MSc in Advanced Materials Science and Engineering

2017 — 2018 Course Handbook

Course Director: Dr Sandrine Heutz
Administrator: Mrs Raj Adcock

Please read this booklet now and refer to it throughout the year
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MSE 318 Surfaces and Interfaces
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MSE 409 High Temperature Alloys
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MSE 414 Nuclear Materials
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Appendix C—Welcome from Dr Janet De Wilde, Head of Postgraduate Professional Development
Appendix D—The Graduate School: Welcome from Sue Gibson (Director)
Appendix E—The Graduate Students Union: Welcome from Luke McCrone
1. Welcome from the Director

It is my great privilege to welcome you on to the MSc Advanced Materials Science and Engineering. On behalf of all members of the academic staff we wish you a rewarding and productive year of study.

The Department of Materials is the oldest and largest department of our kind in the UK. We have internationally-leading research programmes in the synthesis, processing, and modelling of a broad range of materials (metals, ceramics, semiconductors, glasses, ceramic-matrix composites, polymers and functional materials) directed to diverse applications such as nuclear, solid oxide fuel cells, aerospace, biomedical, automotive, communications and electronics to name a few.

This MSc is a stand-alone qualification designed to prepare students to solve problems in Materials Science and Engineering under the exacting conditions we encounter today. The programme is broad, covering many aspects of both the science of materials and engineering applications and includes a varied range of course work, projects, exams and an original research project.

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 familiarise yourselves with its contents. It will act as your first point of call and have 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.

kindest regards

Dr Sandrine Heutz
## 2. People

### Course Director

Dr Sandrine Heutz  
Room B336  
020 7594 672  
s.heutz@imperial.ac.uk

### MSc Administrator

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

### Admissions Tutor & Deputy Course Director

Dr Fang Xie  
Room 103  
020 7594 9693  
f.xie@imperial.ac.uk

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Other people in the Student Office who can also assist you with any enquiries:

- **Head of Student Administration:**  
  Mrs Fiona Thompson  
  Room G03a  
  fiona.thomson@imperial.ac.uk

- **Student Office Administrator:**  
  Miss Ela Calik  
  Room G03a  
  e.calik@imperial.ac.uk

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There are also a variety of other staff in charge of teaching who 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 MSc is split into two main components: a taught and a research element. The taught element has synergies with the MEng in Materials Science and Engineering. There are two compulsory taught modules, and students must take an additional five optional modules. It is possible that some students (those having graduated with a BEng in Materials Science and Engineering in our department) will already have taken one or both of the compulsory MEng modules, in which case these will be replaced by optional modules. To this is added a substantial research element including the research essay, a research project and one module on transferrable skills and research training (the Art of Research), all of which are compulsory. The number of European Transfer Credits (ECTS) are given in parentheses.

The compulsory MEng modules are:

(C1) MSE 302: Material Characterisation (6)
(C2) MSE 317: Materials Modelling (6)

The compulsory research related modules are:

(R1) The Art of Research (3)
(R2) Research Essay (8)
(R3) Research Project (37)

In addition to the core modules 5 optional courses must be taken from the following list:

(O01) MSE 307: Engineering Alloys (6)
(O02) MSE 308: Ceramic and Glasses (6)
(O03) MSE 309: Polymers and Composites (6)
(O04) MSE 310: Electronic Structure and Optoelectronic Behaviour (6)
(O05) MSE 312: Nanomaterials I (6)
(O06) MSE 315: Biomaterials (6)
(O07) MSE 318: Surfaces and Interfaces
(O08) MSE 404: Modelling Materials with Density-Functional Theory (6)
(O09) MSE 409: Advanced Engineering Alloys (6)
(O10) MSE 410: Advanced Thin Film Manufacturing Technologies (6)
(O11) MSE 411: Electroceramics (6)
(O12) MSE 412: Nanomaterials II (6)
(O13) MSE 413: Advanced Structural Ceramics (6)
(O14) MSE 414: Nuclear Materials (6)
(O15) MSE 417: Advanced Biomaterials (6)
(O16) MSE 418: Tissue Engineering (6)

As part of The Art of Research course the students will meet regularly with each other, with PhD students, and the course lecturer (who is also the student mentor). They will also meet regularly with their project supervisors late in the autumn term to discuss their projects, then during the spring term to write the research essays. A full time independent research project will run from the end of the exam period beginning the second week of the summer term to the beginning of September. Projects will be assessed by a final written report and oral presentation.

ECTS summary

Core modules = 12 ECTS
Research modules (R1 and R2) = 11 ECTS
5 x Option = 30 ECTS
Research Project = 37 ECTS
3.1 Thematic Strands

To support coherent course choices that work together and promote learning of more specific aspects of materials the course options are grouped into themes, as outlined below:

Compulsory courses
These courses must be studied by all students regardless of the strand or combination of courses they select.
- Art of Research
- Research Essay
- Research Project
- MSE 302 Materials Characterisation
- MSE 317 Materials Modelling

Ceramics and Glasses
- MSE 308 Ceramics and Glasses
- MSE 411 Electroceramics
- MSE 413 Advanced Structural Ceramics

Metals
- MSE 307 Engineering Alloys
- MSE 409 Advanced Engineering Alloys

Polymers and Composites
- MSE 309 Polymers and Composites
- MSE 413 Advanced Structural Ceramics

Functional Materials
- MSE 310 Electronic Structures and Opto-Electronic Properties
- MSE 318 Surfaces and Interfaces
- MSE 410 Advanced Thin Film Manufacturing Technologies
- MSE 404 Modelling Materials with Density-Functional Theory

Nanotechnology
- MSE 312 Nanomaterials
- MSE 412 Nanomaterials II
- MSE 410 Advanced Thin Film Manufacturing Technologies

Materials Survey
- MSE 315 Biomaterials
- MSE 414 Nuclear Materials
- MSE 417 Advanced Biomaterials
- MSE 418 Advanced Tissue Engineering

Students who have graduated (on the BEng) already from the Department of Materials are forbidden from repeating courses that they have previously completed.
3.2 Examination of Compulsory and Optional Courses

The examination of the compulsory and optional courses is solely by written examination with the exception of MSE 302, MSE 310, MSE 312, MSE 318, MSE 410 and MSE 412 which consist of coursework and written components. MSE 317 is assessed entirely by coursework and a test.

Project

The project is assessed as follows:

- The research essay (Literature review) contributes 20% of the overall mark
- A final presentation (in late September) accounts for 10% of the overall mark and
- A written research report (submitted in early September) accounts for 70% of the overall mark.

The project supervisor and an independent assessor mark the project report and literature review. In addition, supervisors are asked to add notes on the technical aspects of the project, the level of supervision required and any other factors that they feel should be made available to the external examiner. The report’s technical marks are calculated as the weighted average of the two marks (following moderation by the course director if needed).

The course consists of two elements:

- Lecture courses (46% of the total course mark), consisting of the components:
  1. Compulsory courses
  2. Optional courses

- Research Project and Courses (54% of the total course mark), consisting of the components:
  1. The Art of Research
  2. Research based teaching
  3. Research Essay
  4. Written Research Report
  5. Oral Final Presentation

3.3 Term breakdown

Term one:
- Materials characterisation (MSE 302)
- Choose a project supervisor

Term Two:
- Art of Research (students attend a scientific seminar once a week – e.g. those offered by the Thomas Young Centre and the London Centre for Nanotechnology series).
- Materials modelling (MSE 317)
- Research essay which should include a literature review plus a summary of the project aims and objectives (more detail on page 24).
- Start of Research Project—Project Planning.

Term Three:
- Exams early in the term
- Research project for the remainder of the term and carry on until mid August. By the start of September the students will have written a dissertation (more detail on page 24), and at the end of September will give a final oral presentation.
The table (below) gives you important coursework dates that you should remember. Coursework should always be handed in by 4pm into the coursework box (if it’s a hard copy submission) or as stated by the lecturer (this could be online through Blackboard Learn). Failure to hand in coursework on time will likely result in a zero mark for that component or element.

Please note that these dates are **preliminary and may change throughout the year**. You will be notified of changes by the MSc Administrator or the Student Office by email.

<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>Autumn Term</td>
<td>Module Options</td>
<td>Final Module Options</td>
<td>Thurs 5th Oct 2017 3pm</td>
<td>Options forms directly to Raj</td>
</tr>
<tr>
<td></td>
<td>Project</td>
<td>Choice of project title</td>
<td>Tues 24th Oct 2017 4pm</td>
<td>On-line selection</td>
</tr>
<tr>
<td>Spring Term</td>
<td>Research Essay</td>
<td>Literature Review report</td>
<td>Thurs 16th Feb 2018 4pm</td>
<td>See Page 24 for more detail</td>
</tr>
<tr>
<td></td>
<td>Project plan</td>
<td>Thesis</td>
<td>Thurs 22nd March 2018 4pm</td>
<td>Email directly to your project supervisor</td>
</tr>
<tr>
<td>Summer Term</td>
<td>Exams</td>
<td>All options</td>
<td>April to June N/A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Project (full time)</td>
<td></td>
<td>June-Sept N/A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Research Project</td>
<td>Thesis</td>
<td>Thurs 6th Sept 2018 4pm</td>
<td>See Page 24 for more detail</td>
</tr>
<tr>
<td></td>
<td>Project</td>
<td>Final Presentation</td>
<td>17th, 18th &amp; 19th Sept 2018 (All Day)</td>
<td>Oral Presentation</td>
</tr>
</tbody>
</table>

Please note you will also have **other deadlines throughout the year** depending on what modules you pick and the lab group you are in. These will be notified to you by the lecturer/demonstrator in your lectures/lab sessions.
4. Start of the Year

4.1 Fresher’s week
The first week of term has a mixture of welcoming talks and very important compulsory presentations about for example safety and proper use of resources. Also 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 are advised to either wait or collect it from us in the Student Office (during 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
• Transcript
• Degree Confirmation Letter

More detail about these letters can be found on the Student Hub page (http://www.imperial.ac.uk/student-hub/our-services/student-records/)

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 Co-Curricular Studies 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>Details</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 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 department’s 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 (it 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/.

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/.

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 12:00noon 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)

Note that the term dates only refer to the calendar of lectures and the taught element. Your research component will require you to attend College outside term. 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 the student is accompanied by a qualified person to supervise.
Computing rooms
You have access to the student computing room (G.08 & 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 silver 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</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>Grade</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A*</td>
<td>85%-100%</td>
</tr>
<tr>
<td>A</td>
<td>84%-70%</td>
</tr>
<tr>
<td>B</td>
<td>69%-60%</td>
</tr>
<tr>
<td>C</td>
<td>59%-50%</td>
</tr>
<tr>
<td>D</td>
<td>49%-40%</td>
</tr>
<tr>
<td>E</td>
<td>39%-0%</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. 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 Student Office 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.

You will do an online plagiarism awareness course during Fresher’s week to ensure that you have grasped all the concepts relating to good practice (see section 11.2).

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 gets 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 20).

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 email 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 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 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 and Mental Health Advice Service:
Level 4, Sherfield Building, Room 449
Telephone: 020 7594 9637   Email: counselling@imperial.ac.uk
http://www.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/

The Health Centre:
Imperial College Health Centre, 40 Princes Gardens, London SW7 1LY
Telephone: 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: Professor Julian Jones

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 organisation 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 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. http://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.

6. 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

7. 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.
8. Examinations

8.1 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.

8.2 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.

8.3 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.

8.4 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.

8.5 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 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.

9. Departmental policy of failures

9.1 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.

9.2 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.

9.3 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 in the summer, provided always that they have achieved a satisfactory mark in Research Project and Courses (>50% considered together).

9.4 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 either pass or repeat the year. They are required to withdraw from the College permanently.

9.5 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 two 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.
10. Research Project

The project normally starts at the end of the autumn term. At this time you will start a literature report, whilst still at College, to prepare you for your project work in the summer. The project is assessed on the literature you have been conducting 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 towards the end of September.

Art of Research/Research Based Teaching (all year)

Throughout the academic year students will participate in a series of lectures, seminars and small group learning exercises. Students will attended courses delivered by internal and external advisors covering a wide range of relevant topics, including; research ethics, entrepreneurialism, project management, presentation skills, interview skills as well as careers advice and contact with industrial links. In addition students are expected to attend regular scientific seminars within their allocated research groups, departmental seminars as well as centre (Thomas Young Centre and London Centre for Nanotechnology) colloquia, and three 1-page summaries of three of these talks will have to be written and sent to the student office. Students will have to attend two courses from the Graduate School (http://www.imperial.ac.uk/study/pg/graduate-school/professional-skills/masters/).

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. The Literature Review will be submitted through Blackboard Learn (plus additional electronic copy submitted through TurnItIn for a Plagiarism check) by 4pm on Thursday 16th February 2018.

Thesis (Research Project)

The thesis should answer the research question and convey the ability to develop an appropriate methodology to solve the problems posed. A high level of scientific understanding is expected. This includes an awareness of the scope and limitations of the techniques used, an ability to present and interpret results, the discussion of the results in light of the wider literature, and an understanding of the wider implications of the findings.

The literature review presented previously should not be repeated but should be included in the annex. Any significant deviations in the background literature required for the research results should be added in the main body of the report. Literature should of course be considered throughout the thesis as a support to the techniques and research results.

The layout should be discussed with the supervisor, but the recommended general outline is as follows:

- Abstract
- Introduction: brief overview of the background, statement of the aims, overview of the thesis layout.
- Updated literature review (if necessary*)
- Experimental/Materials and methods: brief overview of the techniques used and methods adopted or-developed. The information should be sufficient to allow the work to be reproduced by someone else
• Results and discussion: impeccably plotted graphs and annotated figures with helpful captions are expected. The results should be thoroughly described, with a clear narrative justifying the methods adopted and linking the findings to the aims. Discussions should go beyond simple description and be supported by general and specialised scientific concepts and literature.

• Conclusions and future work: a summary of the results and their implications in the field, as well as suggestions for key future work.

• References: the style should be consistent.

• Appendix (should contain the literature review submitted in February and any other appropriate Appendix materials).

The total word count should not exceed 12500 words, excluding Appendix and references. Therefore this number does not include the previous literature review. It is not necessary to reach 12500 words to do well – the number is intentionally high to allow those who need significant changes to the literature review to incorporate their update within the main body of the report.

Some other things to remember when submitting your thesis:

• Need 1 hard copies (bound)

• Electronic copy submitted through Blackboard Learn (for marking)

• Electronic copy submitted though TurnItIn (plagiarism check)

• Thesis Declaration (find this on Blackboard Learn)

• Normal 12 size font

• Style of font is Calibri or Arial (or similar)

• Should have a word count on the front of the document

• Word count up to 12,500 (a good thesis is concise) this does not include references and the appendixes

• A4 size

Deadline for your Thesis is Thursday 6th September 2018 4pm.

*The updated literature review will not be marked as it is part of the assessment in the Spring term. However please include it in the report appendix, and 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.
Project Planning

Planning is very important for the success of your research and you should discuss the practical aspects of your project, including timelines, samples, and training with your supervisor during the Spring term, and before 22nd March 2018.

We will provide opportunity for training on some shared equipment that you might need to use in the context of your research project. Please discuss with your research supervisor whether this training is required as they will need to formally approve your registration. This can be discussed during the project planning. We will not allow training if justification is not given.

Note that your access to the equipment is subject to availability so please make sure you plan your experiments carefully and be respectful of everybody’s needs on the equipment. Think carefully whether the time on a highly specialised equipment is really required, or if you could get the answers another way, and prioritise your key samples. Please note that any misuse of equipment can lead to your access being revoked.

Lab-work

Please note that safety is our number one priority. If you need to use labs, make sure you use the facilities responsibly and abide to the College, departmental and local safety rules. The compulsory safety lecture by Peter Petrov will provide you with the information you need to work safely, and should be referred to throughout the year.

Failure to abide by the safety rules will be penalised and can have consequences for your degree classification or even result in expulsion from the course.

We want you to experience our excellent research environment to carry out your project, but can only do so if the safety rules are followed. In particular, please note that access to the labs will only be provided following training and if you have demonstrated that you can work safely and responsibly. Access is left at the discretion of the Laboratory Operations Manager(s) and can be revoked at any time. You are also not allowed in the labs outside of College working hours, Monday-Friday, 8am-6pm and should not work on your own.

This still leaves plenty of time for experiments especially as you will need time to plot and interpret your results, and to refresh your knowledge of the literature. Therefore, a healthy balance of lab-work (or simulations in the case of theory-based project), planning, analysis and writing up is key to a successful project.

You should therefore aim to finish your lab-work (or simulations) two weeks before the project submission deadline.
11. The 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 (please see Appendix B for a welcome letter form the Graduate School)

11.1 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/

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
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/]
Appendices

Appendix A – Indicative Module Content

Unless otherwise stated the pass mark for each module is 50% for MSc Advanced Students
(C1) MSE 302: Materials Characterisation Updated

Course Co-ordinator: Prof Stephen Skinner

Aims: This course is designed to give students a firm foundation in the fundamentals of Materials Characterisation required in subsequent years of study, in particular in their long research project and internships. The mission of Materials Characterisation is to explain the use of advanced techniques for the study of structure-property relationships in materials.

Learning outcomes

Diffraction (Prof S Skinner)
At the end of this part of the course the students will be able to:

- Explain what X-rays are and describe their importance in structure determination
- Discuss the components contributing to the formation of a diffraction pattern
- Define and fully explain Bragg’s Law, the Laue equations, reflecting sphere construction and a reciprocal lattice
- Discuss the experimental challenges of obtaining a useful diffraction pattern
- Understand the importance of diffraction maxima for structure determination
- Fully explain the atomic structure factor in terms of X-ray scattering
- Explain the origin of systematic absences
- Index powder patterns for cubic systems
- Describe the similarities and differences between neutron and electron diffraction compared with XRD
- Demonstrate an understanding of the use of Le Bail and Rietveld analysis techniques to diffraction analysis.

Focussed Ion Beam instruments and Secondary Ion Mass Spectrometry (Dr S Fearn)
On successfully completing this course unit, students will be able to:

- Discuss ion-solid interactions for incident ion energies from 1keV to 50keV and the production of secondary particles including neutral atoms and atomic and molecular ions, electrons and photons. This topic includes the modelling program, SRIM.
- Understand the concept of sputter yield
- Understand the concept of secondary ion formation and important effects such as surface oxygen coverage on the efficiency of positive secondary ion formation.
- Discuss the concept of electronic and nuclear stopping powers and their relevance to the origin of sputtered species for surface composition analysis by secondary ion mass spectrometry (SIMS)
- Understand the concept of mass resolution and how this is achieved by time-of-flight, magnetic sector and electric quadrupole mass filters.
- Discuss the application of SIMS to surface analysis and its modes of operation including mass spectra, surface imaging and concentration depth profiling.
- Understand the requirements for the quantification of secondary ion intensities in particular matrix effects and dilute solution cases such as semiconductor dopants.
- Understand the characteristics of primary ion sources including liquid metal, gas ion and thermal ionisation used in focussed ion beam (FIB) and SIMS instruments.
- Discuss characteristics of primary ion sources such as their brightness and limiting effects such as spherical and chromatic aberrations in the formation and resolution of scanned ion beams for FIB and SIMS.
- Discuss the applications and use of Focussed Ion beam instruments (FIB) for the preparation of highly polished surfaces of solid, particularly composites with minimal introduced damage.
- Understand the origin of channelling contrast obtained with highly collimated FIB ion beams.
**Electron Microscopy (Dr Ahu Parry)**

On successfully completing this course unit, students will be able to:

- Explain wave-particle duality and discuss the wave properties of electrons
- Discuss the concept of resolution
- Describe the design and operation of scanning (SEM) and transmission (TEM) electron microscopes, with particular reference to electron sources, electrostatic lenses and electromagnetic lenses
- Describe specimen preparation techniques for SEM
- Describe the specimen preparation for TEM
- Discuss the types of aberration that can arise and current practical resolution limits for SEM and TEM
- Discuss contrast mechanisms in SEM
- Describe and explain secondary electron imaging and backscattered electron imaging in SEM
- Discuss contrast mechanisms in TEM
- Describe and explain bright-field imaging, dark-field imaging and diffraction pattern formation in TEM
- Discuss the theory and use of energy dispersive X-ray analysis and electron energy loss spectroscopy
- Discuss the scanning transmission electron microscope and the use of high-angle annular detectors for imaging

**Scanning Probe Microscopies (Dr V. Bemmer)**

On successfully completing this course unit, students will be able to:

- Explain what scanning probe microscopy is.
- Discuss the lateral imaging range and sensitivity to structure and properties
- Specifically describe the theory, use and operation of the STM and AFM including strengths and weaknesses of each technique
- Discuss applications of SPM to materials characterisation

**Thermal analysis (Mr R Sweeney)**

At the end of the course the students will be able to:

- Describe the different types of thermal analysis techniques available
- Interpret DSC, TG and DTA data for simple materials

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

| B | Structure from Diffraction Methods, Eds. D.W. Bruce, D. O’Hare and R.I. Walton, John Wiley & Sons Ltd, Chichester, UK, 2014 |
| C | Characterization of Materials Elton N. Kaufmann, Wiley InterScience (Online service), Hoboken, NJ : John Wiley and Sons 2012 2nd ed. |

**Structure, teaching and learning methods**

26 lectures: Autumn term
1 classwork exercises: Autumn term
4 practical lab sessions: Autumn term
Examination
The course is examined in the summer term. The examination paper, duration 2½ hours, has 8 questions and is comprised of a mixture of short questions plus a long question that is based on analysing a series of experimental results and writing a reasoned interpretation of these data.

Coursework
Students are expected to submit a report for each of the four practical labs associated with the course.

Weighting
Exam: 50%
Coursework: 50%

*The pass mark for the module is 50% for MSc Advanced Students.*

<table>
<thead>
<tr>
<th>Staffing</th>
<th>Lectures</th>
<th>Classwork</th>
<th>Lab sessions</th>
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<td>Prof Skinner</td>
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<td>Dr Bemmer</td>
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<th>Course Material</th>
<th>PowerPoint Lectures</th>
<th>Lecture Handouts</th>
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<tr>
<td>Mr Sweeney</td>
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(C2) MSE 317 Materials Modelling

Course Co-ordinator: Dr A Horsfield

Aims: This course introduces students to a selection of important modelling techniques. It covers methods applicable to a range of length scales and materials types that can be used to solve practical problems in Materials Science and Engineering. Students will have an opportunity to use these methods by performing simulations using code that will be provided.

Learning outcomes
By the end of the course, students should know and understand the following concepts and methods and be able to apply them to practical materials problems.

Introduction (Dr A Horsfield)
- Overview of computer simulation
- Length and time scales
- Introduction to MATLAB

Finite Elements and Crystal Plasticity (Dr Zebang Zheng)
- Hamilton’s principle
- Use of 1D truss and 2D continuum finite elements for elastic problems
- Crystal slip and the slip rule
- 1D crystal plasticity in fcc single crystals
- 2D FE fcc polycrystal plasticity

Monte Carlo Methods (Dr A Horsfield)
- Understand the algorithm for Metropolis Monte Carlo
- Apply Metropolis Monte Carlo to finding the equilibrium distribution of one or more particles

Diffusion (Dr A Horsfield)
- Understand the diffusion equation and how to solve it using finite differences and Fourier Transforms
- Understand the merits of explicit and implicit solvers
- Apply kinetic Monte Carlo to solve the diffusion equation

Phase Field Methods (Dr A Horsfield)
- Understand the concept of a phase field
- Understand the relation of the free energy to the equation of motion of the phase field
- Understand the Cahn-Hilliard equation for spinodal decomposition
- Solve the Cahn-Hilliard equation for the spinodal decomposition of a binary alloy

Energy landscapes (Dr P Tangney)
- Understand the concept of a potential energy surface in the context of aggregates of atoms
- Understand how the atoms’ real potential energy surface may be approximated to make atomistic calculations tractable
- Understand the basics of how different types of bonding (ionic, covalent, metallic, van der Waals) are modelled
- Understand what it means to find the minimum-energy structure of a molecule or crystal.

Molecular Dynamics (Dr P Tangney)
- Understand the molecular dynamics method for calculating finite temperature properties
- Understand how to perform a Molecular Dynamics simulation (velocity Verlet) and a simple way to introduce the effect of a surrounding medium (Langevin dynamics)
- Use Langevin dynamics to compute equilibrium properties of a model polymer in solution
Research Lecture (TBC)
- Understand a current research topic that employs computer simulation

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

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Structure, teaching and learning methods
24 hours lectures plus exercise classes (MEng and BEng), or 27 hours lectures plus exercise classes (MSc): Spring term

Coursework
Assessment is through 3 problem sets, a 2 hour online multiple-choice test, and a research essay (MSc only). For **MEng and BEng** students, the problem sets have equal weight and together are worth 70 marks; the test is worth 30 marks. For **MSc students**, the problem sets have equal weight and together are worth 60 marks; the test is worth 30 marks, and the essay is worth 10 marks.

**The module contributes 100 marks of the third year. The pass mark for the individual module is 40% for BEng and MEng students. The pass mark for the MSc Advanced Materials programme is 50%.**

Weighting
Test: 30%
Coursework: 70%

The pass mark for the module is 50% for MSc Advanced Students.

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<td>Dr P Tangney</td>
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</table>
Aims: The aim of the course is to build an understanding of how to work with alloy systems; how metallurgists think about alloy development and select and process alloys for different uses. Case studies of incidents are used to explore how production and repair can impact upon life and lead to premature component failure. The alloys used as exemplar systems will depend on the interests of the teaching staff but historically aerospace materials have formed a significant focus.

Learning outcomes

Introduction; Alloys and Alloy Design (Prof D Dye)
- Materials selection using Aerospace systems as an example; balance-of-properties vs Ashby map optimisation; fatigue and fatigue lifing; fatigue lifing approaches.
- Alloying: Hume-Rothery rules, limitations on elastic moduli for stability and ductility, phonons
- Low defect processing: VIM, VAR, ESR and subsequent open die and closed die forging; Ti and Zr alloys vs Ni alloys.
- Case study: Sioux City. Failure investigation, engineering systems vs component failures; defect control (VAR vs EBCHR).

Titanium Alloys (Prof D Dye)
- Phases: Production of titanium; phases and crystallography of phase transformations; alpha and beta stability; titanium alloy classifications and uses; Ti3Al as ordered alpha-Ti and relationship to dislocation mechanisms.
- Microstructures: Production of lamellar / colony / basketweave, equiaxed and bimodal microstructures in Ti-6Al-4V, macrozones and variations; Ti-5553 as an example; omega and nucleation.
- Micromechanics 1: elastic anisotropy of the alpha phase, alpha/beta OR and slip localisation, texture and fracture surfaces depending on grain orientation.
- Micromechanics 2 and Applications: Dwell Fatigue, melt anomalies, armour applications, creep resistance titanium alloys, near-beta landing gear alloys, biomedical superelastic beta alloys.

Aluminium Alloys (Dr V Vorontsov)
- Major alloys: production of Al alloys; alloy classification system.
- Physical metallurgy: strengthening mechanisms and phases; heat treatment; processing for properties.
- Applications: airframes, auto-parts and beverage cans.
- Novel alloys and processing: high temperature alloys Al-Zr and Al-Sc; spray forming.
- At the end of this part of the course, the student will be:
- Able to discuss the major types of Al alloys

Nickel (Dr V Vorontsov)
- Alloy design: phases, Ni3Al; alloy types and uses; strengthening mechanisms; drivers of alloy evolution.
- Alloy types: deriving a creep-rupture performance parameter; Classification as wrought / DS / SX, processing, P/M, weldability, lifing, TBCs.
- Application of Ni superalloys in aerospace.

Steels
- Deformation and strengthening
- Phase transformations
- Growth of ferrite
- Low alloy steels
- Bainite
- Martensite
- Thermomechanical processing
**Recommended textbooks** A = required, B = recommended but not essential, C = background reading

<table>
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<tr>
<th>Level</th>
<th>Title</th>
<th>Authors/Editors</th>
<th>Notes</th>
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<tr>
<td>B</td>
<td>The Microstructure of Superalloys. Durrand-Charre</td>
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<td>B</td>
<td>Air Accident Reports on Sioux City, NTSB</td>
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<td>B</td>
<td>Titanium</td>
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<td>B</td>
<td>Baintite in Steels, H. K. D. H. Bhadeshia, IOM, 2001</td>
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<td>B</td>
<td>The Superalloys, RC Reed</td>
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<td>C</td>
<td>Metals Speciality Handbooks in Nickel and Titanium</td>
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<tr>
<td>C</td>
<td>Fatigue of Materials</td>
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**Structure, teaching and learning methods**

24 lectures: Spring term

**Examination**

The course is examined in the summer term in a single 3 hour examination paper composed of 6 questions. Students answer 4 questions from the 6 available. The balance of questions will broadly reflect the balance of lectures.

**Weighting**

Exam: 100%

The pass mark for the module is 50% for MSc Advanced Students.

<table>
<thead>
<tr>
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<th>Lectures</th>
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<tr>
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<tr>
<td>Dr VA Vorontsov</td>
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<tr>
<td>Prof AT Paxton</td>
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(O02) MSE 308: Ceramics and Glasses Updated

**Aims:** The overall aim of this course is to introduce students of the main methods and fundamental principles used for the processing of engineering ceramics (and, to a lesser degree, glass and glass ceramics) and develop an understanding of the factors that influence their mechanical properties. Furthermore, the course will give an introduction to microwave application of ceramics and discuss the electrodynamic response from dc to infrared frequencies and its correlation to the microstructure.

**Learning outcomes**

*Part 1: Processing of bulk and thin film ceramics (Prof E Saiz)*

At the end of this part of the course the student will be able to:
• Define the chemical composition and physical properties of ceramic materials and explain the difference between traditional ceramics and advanced ceramics.
• Describe the structure of glasses and their formation. Explain the models of glass structure: crystallite model and random network model. Describe the structure of oxide glasses: silica, silicate glasses, borate glasses.
• Understand general concepts in solid-liquid-vapour systems: surface/interface energies; wetting and contact angles; capillary forces and the relevance of these concepts to ceramic and glass processing.
• Understand the importance of rheology in ceramic and glass processing including rheology of liquids (e.g. melt glass) and suspensions of solid particles in liquid (e.g. ceramic slips). Newtonian liquids. Non-Newtonian flow. Viscosity of molten glasses and ceramic slurries.
• Describe powder synthesis methods (mechanical and chemical methods) and explain the desirable powder characteristics including size distribution; surface area; shape; particle packing; mixing and milling.
• Understand the parameters that control powder packing and the dry pressing of ceramic powders.
• Describe the different types of particles (particles, agglomerates, granules, flocs, colloids, aggregates).
• Describe the different techniques for measuring the particle size distribution of ceramic powders (light scattering, microscopy, sieving, sedimentation) and derive an expression for the sedimentation rate of particles in a powder suspension.
• Describe how to determine characteristics of powders (shape, surface area, porosity, crystallographic structure, agglomeration).
• Describe the origins and characteristics of different forces between powder particles including their typical orders of magnitude.
• Explain the types of colloids and explain the different methods to stabilize colloidal suspensions (electrostatic stabilization, steric stabilization, electrosteric stabilization).
• Define the terms zeta potential, isoelectric point, flocculation, coagulation and gelation and explain qualitatively how they are related to interparticle forces.
• Describe the different stages of solid state sintering, the mass transport processes occurring and their consequences for the developing microstructure.
• Explain the interaction between grain growth, pore stability and microstructure in solid state sintering and how this can be controlled to give dense fine-grained final microstructures.
• Describe qualitatively the processes taking place during liquid phase and viscous glass and viscous composite sintering, explain the dominant factors in selection of a suitable liquid and critically compare its advantages/disadvantages with respect to solid state sintering.
• Describe glass-ceramics, their formation from crystallisation and the types of glass-ceramic microstructures.

Mechanical properties of ceramics and glasses (Dr F Giuliani)
At the end of this part of the course the student will be able to:
• Understand the mechanical properties of ceramics in particular, fracture strength, Young’s modulus and fracture toughness
• Calculate elastic constants of two-phase ceramics by analytical methods
• Appreciate the effect of microcracking on Young’s modulus
• Understand the Griffith’s energy balance criterion in a crack brittle solid
• Understand the link between cracks and stress concentrations
• Appreciate the role of Griffith’s flaw in determining fracture strength of ceramics
• Appreciate the major effect of porosity and other microstructural features on mechanical strength
• Appreciate the statistical nature of the fracture strength of ceramics
• Calculate Weibull modulus of ceramics submitted to fracture strength tests
• Understand the development of internal thermal stresses in ceramics
• Understand toughening mechanisms in ceramics
• Distinguish between different toughening mechanisms as their correlation with microstructure
• Understand thermal and time aging effects in ceramics, including creep, subcritical crack growth and thermal shock behaviour
• Determine the relationship between microstructural features, in particular porosity, and thermal shock resistance

**Part 3: Electrodynamic properties and high-frequency applications of ceramics (Prof N Klein)**
• Explain and calculate the relation between the electrical polarizability and dielectric constant by the Clausius-Mossotti equation.
• Explain the temperature dependence of the dielectric constant by the Clausius-Mossotti equation.
• Be able to explain and apply the concept of the complex dielectric permittivity and its relation to the reflection and absorption of electromagnetic waves.
• Explain the concept of a dielectric resonator and its applications in microwave communication technology.
• Explain the definition of the Q factor, its relation to the loss tangent and how it is being measured.
• Explain and calculate the dielectric function of an ionic crystal in terms of the harmonic oscillator model and explain its relation to infrared absorption by phonons.
• Explain intrinsic and extrinsic microwave losses of ceramics.

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

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<tr>
<th>Level</th>
<th>Book Title</th>
<th>Author(s)</th>
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<tbody>
<tr>
<td>A</td>
<td>Introduction to Ceramics</td>
<td>W. D. Kingery</td>
<td>J. Wiley &amp; Sons (1976)</td>
</tr>
<tr>
<td>B</td>
<td>Ceramic processing and sintering</td>
<td>M.N. Rahaman</td>
<td>Marcel Dekker (1995)</td>
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<tr>
<td>C</td>
<td>Concise Encyclopedia of Advanced Ceramic Materials</td>
<td>ed. R. J. Brook</td>
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<td>C</td>
<td>Modern Ceramic Engineering</td>
<td>D. W. Richerson</td>
<td>Marcel Dekker</td>
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<td>C</td>
<td>Glasses and the Vitreous State</td>
<td>J. Zarzycki</td>
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**Structure, teaching and learning methods**
The course is delivered by lectures in the Autumn term (with some class exercises) and parts A and B and C are given concurrently.

**Examination**
The course is examined in the summer term. The examination paper, duration 3 hours, has 6 questions and students must answer 4.

**Weighting**
Exam: 100%

The pass mark for the module is 50% for MSc Advanced Students.

<table>
<thead>
<tr>
<th>Staffing</th>
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<tbody>
<tr>
<td>Prof E Saiz</td>
<td>8</td>
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<td>Dr F Giuliani</td>
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<td>Prof N Klein</td>
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</table>
Aims: The overall aim of this course is to introduce students to the main methods and fundamental principles used for the processing of polymers and composite materials and to develop an understanding of the factors that influence their mechanical properties.

Learning outcomes

**Polymers (TBC)**
At the end of this part of the course the student will be able to:

- Describe the characteristics of high-strength polymer structures
- Understand the influence of molecular weight and macroscopic properties
- Understand the interrelationships of processing and properties
- Understand how high-strength fibres can be produced
- Understand how molecular chain conformation influences which processing methods need to be selected
- Have knowledge what processing routes exist to produce high-strength fibres
- Understand the difference between lyotropic and thermotropic

**Elastic behaviour of composites (Dr L Vandeperre)**
At the end of this part of the course the student will be able to:

- To define a composite material, and give examples of common matrices and fibrous reinforcements, their properties and how they are made
- Explain the relevance of fibre flexibility and can quantify it
- Argue the advantages and disadvantages of classifying composites on the basis of matrix or architecture
- Make a quick assessment of realistic property ranges that can be obtained when making a composite of 2 materials
- Derive expressions for the elastic properties of long fibre composites, discuss which of these are likely to be accurate and be aware of empiric expressions, which give better results
- Use tensor notation to express the in-plane elastic response of long fibre composites and can use this approach to determine off-axis elastic properties
- Sketch the variation with loading angle of the elastic properties and can explain why this variation is as observed
- Discuss how polymer laminates reduce the anisotropy due to aligned fibre laminae and appreciate how the properties of a laminate can be calculated
- Explain the shear-lag model for composites with short reinforcements and derive the stress and strain distribution around a reinforcement, understand the significance of the stress transfer length concept and are aware that normal stress transfer can be important
- Describe the principles underpinning the Eshelby method including background stress for improved prediction of composite stiffness
- Predict the thermal expansion of simple composites and hence of residual stresses due to cooling from processing temperatures and have a good awareness of how heat is conducted through composites and the importance of heat transfer across interfaces
- Discuss a range of failure modes for fibre reinforced composites (axial and transverse tensile failure, axial compression failure)
- To analyze the axial tensile failure of fibre reinforced composites in detail and hence to derive a simple criterion for axial tensile strength
- To derive the relation between matrix shear yield strength and buckling induced compressive failure

**Metal Matrix Composites (Prof E Saiz)**
At the end of this part of the course the student will be able to:

- Appreciate the key engineering and scientific reasons for the development of metal-matrix composites
- Describe and classify processing technologies for metal-matrix composites
- Understand the role of wetting and adhesion at dissimilar interfaces in the fabrication and mechanical response of composites
• Use simple micromechanical models to describe the reinforcement mechanisms in metal-matrix composites
• Develop material selection criteria for different applications

Ceramic Matrix Composites (Prof E Saiz)
At the end of this part of the course the student will be able to:
• Discuss the importance of chemical and thermal compatibility in choosing reinforcement and matrix material
• Compare and contrast conventional powder processing techniques for ceramic matrix composites such as cold isostatic pressing, sintering and hot pressing
• Be able to discuss specific advantages of unconventional techniques for ceramic matrix composite fabrication including reaction bond processes, infiltration, The Lanxide process, in-situ chemical processes such as chemical vapor deposition (CVD) or infiltration (CVI), reactive consolidation or liquid phase sintering, sol-gel, polymer infiltration and pyrolysis (PIP), Self-propagating high temperature synthesis (SHS), Electrophoretic Deposition
• Explain the role of interfaces in toughening and crack propagation in CMCs

Polymer Matrix Composites (Dr L Vandeperre)
At the end of this part of the course the student will be able to:
• Describe a number of processing technologies for polymer matrix composites
• Be aware of a range of new architectures based on fabrics to address the problem of interlaminar cohesion

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

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<tr>
<td><strong>A</strong> RJ Young and PA Lovell “Introduction to polymers” Chapman and Hall 1983</td>
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<tr>
<td><strong>B</strong> RJ Crawford “Plastics Engineering” Pergamon 1987</td>
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<tr>
<td><strong>B</strong> AJ Kinloch and RJ Young “Fracture behaviour of polymers” Applied Science 1983</td>
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<td><strong>B</strong> JG Williams “Fracture Mechanics of polymers” Ellis Horwood 1984</td>
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<td><strong>B</strong> CB Bucknall “Toughened Plastics” Applied Science 1977 (Dated Introductory parts only)</td>
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<td><strong>B</strong> Concise Encyclopaedia of Composite Materials, ed. by A. Kelly, Elsevier, 1999</td>
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<td><strong>C</strong> M. Taya, R. J. Arsenault, Metal Matrix Composites – Thermomechanical Behaviour, Pergamon Press, 1989</td>
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<td><strong>C</strong> K. K. Chawla, Ceramic Matrix Composites, Chapman and Hall, 1993</td>
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<tr>
<td><strong>C</strong> Handbook of Ceramic Composites, ed. by N. P. Bansal, 2005</td>
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Structure, teaching and learning methods
The course is delivered by lectures and course material is available through Blackboard.

Examination
The course is examined in the summer term. The examination paper, duration 2½ hours, has 6 questions. Students are required to answer 3 questions.

Weighting
Exam: 100%

The pass mark for the module is 50% for MSc Advanced Students.
Aims: This course describes the electronic devices used to emit light, transmit light and detect light and to show how these elements can be combined to create integrated systems for fibre optic communications, solar energy conversion and displays.

Learning outcomes
The students will be able to:

- Explain the background physics necessary for an understanding of the optoelectronic properties of materials;
- Discuss how reflection and refraction give rise to colour from transparent materials;
- Describe the influence of microstructure on colour (scattering and diffraction);
- Illustrate the absorption and luminescence of light from a material;
- Design a material with a specified absorption edge;
- Rationalise the broad emission obtained from a phosphor;
- Describe a fibre optic communication link;
- Compare and contrast a fibre optic link and a copper wire for data communication;
- Describe the materials used and principles of operation of light emitting diodes (LEDs) working in the visible and infra-red parts of the electromagnetic spectrum;
- State the principal materials requirements of a LED and define the materials selection criteria;
- Justify the need for a population inversion in an semiconductor laser and will be able to explain how this is achieved in a homojunction laser, a single heterojunction laser and a double heterojunction laser;
- Describe semiconductor lasers with reference to band gap and refractive index engineering as well as optical feedback;
- Explain, with examples, the difference between passive and active solar energy and direct and indirect solar devices;
- To discuss the economic and environmental viability of photovoltaic cells and define energy pay-back time;
- To give and utilise equations that relate fill factor, voltage and current to solar cell efficiency;
- Justify why silicon is a material used in solar cells despite the fact that it is an indirect band gap semiconductor;
- Describe recent developments in silicon solar cell technology aimed at increasing efficiency and reducing unit cost;
- Sketch band diagrams for hetero-junction cells, list materials used, explain processing procedures and discuss concerns about the viability of such cells;
- To compare and contrast solar cells in which charge transfer is driven by the junction potential and an excitonic cells;
- Describe the different types of excitonic solar cells and the challenges in commercialisation of the technology;
• Sketch the different phases a liquid crystal may exhibit and explain how the different phases can be characterised;
• Explain why a chiral liquid crystal acts as a waveguide;
• Discuss how liquid crystals orientate in a field and evaluate the importance of the Fréedericksz transition; and
• Sketch and clearly label the key components of a liquid crystal display.

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

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Structure, teaching and learning methods
The course is delivered by lectures and course material is available through Blackboard.

Assessment
For BEng and MEng students the module contributes 100 marks of the third year and is assessed by examination. The pass mark for the BEng and MEng cohorts is 40%.

For students following the MSc Advanced Materials Science and Engineering programme the module is assessed by examination (80% of component mark) and coursework (20% of component mark). For MSc students the pass mark for the component is 50%. The component is an optional module within the lecture element of the MSc programme.

Examination
The course is examined in the summer term. The examination paper last 2.5 hours. Students may select any three questions from 5.

Weighting
Exam: 80%
Coursework: 20%

The pass mark for the module is 50% for MSc Advanced Students.

<table>
<thead>
<tr>
<th>Staffing</th>
<th>Lectures</th>
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<tbody>
<tr>
<td>Dr M Oxborrow</td>
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<tr>
<td>Prof J Riley</td>
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<tr>
<td>Prof J Riley</td>
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</table>
O05) MSE 312 Nanomaterials Updated

Aims: This course is designed to provide the student with a fundamental understanding of nanoscience and how this can be applied in technological devices. A mechanistic description of the structure/property relationships will be covered for each class of material with a focus on the specific advantages that nanoscale materials can provide. The student will gain an understanding of the processing routes to produce controlled nanostructures.

Learning outcomes

Properties and Processing of Nanostructured Materials (Prof M Ryan)
- Explain the effect of nanoscale structure on the mechanical properties of materials
- Describe the formation, properties and applications of nanoporous materials
- Understand the effects of surface energy on the thermodynamics of nanoscale systems
- Describe bottom-up versus top-down routes for nanomaterials processing
- Discuss nucleation versus growth of nanostructures and describe surface versus diffusion limited growth regimes

Electronic Properties of Nanostructured materials (Prof J Riley)
- Explain surface plasmon resonance in metals
- Discuss why the colour of metal nanoparticles differs from that of the bulk material
- Calculate the Bohr radius of an exciton
- Describe quantum confinement in semiconductor Q-dots
- Interpret Coulomb blockade in nanoparticles arrays
- Illustrate how nanowires can be employed in sensor applications
- (Debate how band-edge tuning influences charge transfer to and from nanoparticles

Vapour Phase Deposition of Thin Film Nanostructures (Dr P Petrov)
- Describe chemical and physical methods for thin film deposition
- Understand device patterning and discuss the limitations of lithographic techniques
- Give examples of device structures that are formed using vapour phase patterning
- Describe the methods for testing and characterisation of thin film device structures

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

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<tbody>
<tr>
<td>B</td>
<td>Nanostructures and Nanomaterials - Synthesis, Properties and Applications</td>
</tr>
<tr>
<td></td>
<td>Guozhong Cao, Imperial College Press.</td>
</tr>
<tr>
<td>C</td>
<td>Metal Nanoparticles – Synthesis, Characterization and Applications</td>
</tr>
<tr>
<td></td>
<td>D. Feldheim and C. Foss, Marcel Decker</td>
</tr>
</tbody>
</table>
Structure, teaching and learning methods
24 lectures: Autumn term

Examination
The course is examined in the summer term. The examination paper, duration 2½ hours, has 5 questions. Students must answer 3 questions.

Coursework:
Part 1: Tutorial questions
Part 2: Collaboration project with Victoria and Albert Museum

Weighting
Exam: 80%
Coursework: 20%

The pass mark for the module is 50% for MSc Advanced Students.
Aims: This course is designed to give students the firm foundation in the fundamentals of Biomaterials required in subsequent years of study for those taking Advanced Biomaterials in year 4 and for those taking the MEng in Biomaterials and Tissue Engineering and to serve as a self-standing unit. The missions of Biomaterials are to explain the types and properties of materials needed for various medical applications and how to synthesise and characterise them.

Learning outcomes
At the end of the module the student should be able to:

• Identify various components of the human body, describe their function and explain the effects of ageing on the structure and mechanical properties of various groups of tissues and organs.
• Describe the major classes of biomedical implant materials, their means of fixation, stability and advantages and disadvantages when used as implants devices and in artificial organs.
• Explain the types of failure of implants and devices in various clinical applications and reasons for failure.
• Describe the physiological principles involved in the replacement of various parts of the body with artificial organs, transplants or tissue engineered constructs and the clinical compromises involved.
• Defend the relative merits of replacing a body part with a tissue engineering construct, discuss the principles involved in growing body parts in vitro and describe the physiological and clinical limitations involved.
• Be capable of rapidly researching the literature for new developments in replacement of tissues and organs.
• Be able to communicate alternative means to repair or replace parts of the body to both healthcare professionals and patients.

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

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Structure, teaching and learning methods
24 lectures: Autumn Term

This course is aimed at a variety of students. Approximately 170 take the course:

• Department of Materials: 3rd year BEng and MEng undergraduates as an advanced option of Materials Science and Engineering degree and its variations. 3rd year MEng students compulsory course for Biomaterials and Tissue Engineering students, option for MSc Advanced Materials.
• Department of Bioengineering: 3rd year BEng and 4th year MEng undergraduates, MSc (taught postgraduates).

Following an introductory lecture, students are split into two groups for two further introductory lectures to bring students from different backgrounds up to speed for the course. The lecture schedule and course layout is attached Materials and Mechanical Engineering students are given two lectures on basic biology concepts in Biology for engineers, Bioengineering students are given an introduction to the properties and structure of metals, ceramics, polymers and composites.
Handouts given at lectures are the slides presented by the lecturer, with space for extra notes. Full notes are not given as this may discourage students from attending.

A published book has been created as a companion to the course. This also contains a CDROM that has supplementary lectures and study questions. Copies are available in the library.

Panopto is used in full.

**Assessment**

*Examination*

The course is examined in the summer term. The examination paper, duration 2.5 hours, has 5 questions of which students must answer 3 (20 marks per question).

The module contributes 100 marks of the third year. The pass mark for the individual module in the BEng scheme and MEng scheme is 40%. The pass mark for the MSc programmes is 50%.

**Weighting**

Exam: 100%

The pass mark for the module is 50% for MSc Advanced Students.

<table>
<thead>
<tr>
<th>Staffing</th>
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<tbody>
<tr>
<td>Prof J Jones</td>
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<tr>
<td>Dr I Dunlop</td>
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<tr>
<td>Prof E Saiz</td>
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<tr>
<td>Prof M Stevens</td>
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<td>Prof J Jones</td>
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</table>
(007) MSE 318 Surface & Interfaces

**Aims:** This course is designed to provide the students with the basic knowledge of the properties of surfaces and interfaces, focusing on their structure, energy, electronic and chemical properties. Consequences in a range of applications including thin film growth, the shape of nanostructures, the underlying physics of electronic and magnetic devices, will be discussed. The course will provide a thorough overview of the typical analytical techniques used to characterise surfaces and buried interfaces.

**Learning outcomes:**
1. **Structure of surfaces (4 hours)**  
   - Nomenclature  
   - Defects  
   - Techniques: LEED, RHEED, STM/SPM, GIXD
2. **Energy of surfaces (2 hours)**  
   - Surface free energy, surface tension  
   - Wulff shape  
   - Curved interfaces
3. **Electronics and chemical bonding at interfaces (6 hours)**  
   - Recap on bonding  
   - Charge distribution at surfaces and interfaces  
   - Electronic states at surfaces  
   - Techniques: XPS, HAXPES, UPS
4. **Reactions at surfaces (3 hours)**  
   - Adsorption: chemisorption vs physisorption  
   - Diffusion  
   - Introduction to film growth (link with MSE 412)
5. **Characterising buried interfaces (3 hours)**  
   - TEM, SIMS, EXAFS, neutron reflectivity
6. **Case studies (3 hours)**  
   - Magnetism  
   - Organic electronics  
   - Energy

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

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<tr>
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<tbody>
<tr>
<td>A</td>
<td>Surface Analysis - The Principal Techniques, John C. Vickerman, Ian S. Gilmore</td>
</tr>
<tr>
<td>B</td>
<td>Surfaces and Interfaces of Solids, Hans Lüth</td>
</tr>
<tr>
<td>C</td>
<td>Physics of Surfaces and Interfaces, Harald Ibach</td>
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</table>

**Structure, teaching and learning methods**

- 21 lectures Spring term  
- 3 hours student-led article discussion

**Examination**

The course is examined in the summer term. The examination paper, duration 2½ hours, is in 2 sections. Section A is contains short questions and is compulsory (40 marks); section B contains 5 long questions worth 20 marks each, and the students should answer three of those.

**Coursework**

20 marks are associated with the article presentation exercise (preparation and presentation).
Weighting
Exam: 80%
Coursework: 20%

The pass mark for the module is 50% for MSc Advanced Students.

<table>
<thead>
<tr>
<th>Staffing</th>
<th>Lectures</th>
<th>Tutorials</th>
<th>Article presentation exercise</th>
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<tbody>
<tr>
<td>Dr Sandrine Heutz</td>
<td>14</td>
<td>2</td>
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<tr>
<td>Dr David Payne</td>
<td>7</td>
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(O08) MSE 404 Modelling Materials with Density-Functional Theory Updated

Course Co-ordinator: Dr Johannes Lischner

Aims: This course will introduce students to the modelling of materials with density-functional theory. After a brief review of the quantum-mechanical foundations of density-functional theory, the course will focus on the application of this technique to the calculation of material properties, such as elastic constants, equilibrium structures, phase diagrams or band structures. The concepts introduced in the lectures will be put to practical use in the computer lab session, where students will learn to use a density-functional theory software package and compute the properties of real materials from first principles.

Learning outcomes
At the end of the course the student will be able to:-

* Explain the basic principles and capabilities of materials modelling with density functional theory (DFT)
* Explain the quantum-mechanical basis of DFT and its limitations
* Use a standard DFT software package to compute material properties, including:
  * The total energy of the electronic ground state
  * Atomic forces using the Hellmann-Feynman theorem
  * Equilibrium structures of molecules and crystals
  * Elastic constants
  * Energies of vibrations in molecules and solids
  * Phonon band structure and density of states
  * IR and Raman intensities
  * Cohesive energies
  * Phase diagrams
  * Electronic band structures of metals, insulators and semiconductors
  * The dielectric function of a solid and optical properties
  * The effect of approximations to exchange and correlation on calculated properties
  * The effect of pseudopotential approximations on calculated properties

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

|-----|----------------------------------------------------------------------------------------------------------------------|
Structure, teaching and learning methods

Autumn Term:
12 lectures, 12 computer lab sessions

Assessment

Assessment is through weekly problem sets and a written exam. The problem sets are worth 40% and the exam 60%.

The pass mark for the module is 40% for MEng students and for MSc students the pass mark is 50%. The module contributes 100 marks of the fourth year.

Weighting

Exam: 60%
Coursework: 40%

The pass mark for the module is 50% for MSc Advanced Students.

<table>
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<tr>
<td>Dr Johannes Lischner</td>
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<td>Dr Eamonn Murray</td>
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<td>Dr Johannes Lischner</td>
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Aims: This course builds on knowledge acquired from MSE307 (Engineering Alloys) and addresses aspects of processing (particularly casting) through to resultant microstructure and properties, and then considers alloy structural behaviour and performance in service under mechanical and thermal loading. The links between processing, microstructure, properties and performance of engineering alloys in service are emphasised. Two case studies, one in each of processing and performance, are included to relate the course content to engineering practice and to reinforce the process-microstructure-properties-performance paradigm.

Learning outcomes
At the end of each part of the course the student will be able to:

Microstructure formation during solidification  (Dr C M Gourlay)
- use heat transfer approaches to calculate and estimate casting parameters
- understand interface undercooling and constitutional supercooling and their role in (i) the columnar-to-equiaxed transition and (ii) the control of grain size.
- understand the physical basis for the Jackson-Hunt equations for regular eutectic growth and use it to predict interphase spacings and eutectic morphologies
- understand competitive solidification criteria for single phase dendrites vs. fully-eutectic growth; stable vs. metastable eutectic growth; and nucleation controlled phase selection.
- calculate simple microstructure selection maps from solidification models and data, and use them to predict microstructures from processing parameters.
- Use all of the above to discuss microstructure selection in light alloy castings for aerospace applications

Microstructure and performance (Prof F P E Dunne)
- understand generalized crystal deformation – stretch, slip and rigid body rotation
- understand slip in fcc, bcc, and hcp crystal lattices and slip systems, Schmid rule, strain from slip, strain and rotation rates
- understand and use slip rules and slip by dislocation glide and thermally-activated climb; self and latent hardening
- understand EBSD, texture and its representation, pole figures and Kearns factors;
- cold dwell fatigue in the Ti alloys; mechanistic assessment, crystallography; role of rate sensitivity; load shedding; microstructure (morphology and micro-texture); thermal alleviation

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

<table>
<thead>
<tr>
<th>A</th>
<th>Links to underpinning scientific journal papers are provided on WebCT</th>
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</table>

Structure, teaching and learning methods
24 lectures: Spring term

Assessment
Examination
The course is examined in the summer term. The examination is 2.5 hours and consists of 5 questions, of which the students have to answer 3. Questions could be from a single part of the course or be more general in nature and require the students to use elements from several parts of the course.
The pass mark for the module is 40% for MEng students and for MSc students the pass mark is 50%. The module contributes 100 marks of the fourth year.

Weighting
Exam: 100%

The pass mark for the module is 50% for MSc Advanced Students.

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<tr>
<td>Professor Dunne</td>
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(O10) MSE 410 Advanced Thin Film Manufacturing Technologies Updated

Course Co-ordinator: Dr Peter Petrov

Aims:
- To familiarise students with the basic vacuum concepts.
- To explain the essential concepts involved in using vapour deposition techniques to develop thin films.
- To provide a foundation required to successfully use lithographic and other microfabrication methods.
- To provide students with the basics for working in, and understanding the microfabrication in production environment.
- To provide hands-on experience in thin film deposition (magnetron sputtering, e-beam evaporation), photolithography and ion-milling.

Learning outcomes
At the end of each part of the course the student will be able to:

Introduction to vacuum technologies:
- Explain on the principles of vacuum production and its classification.
- Understand the working principles and limitations of the vacuum pumps and gauges.

Principles and equipment for thin film deposition processes:
- Understand essential concepts involved in using vapour deposition techniques to develop thin films.
- Describe the most common types of vapour deposition technologies (chemical vapour deposition (CVD), physical vapour deposition (PVD) and mixed deposition).
- Explain the three basic PVD techniques: vacuum evaporation (thermal/e-beam evaporation), sputter deposition (DC-, RF-, reactive- magnetron sputtering) and pulsed laser deposition.
- Discuss the connection between vapour deposition parameters and thin film properties.
- Identify the most appropriate method/equipment for a deposition process and discuss its advantages and disadvantages.

Principles and equipment for thin film patterning:
- Understand the characteristics and practical limitations of basic lithographic methods (e.g. photo-, e-beam-, and x-ray lithography) used today for integrated circuit manufacturing.
- Discuss and compare the etching methods used in a microfabrication process e.g. wet etching, ion milling, reactive ion etching and focused ion milling.
Identify the most appropriate method and equipment for a patterning process (e.g. mask-aligner, spinner) and outline their principles of operation and limitations.

**Thin film manufacturing environment:**
- Understand the basics principles for working in hi-tech (e.g. semiconductor) production environment.
- Know the Clean room classification, Clean room design principles and Clean room control measures (gowning, equipment and consumables).

**Lab sessions:**
- Prepare samples for further processing.
- Assist in thin film deposition (magnetron sputtering, e-beam evaporation), photolithography and ion-milling processes.

**Recommended textbooks**

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<tr>
<th>Grade</th>
<th>Author(s)</th>
<th>Title</th>
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<tbody>
<tr>
<td>B</td>
<td>Fundamentals of Vacuum Technology (revised and compiled by W Umrath)</td>
<td>Oerlikon Leybold Vacuum 00.200.02 Kat.-Nr. 199 90</td>
</tr>
</tbody>
</table>

**Structure, teaching and learning methods**
18 lecture hours and 3 lab sessions (2 hours each): Autumn term

**Assessment**

**Examination (70%)**
The course is examined in the summer term. The exam is 2½ hours and consists of 5 questions from which students must answer 3.

**Lab work (30%)**
Each lab session (three in total) is assessed on the basis of the following criteria:
- Preparation for the lab session (40%): 15-20 min Q&A session before the experimental work starts
- Engagement in the experimental work (20%)
- Lab report (40%): to be submitted within one week after the lab session

The pass mark for the module is 40% for MEng students and for MSc Advanced Materials Science and Engineering students it is 50%, formed from at least 35% Examination and at least 15% Lab works.

**Weighting**
Exam: 70%
Lab Coursework: 30%

The pass mark for the module is 50% for MSc Advanced Students.

**Staffing**

<table>
<thead>
<tr>
<th>Lectures</th>
<th>Tutorials</th>
<th>Lab sessions</th>
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<tr>
<td>Dr PK Petrov</td>
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<tr>
<td>Dr Bin Zou</td>
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**Course Material**

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<tr>
<td>Dr Bin Zou</td>
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</table>
Aims: The aim of the course is to gain an understanding of the fundamental science governing the electronic and ionic conductivity of metal oxides and to then use this knowledge to describe the operation of devices based on these properties, such as gas sensors, fuel cells, batteries, varistors and thermoelectrics.

Learning outcomes
At the end of this part of the course the student will be able to:

Electroceramic Materials (Dr Ainara Aguadero)
- Obtain a full set of algebraic expressions for the point defect concentrations in pure and doped oxide materials. They will be able to write out the intrinsic defect equilibria for a simple binary oxide and the appropriate redox equilibria. They will be able to apply the neutrality condition to obtain a set of linked defect equations
- Further develop the expressions obtained above to identify suitable approximations to the full neutrality condition, and hence solve the defect equations and construct a simple Brouwer diagram for a binary oxide. They will be able to use the diagram to predict the conductivity variation with PO2 for a simple binary oxide
- Explain the origins of the energy barriers that arise at the grain boundaries of semiconducting polycrystalline materials. They will also be able to derive a simple expression for the barrier height in terms of the electrical parameters of the semiconducting material
- Describe operation of a zinc oxide varistor. They will also be able to describe the theory of operation of the varistor in terms of the band structure and grain boundary barriers present in these semiconducting ceramics, and perform a simple calculation to estimate the breakdown voltage of a typical ceramic varistor
- Describe the principle of operation of devices based on the Negative and Positive Temperature Coefficients of Resistance (NTC and PTCR’s)

Fuel cells, sensors and devices (Prof S Skinner)
- Explain the concept of anionic, cationic and mixed conductors. They will be able to derive an algebraic expression for the temperature dependence of the ionic conductivity of an oxide ion conductor and identify oxide materials with superior ionic conductivity
- Derive a simple relationship for the operation of a ceramic membrane device and use this expression to select appropriate materials for the fabrication devices such as a single SOFC cell
- Explain the operation of a fuel cell and give an account of the basic details of the four main types of cell. They will be able to describe the main features of the competing designs of Solid Oxide Fuel Cells (SOFC’s)
- Define the excess air factor $\lambda$ and describe the variation of the P$_{O2}$, and pollutant content, of the exhaust gasses of an internal combustion engine as a function of $\lambda$
- Describe the operation of two oxide based sensors which can be used to sense the changes in oxygen activity arising from the $\lambda$ curve, the common zirconia based $\lambda$ probe, and the semiconducting TiO$_2$ sensor
- Describe a further sensor based on the amperometric technique for determining the P$_{O2}$ of the exhaust gasses in an internal combustion engine in the lean burn region of operation
- Describe two simple sensors for the detection of flammable gasses based on the surface absorption and acceptor activity of oxygen
- Brief introduction to thermoelectric materials.
### Recommended textbooks

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

<table>
<thead>
<tr>
<th></th>
<th>Title</th>
<th>Author(s)</th>
<th>Publisher/Year</th>
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<tbody>
<tr>
<td>B</td>
<td>Physical Ceramics, Chiang, Birnie and Kingery</td>
<td>John Wiley and Sons (1997)</td>
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<tr>
<td>B</td>
<td>High-temperature solid oxide fuel cells: fundamentals, design and</td>
<td>Edited by Subhash C. Singhal and</td>
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<tr>
<td>C</td>
<td>Solid oxide fuel cell technology: Principles, performance and</td>
<td>Kevin Huang and John B. Goodenough,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>operations</td>
<td>Woodhead Publishing Ltd (2009)</td>
<td></td>
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### Structure, teaching and learning methods

24 lectures: Spring term

### Examination

The course is examined in the summer term. The examination paper, duration 2½ hours, is in two sections. Section A (20 marks) is compulsory and consists of a single question on all parts of the course. Section B contains 3 questions of which students must answer 2 (20 marks per question).

### Weighting

Exam: 100%

**The pass mark for the module is 50% for MSc Advanced Students.**

### Staffing

<table>
<thead>
<tr>
<th></th>
<th>Lectures</th>
<th>Tutorials</th>
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<tr>
<td>Dr A Aguadero</td>
<td>10</td>
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<td>Prof S Skinner</td>
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### Course Material

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<tr>
<td>Dr Aguadero</td>
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<td>Prof Skinner</td>
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(O12) MSE 412 Nanomaterials II

- Have a detailed understanding of the structure of self-assembled colloidal crystals
- Be able to describe the relationships between structure, materials, properties and preparation methods of 3D periodic porous solids and nanocomposites

Plasmonic Nanoparticles (Dr Fang Xie)

- Understand the general synthetic routes including top-down and bottom up methods
- Understand the factors to control nanoparticles size and shape
- Be able to describe the possible growth mechanism of metal nanoparticles including Au, Ag, and Pd
- Understand the optical properties of metal nanoparticles and their size/shape dependency
- Be able to describe metal nanoparticles’ application in medical diagnosis, therapy, and solar energy conversion.

Two-dimensional materials for electronics and optoelectronics (Dr Cecilia Mattevi)

- Discuss the chemical characteristics of layered compounds and their elementary building blocks
- Describe the electronic band structure of graphene and group VI of transition metal disulphide and diselenide.
- Discuss the properties of graphene and group VI of transition metal disulphide and diselenide relevant for applications
- Discuss the chemical vapour deposition synthesis method for graphene.

Nanotoxicity (Dr Angela Goode):

- Describe the routes of exposure of nanoparticles to the body.
- Understand and discuss the effect of shape, size and chemistry of nanostructures on the interaction of nanoparticles with the body.
- Assess critically the potential risk of nanoparticles to human health.

Recommended textbooks

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

TBC

Structure, teaching and learning methods

21 lectures: Autumn term
3 hour poster presentation

Examination

The course is examined in the summer term. The examination paper, duration 2½ hours is in 2 sections. Section A contains 5 short calculation-type questions (6 marks each); section B contains 2 essay questions (20 marks each). All questions are compulsory.

Coursework

30 marks are associated with the poster exercise (preparation and presentation).

Weighting

Exam: 80%
Lab Coursework: 20%

The pass mark for MSc Advanced Students is 50% for the module.

<table>
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<tr>
<th>Staffing</th>
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<td>Dr M McLachlan</td>
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<td>Dr S Heutz</td>
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<td>Dr A Goode</td>
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<tr>
<td>Dr C Mattevi</td>
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<td>3</td>
</tr>
<tr>
<td>Dr F Xie</td>
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</table>
Aims:

- To review microstructural aspects of the behaviour of major ceramic families such as alumina, silicon carbide, silicon nitride, zirconia and glass and contrast microstructural control aimed at increases strength with microstructural approaches aiming to improve toughness to offer a reference frame in which to understand current research and development
- To clarify the need for composites and to contrast the mechanical response of ceramic composites with that of monoliths
- To re-examine the general theoretical concepts underpinning the structural performance of materials developed in MSE.203 Mechanical behaviour with an aim to strengthen the students ability to apply the general principles to ceramics
- To explore the transitions in mechanical behaviour and relate these to the different micro-mechanism of deformation that act in ceramics so that students can judge how microstructure, time, scale and deformation rate can alter the response
- To explain the concepts underpinning the state-of-the-art methodologies, which can be used to design monolithic ceramic components with confidence
- To train students in fractography of ceramics
- To discuss high temperature ceramics, the various forms in which these materials are used such as coatings, fibres and composites and how they are made.
- To examine the fundamental quantitative factors that control stability, mechanical performance and damage accumulation under service conditions.

Learning outcomes

At the end of the course the student will be able to:

**Design implications of reliability and fracture of ceramics (Dr L Vandeperre, 12 lectures)**

- State a range of classical families of advanced structural ceramics including alumina, zirconia, silicon nitride, silicon carbide and ceramic matrix composites
- List and explain approaches to improve the strength of these materials
- List and explain approaches to improve the toughness of these materials
- List and explain a range of ceramic composite approaches and their failure modes
- Distinguish between inherent toughness, apparent toughness, and fracture energy
- Predict crack progression for stable cracking and for materials with R-curve behaviour
- Calculate the driving force for cracking under mixed mode loading and for published crack configurations
- Be aware of existing failure criterions for mixed mode loading and their limitations
- Have some understanding of possible fatigue effects in ceramics
- Inspect a ceramic fracture surface and determine failure origin, and failure type
- Describe the mechanism of slow crack growth (subcritical crack growth)
- Calculate expected life-time accounting for slow crack growth.
- Determine Weibull distributions including choice of probability estimator and fitting methodology and understand the link with defect distributions
- Calculate material Weibull parameters and test Weibull parameters and covert between both
- Estimate the probability of failure for simple loading cases
- Incorporate proof testing or non-destructive evaluation in a reliability strategy
- Outline a design methodology for complex ceramic components based on probability of failure

**Deformation of ceramics (Dr F Giuliani, 6 lectures)**

- Compare and contrast deformation behaviour of ceramics with other materials
- Identify the deformation mechanisms active in ceramics
- Draw out a schematic representation of the bounds on stress, temperature and strain rate where the different mechanisms can be expected to operate
• Sketch out microstructural influences on transitions in deformation mechanisms
• Predict the mechanical response from deformation mechanism maps
• Justify why scale affects the deformation response
• Produce an experimental strategy to investigate the different deformation mechanisms
• Discuss strengths and problems associated with different experimental approaches (both small scale measurements and microscopic measurements).

The Effect of High Temperature on Ceramics (Dr Luc Vandeperre, 6 lectures)

• Understand the importance of thermo-mechanical properties at temperature
• Understand the thermodynamics and kinetics behind degradation mechanisms of ceramic at high temperature due to stress including creep, fatigue and thermal shock, due to corrosion or due to radiation
• Understand mechanical damage mechanisms in ceramics including from wear and impact/erosion.
• Distinguish between local and global chemical equilibrium
• Describe applications of high temperature ceramics and why they are used thermal protection systems, thermal barrier coatings in jet engines, and processing equipment in glass making, steel making and other industrial high temperature processes.
• Choose appropriate refractory materials for specific applications
• Understand the limits of established material systems and recognize underpinning principles in new developments.

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

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<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>A</td>
<td>Links to research papers are provided on Blackboard</td>
</tr>
</tbody>
</table>
Ceramic Microstructures, Property Control by Processing, WE Lee and WM Rainforth, (Chapman & Hall 1994).  
| C | See weblinks on WebCT |

Structure, teaching and learning methods
24 lectures: Autumn term

Assessment

Examination

The course is examined in the summer term. The exam paper is 2.5 hours and consists of 5 questions, students should answer 3 questions.

The pass mark for the module is 40% for MEng students and for MSc students the pass mark is 50%. The module contributes 100 marks of the fourth year.

Weighting

Exam: 100%

The pass mark for the module is 50% for MSc Advanced Students.
## Staffing

<table>
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<tr>
<th></th>
<th>Lectures</th>
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<tr>
<td>Dr L Vandeperre</td>
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<tr>
<td>Dr F Giuliani</td>
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## Course Material

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<tr>
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<th>PowerPoint Lectures</th>
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<th>Tutorial Sheets</th>
<th>Lab Scripts</th>
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<tr>
<td>Dr L Vandeperre</td>
<td>15</td>
<td></td>
<td>3</td>
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<td>Dr F Giuliani</td>
<td>6</td>
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</table>
(O14) MSE 414 Nuclear Materials

**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**
At the end of the course students should be able to:

*Prof R W 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 M 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 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**

<table>
<thead>
<tr>
<th>A = required</th>
<th>B = recommended but not essential</th>
<th>C = background reading</th>
</tr>
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<tbody>
<tr>
<td><strong>B</strong></td>
<td>G S Was “Fundamentals of Radiation Materials Science” Springer (978-3-540-49471-3)</td>
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<tr>
<td><strong>C</strong></td>
<td>P D Wilson (Editor) “The Nuclear Fuel Cycle: From Ore to Waste” (0198565402W)</td>
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Structure, teaching and learning methods
24 lectures: Autumn term

Examination
The course is examined in the summer term and the exam paper is 2½ hours in duration. It consists of 5 questions and students answer any 3.

Weighting
Exam: 100%

The pass mark for the module is 50% for MSc Advanced Students.

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

(O15) MSE 417 Advanced Biomaterials Updated
Course Coordinator: Prof J R Jones

Aims: The course aims to introduce students to the latest developments in hard tissue biology.

Learning outcomes
At the end of this lecture series the students should be able to describe the main classes of natural polymers, their structure and their applications.

Synthetic scaffolds (Prof J Jones)
At the end of the module the student should be able to:
- Explain the shortfalls of bone replacement materials to the biomaterials industry and investors
- Have knowledge of commercially available bone graft replacement materials and be able to discuss their benefits and shortfalls.
- Present alternative means to repair skeletal tissues to both healthcare professionals and patients.
- Communicate the differences between melt and sol-gel derived bioactive glasses, their mechanisms of bioactivity and application
- Design an ideal bone replacement material
- Discuss processing methods for production of artificial bone grafts including advantages and disadvantages of each, including the various 3D printing methods
- Explain the challenges involved with transfer of laboratory inventions to a clinical product

Bioactive nanoparticles (Dr Alexandra Porter)
At the end of the course students should be able to describe:
- Production and application of HA and bioactive glass nanoparticles
- Cell uptake routes and nanotoxicity of both classes of nanoparticle
- Concepts of non-conventional pharmaceuticals

Nanotoxicology, Nanotherapeutics (Dr Alexandra Porter)
At the end of the course students should be able to discuss:
- Types of therapeutic nanomaterials and their applications
- Cancer treatment through the use of particles
- Cell uptake routes and nanotoxicity of both classes of nanoparticle
- Transformations and translocation of nanomaterials in the body: Physiological responses to biomaterials and how materials properties determine outcome.
Ion doped ceramics (Dr Alexandra Porter)
At the end of the course the students should be able to describe:
• To compare the composition of hydroxyapatite and bone apatite
• To understand the different routes for processing synthetic hydroxyapatite
• To describe the mechanism of bioactivity of hydroxyapatite and the dissolution-reprecipitation mechanism leading to bone formation around the implant surface.
• To understand the limitations of HA and the need for and advantages of using substituted hydroxyapatites: Si-HA, CHA
• To be able to describe the different applications and forms of HA used in bone grafting applications

Interactions in biomaterials (Dr Stefano Angioletti-Uberti)
At the end of the course students should be able to discuss:
• Describe qualitatively through simple models some of the major types of microscopic interactions in biomaterials: ionic interactions, polymer-mediated and water-mediated interactions, ligand-receptor interactions
• Understand the microscopic origins generating and controlling the aforementioned interactions.
• Understand their effect in the development of applications, e.g. in drug-delivery, controlled protein adsorption or biosensing.

Characterisation of material: biomaterial-tissue and biomaterial-cell interfaces (Dr Alexandra Porter)
By the end of this lecture series, the students should understand how the following techniques can be used to characterise biomaterials:
• Methods for testing bio and nanomaterials including: Simulated body fluid, in vitro and in vivo testing methods
• Chemical characterisation: Appreciate the need for using a range of techniques to characterise the physicochemistry of nanomaterials.
• To understand SIMS, Raman spectroscopy and Zeta potential measurements
• Imaging interfaces between biomaterials-protein/cells/ tissues
• Scanning probe techniques (AFM), optical microscopy, confocal microscopy
• Imaging and analysis of biomaterials: SEM, TEM
• 3D imaging of nanomaterials inside cells

Commercialisation/ translation of medical devices (Prof J Jones)
Students will have an understanding of the mechanism and stages needed to take a new device from concept to clinic. This will be achieved through a practical Dragon’s Den exercise in groups
• Patenting
• Regulatory procedures and claims
• Clinical trials
• Good manufacturing practice

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

<table>
<thead>
<tr>
<th>A</th>
<th>Various printed publications</th>
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Structure, teaching and learning methods
24 lectures, 3 feedback sessions; Spring term. 1 revision lecture: summer term
Assessment

Examination

The course is examined in the summer term. The exam is 2.5 hours in duration and consists of 5 questions, from which students must answer 3 questions (each marked out of 20).

The pass mark for the MEng cohort is 40% and for an MSc course is 50%. The module contributes 100 marks of the fourth year.

Weighting
Exam: 100%

The pass mark for the module is 50% for MSc Advanced Students.

<table>
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<td>Dr A Porter</td>
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<td>Dr S Angioletti-Uberti</td>
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<tr>
<td>Prof Jones</td>
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<tr>
<td>Dr A Porter</td>
<td>8 (+reading)</td>
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<tr>
<td>Dr S Angioletti-Uberti</td>
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<td>2 (+reading)</td>
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(O16) MSE 418 Advanced Tissue Engineering

Aims: Students will learn about modern developments in tissue engineering, and about the principles on which they are based.

Learning outcomes

Cellular responses to the local environment (Dr I Dunlop)
- Describe and explain the role of cellular responses to the local environment in tissue engineering.
- Distinguish between empirical and rational design approaches to tissue engineering.
- Describe and explain the principles and basic mechanisms of cellular signalling, in the abstract, and with reference to the examples given in the course. Apply this knowledge to newly encountered systems.
- Describe and explain the principles and mechanisms of cellular mechanotransduction.
- Describe and explain the aspects of surface chemistry and protein adsorption that are most relevant to tissue engineering. Explain the importance and relevance of this topic.

Materials synthesis for tissue engineering (Dr Theoni Georgiou)
- Describe and provide reasoning for the property requirements of scaffold materials for regenerative biological applications.
- Describe, with aid of suitable recent examples, various strategies to fabricate porous materials. Suggest drawbacks and advantages of these approaches.
- Describe different approaches to functionalisation of porous materials and apply this to newly encountered systems.
- Demonstrate the ability to inter-link the above three learning outcomes to address new (i.e., potentially “unseen”) materials.

Clinical aspects of tissue engineering (Prof Molly Stevens)
- Describe and explain the role and importance of the extracellular matrix in tissue engineering
- Understand the advantages and disadvantages of hydrogels and other scaffolds for tissue engineering.
- Give examples of the applications of scaffolds for tissue engineering of tissues such as heart, bone, liver, kidney, nervous system.
- Describe the application of polymers in drug delivery as a basis of polymer structure
- Describe and explain the clinical case studies presented, and relate them to the concepts taught previously.

Structure, teaching and learning methods

24 lectures: Spring term

Examination
The course is examined in the summer term. The paper is 2½ hours and students are required to answer 3 questions from 5.

Weighting
Exam: 100%

The pass mark for the module is 50% for MSc Advanced Students.

<table>
<thead>
<tr>
<th>Staffing</th>
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<tr>
<td>Dr Dunlop</td>
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<td>Dr Georgiou</td>
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<tr>
<td>Prof Stevens</td>
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</table>
Appendix B

Head of Department:
Prof Peter Haynes  PDH   201B   p.haynes@imperial.ac.uk
Prof Neil Alford  NMA   205   n.alford@imperial.ac.uk
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Dr Stefano Angioletti-Uberti  SAU   s.angioletti-uberti07@imperial.ac.uk
Prof Alan Atkinson  -   214   alan.atkinson@imperial.ac.uk
Dr Ben Britton  BB   B301E   b.britton@imperial.ac.uk
Dr Iain Dunlop  ID   102   i.dunlop@imperial.ac.uk
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Prof David Dye  DD   109   d.dye@imperial.ac.uk
Prof Mike Finnis  MWF   227B   m.finnis@imperial.ac.uk
Dr Paul Franklyn  PF   G03B   p.franklyn@imperial.ac.uk
Dr Theoni Georgiou  TG   105   t.georgiou@imperial.ac.uk
Dr Chris Gourlay  CG   B301D   c.gourlay@imperial.ac.uk
Dr Finn Giuliani  FG   LM04D   f.giuliani@imperial.ac.uk
Prof Robin Grimes  RWG   B301C   r.grimes@imperial.ac.uk
Dr Sandrine Heutz  SH   B336   s.heutz@imperial.ac.uk
Dr Andrew Horsfield  APH   B331   a.horsfield@imperial.ac.uk
Prof Julian Jones  JRJ   207   julian.r.jones@imperial.ac.uk
Prof Norbert Klein  NK   201C   n.klein@imperial.ac.uk
Prof John Kilner  JAK   214   j.kilner@imperial.ac.uk
Dr Johannes Lischner  JL   B342   j.lischner@imperial.ac.uk
Dr Cecilia Mattevi  CM   221   cecilia.mattevi@imperial.ac.uk
Dr Martyn McLachlan  MAM   G03C   martyn.mclachlan@imperial.ac.uk
Dr Arash Mostofi  AAM   B332   a.mostofi@imperial.ac.uk
Dr Mark Oxborrow  MO   204   m.oxborrow@imperial.ac.uk
Dr David Payne  DP   209   d.payne@imperial.ac.uk
Dr Peter Petrov  PP   B333   p.petrov@imperial.ac.uk
Dr Minh-Son Pham  M-SP   B301F   a.p.pham@imperial.ac.uk
Dr Alexandra Porter  AEP   B341   a.porter@imperial.ac.uk
Prof Jason Riley  DJR   B337   jason.riley@imperial.ac.uk
Prof Mary Ryan  MPR   B338   m.p.ryan@imperial.ac.uk
Prof Eduardo Saiz  ES   LM04B   e.saiz@imperial.ac.uk
Prof Milo Shaffer  MS   M221   m.shaffer@imperial.ac.uk
Prof Stephen Skinner  SJS   206   s.skinner@imperial.ac.uk
Dr Ifan Stephens  IS   203B   i.stephens@imperial.ac.uk
Prof Molly Stevens  MMS   208   m.stevens@imperial.ac.uk
Dr Paul Tangney  PT   B330   p.tangney@imperial.ac.uk
Dr Luc Vandeperre  LV   LM04C   l.vandeperre@imperial.ac.uk
Prof Aron Walsh  AW   210   a.walsh@imperial.ac.uk
Dr Mark Wenman  MW   B301A   m.wenman@imperial.ac.uk
Dr Fang Xie  FX   103   f.xie@imperial.ac.uk

Student Office Staff:
MRS Fiona Thomson  G03a   fiona.thomson@imperial.ac.uk
MRS Raj Adcock  G03a   raj.adcock@imperial.ac.uk
Miss Ela Calik  G03a   ela.calik@imperial.ac.uk
Appendix C

Welcome from Dr Janet De Wilde, Head of Postgraduate Professional Development

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 D

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
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

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