduction to, and description of, the Nuclear Energy Policy module
2. Energy Policy – setting the scene
3. British Energy Policy History
4. Electricity – an unusual commodity
5. Energy Policy in Europe
6. Public Policy and communication
7. Nuclear New Build and the Energy Policy Triangle
8. Nuclear Energy Economics an Introduction
9. UK Nuclear Renaissance - latest
10. UK Nuclear Renaissance
11. Why Nuclear Power is Special
12. Special Topics – to be advised later

This list may be subject to alteration

Method of Assessment:
The module is to be assessed by coursework.

Two Individual Assignments (each weighted 50%)
The two individual assignments both form part of a single assessment. Each written assignment is weighted equally. These assignments are individual assignments. All sources of third-party information must be properly acknowledged and plagiarism policies will be strictly enforced. These assignments will be papers of maximum length 1,500 words.

The pass mark for the module is 50% for the MSc Nuclear Students
### Required Textbooks:

<table>
<thead>
<tr>
<th>Title</th>
<th>Sustainable Energy Without the Hot Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author</td>
<td>McKay, D</td>
</tr>
<tr>
<td>Publisher</td>
<td>UIT: Cambridge, 2009</td>
</tr>
<tr>
<td>ISBN</td>
<td>9780954452933</td>
</tr>
</tbody>
</table>
| Note                                       | Note this text is available as a free download from: https://www.withouthotair.com/  
It is also for sale as a bound book published by UIT Cambridge |

### Recommended Textbooks:

<table>
<thead>
<tr>
<th>Title</th>
<th>The Economics and Uncertainties of Nuclear Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author</td>
<td>François Lévêque</td>
</tr>
<tr>
<td>Publisher</td>
<td>CUP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Title</th>
<th>The Carbon Crunch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author</td>
<td>Helm D.</td>
</tr>
<tr>
<td>Publisher</td>
<td>Yale University Press</td>
</tr>
<tr>
<td>ISBN</td>
<td>9780300186598</td>
</tr>
</tbody>
</table>

### Other Readings to Consider:

<table>
<thead>
<tr>
<th>Title</th>
<th>The Paralysis in Energy Decision Making ear Energy Outlook 2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author</td>
<td>Malcolm Grimston</td>
</tr>
<tr>
<td>Publisher</td>
<td>Whittles Publishing</td>
</tr>
</tbody>
</table>

EBook available: http://www.whittlespublishing.com/  
The_Paralysis_in_Energy_Decision_Making

<table>
<thead>
<tr>
<th>Title</th>
<th>Nuclear Power: Past, present and future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author</td>
<td>David Elliott</td>
</tr>
<tr>
<td>Publisher</td>
<td>IOP Science (2017)</td>
</tr>
<tr>
<td>ISBN</td>
<td>978-1-6817-4504-6</td>
</tr>
</tbody>
</table>

A critical look at nuclear power
<table>
<thead>
<tr>
<th>Title*</th>
<th>Nuclear Renaissance: technologies and policies for the future of nuclear power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author</td>
<td>Nuttall, W. J.</td>
</tr>
<tr>
<td>Publisher</td>
<td>IOP Pub: Bristol, 2005</td>
</tr>
<tr>
<td>ISBN</td>
<td>0750309369</td>
</tr>
<tr>
<td>Note</td>
<td>Now rather out of date</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Title*</th>
<th>The Fall and Rise of Nuclear Power in Britain - A history</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author</td>
<td>Taylor, S</td>
</tr>
<tr>
<td>Publisher</td>
<td>UIT Cambridge UK (2016)</td>
</tr>
<tr>
<td>ISBN</td>
<td>9781906860318</td>
</tr>
</tbody>
</table>
I would like to welcome you to the Graduate School’s programme of professional development for Master’s students. Our team of tutors come from a wide variety of experiences and we understand just how important it is to develop professional skills whilst undertaking postgraduate studies. Not only does our programme help you to progress in your academic studies, it can also be part of your preparation for your future career. We provide the opportunity for you to practice your presentation skills, academic writing skills and other key skills. It will also give you the chance to meet students from a variety of subject disciplines building your network.

We offer a range of interactive courses including face-to-face workshops, interactive webinars and online self-paced courses. I encourage you to explore and engage with the diverse range of opportunities on offer from the Graduate School and I wish you well in your studies.

Janet De Wilde
Appendix C

The Graduate School
Welcome from Professor Sue Gibson, Director of the Graduate School

The Graduate School has several roles but our main functions are to provide a broad, effective and innovative range of professional skills development courses and to facilitate interdisciplinary interactions by providing opportunity for students to meet at academic and social events. Whether you wish to pursue a career in academia, industry or something else, professional skills development training will improve your personal impact and will help you to become a productive and successful researcher.

Professional skills courses for Master’s students are called “Masterclasses” and they cover a range of themes, for example, presentation skills, academic writing and leadership skills (http://www.imperial.ac.uk/study/pg/graduate-school/professional-skills/masters/). All Masterclasses are free of charge to Imperial Master’s students and I would encourage you to take as many as you can to supplement your academic training. The Graduate School works closely with the Graduate Students’ Union (GSU) and is keen to respond to student needs so if there is an area of skills training, or an activity that you would like us to offer, but which is not currently provided, please do get in touch (graduate.school@imperial.ac.uk).

The Graduate School also runs a number of exciting social events throughout the year which are an opportunity to broaden your knowledge as well as to meet other students and have fun. Particular highlights include the Ig Nobel Awards Tour Show, the Chemistry Show and the Master’s 360 competition. You should regularly check the Graduate School’s website and e-Newsletters to keep up to date with all the events and training courses available to you.

Finally, I hope that you enjoy your studies here at Imperial, and I wish you well.

Sue Gibson
Appendix D

Welcome from the Graduate Students’ Union (GSU)

I am delighted to be able to welcome you to Imperial College and to introduce you to the Graduate Students’ Union (GSU). The GSU ultimately serves to represent you as a postgraduate student and to ensure you have the most fulfilling and enjoyable time possible at Imperial.

The GSU is a university-wide representative body for postgraduate students with a committee comprised of democratically elected postgraduate students. The GSU works to support students on welfare fronts, represent students on educational matters by working with you to voice your concerns to College/departments, whilst also hosting recreational events throughout the year.

Imperial College London is undoubtedly a world-class institution with unique strengths in both teaching and research. Having been an Imperial student for 5 years myself I can fully appreciate that the university is nothing more than the people that comprise it – you’re among some of the brightest minds in the world and Imperial welcomes your contributions and enthusiasm in every sense! I encourage you to make the most of being a valued member of the Imperial community. I hope you have a fantastic time here at Imperial and manage to take advantage of the richness of opportunity that awaits you. If you have any questions at this stage, then please do get in touch.

Luke McCrone, GSU President 2017/18
gsu.president@imperial.ac.uk