

# Imperial College London

Faculty of Engineering  
Department of Materials

MSc  
Advanced Materials Science and  
Engineering

**Student Handbook**

**2021-22**



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## Welcome to the College

Congratulations on joining Imperial College London, the only university in the UK to focus exclusively on science, medicine, engineering and business.

From Fleming's discovery of Penicillin to Gabor's invention of holography, Imperial has been changing the world for well over 100 years. You're now part of this prestigious community of discovery and we hope you will take this opportunity to make your own unique contribution.

You're now very much a part of this community of discovery and we hope you will take this opportunity to make your own unique contribution. At Imperial, we expect all members of our community, whether students or staff, to share and demonstrate our values of respect, integrity, collaboration, innovation and excellence in all we do and strive to achieve.

We understand that this is a challenging time for our student community due to the impact of coronavirus and we are committed to providing you with the very best academic resources to enrich your experience. Information on teaching and learning, services and facilities to support the wider student experience during the Covid-19 pandemic can be found on the College's webpages, alongside local information provided by your Department. We also provide a dedicated support network and a range of specialist support services to make sure you have access to the appropriate help, whether that's further training in an academic skill like note taking or simply having someone to talk to.

You'll have access to an innovative range of professional development courses within our Graduate School throughout your time here, as well as opportunities to meet students from across the College at academic and social events – see page 4 for more information.

We actively encourage you to seek out help when you need it and try to maintain a healthy work-life balance. Our choice of over 360 clubs, societies and projects is one of the largest of any UK university, making it easy to do something different with your downtime. Access to the gym and other sporting facilities will be dependent on government guidance. We are working to ensure that you have access to a variety of resources online to support your health and wellbeing if there are restrictions.

As one of the best universities in the world, we are committed to inspiring the next generation of scientists, engineers, clinicians and business leaders by continuing to share the wonder of what we do through public engagement events. Postgraduate students, alongside our academics and undergraduate students, make a significant contribution to events such as our annual Imperial Festival and our term-time Imperial Fringe events – if you're interested in getting involved then there will be opportunities for you to do so.



## Our Principles

In 2012 the College and Imperial College Union agreed 'Our Principles' a series of commitments made between students and the College. The Principles are reviewed annually by the Quality Assurance and Enhancement Committee and changes recommended for Senate approval.

### **Imperial will provide through its staff:**

- A world class education embedded in a research environment
- Advice, guidance and support
- The opportunity for students to contribute to the evaluation and development of programmes and services

### **Imperial will provide students with:**

- Clear programme information and assessment criteria
- Clear and fair academic regulations, policies and procedures
- Details of full programme costs and financial support
- An appropriate and inclusive framework for study, learning and research

### **Imperial students should:**

- Take responsibility for managing their own learning
- Engage with the College to review and enhance provision
- Respect, and contribute to, the Imperial community

### **The Imperial College Students' Union will:**

- Support all students through the provision of independent academic and welfare assistance
- Encourage student participation in all aspects of the College
- Provide a range of clubs, societies, student-led projects and social activities throughout the year
- Represent the interests of students at local, national and international level



[www.imperial.ac.uk/students/our-principles](http://www.imperial.ac.uk/students/our-principles)



## Welcome from the Graduate School



Welcome to Imperial College London and the Graduate School!

The Graduate School is responsible for the postgraduate experience at the College and we work closely with the Union and the Graduate Students' Union to ensure that when decisions are being made, which affect your time at Imperial, your voice is heard.

Another important aspect of our role is to offer you a free and exciting range of professional development opportunities which you can access wherever you are in the world.

Our team of tutors have a variety of research and other career experiences. We understand the importance of developing professional skills and our programmes will help you to progress in your academic studies and research and will prepare you for your future career. Whether you wish to pursue a career in academia, industry or something else, professional development training will improve your personal impact. You will also get to meet students from other Departments when attending our courses.

The Graduate School runs exciting competitions throughout the year which are an opportunity to broaden your knowledge as well as to meet other students and have fun. Our primary way to communicate to you will be through our monthly newsletter. However, do check our website, blog and social media platforms to keep up to date with all the latest activities available to you.

Finally, Imperial College is an extremely exciting, stimulating and diverse environment in which to work, to study and to research. Do make the most of all that the College and your programme has to offer.



## The Graduate School

You automatically become a member of the Graduate School when you register as a postgraduate student at Imperial.

The Graduate School has been set up to support all postgraduate students at the College through:

- Training and development courses
- Networking activities, social and academic events to encourage cross-disciplinary interactions
- Forums to represent the views of postgraduate students throughout the College

### 'Masterclass' professional skills courses


You can see the full range of free professional skills courses for postgraduate students on the Graduate School website:


 [www.imperial.ac.uk/study/pg/graduate-school/students/masters/](http://www.imperial.ac.uk/study/pg/graduate-school/students/masters/)

All courses can be booked online.



### Contact us

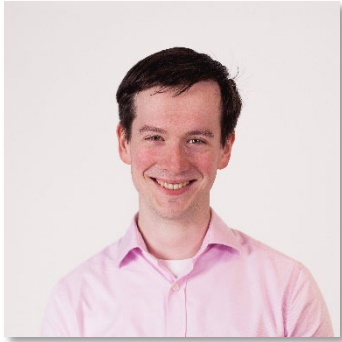
 Level 3, Sherfield Building, South Kensington Campus

 020 7594 1383

 [graduate.school@imperial.ac.uk](mailto:graduate.school@imperial.ac.uk)

 [www.imperial.ac.uk/graduate-school](http://www.imperial.ac.uk/graduate-school)

## Introduction from the President of Imperial College Union



Welcome to Imperial College!

I'm Lloyd – President of Imperial College Union (ICU).

ICU is the representative body for all students at Imperial College. We advocate on behalf of students' interests, including through a network of elected student representatives across all Departments and levels of study. We also provide services to students – we operate a number of bars (including h-bar, our Postgraduate bar), shops, a nightclub, and a cinema; we run over 360 clubs and societies, and we have an Advice Centre which offers confidential, impartial advice on academic and wellbeing matters.

ICU is led by myself and a team of Deputy Presidents – students who are elected to take a sabbatical year out of, or at the end of our degrees to work full time leading the Union. I myself recently completed my PhD in Physics. As a Postgraduate student, it was clear that there were plenty of ways that the Union and the College could be better supporting Postgraduate students, which is one of my main focusses for this year.

As we emerge from the pandemic and things are becoming more normal, we are keen to help rebuild the sense of student community that has suffered over the last 18 months. We are so excited to be offering a range of in-person social events through October (including a Postgraduate mingle on October 7th), and to see our clubs and societies returning to running their activities in person.

October also sees our Autumn Elections, where we elect student representatives across the College. If you'd like to be a voice for your peers and help improve the student experience, you should definitely consider running for a role. It's great fun, and an excellent way to meet new people and give something back to the student community.

I'm excited to meet many of you in person in the coming weeks, and I hope you have a fun, and safe, start to your time at Imperial.

Kind regards,

Lloyd James

*Imperial College Union President 2021-22*

 [union.president@imperial.ac.uk](mailto:union.president@imperial.ac.uk)

 [imperialcollegeunion.org](http://imperialcollegeunion.org)

## 1. Introduction to the Department

### Welcome from MSc Course Director



On behalf of all members of the academic and support staff I would like to welcome you to the MSc in Advanced Materials Science and Engineering. We hope you will enjoy your year with us and will benefit from the opportunities our programme offers.

By studying in the Department of Materials at Imperial College, you have become a member of the oldest and largest department of its kind in the UK. We are proud of our internationally leading research programmes in the synthesis, processing, characterisation, and modelling of a broad range of materials (metals, ceramics, semiconductors, glasses, ceramic-matrix composites, polymers and functional materials). The research is applied to a wide range of contemporary problems: nuclear power, battery technology, aerospace engineering, biomedical innovations, automotive engineering, communications, electronics, and more. Please feel free to

talk to the academics about their research. By carrying out a research project during your time here, you will be making your contribution to our shared success.

The MSc is a stand-alone qualification designed to:

1. Provide you the core skills needed to pursue research and development in materials and related areas.
2. Provide you up-to-date knowledge of major themes in materials.
3. Prepare you for a wide range of careers in materials.

We aim to achieve these goals by:

1. Teaching you about materials characterisation and modelling, offering research seminars for you to attend and giving you a research project.
2. Allowing you to select a number of options, so you can decide what areas you wish to specialise in.
3. Providing you with transferrable skills courses and opportunities for industry engagement.

This handbook is designed to inform and help you: time taken now to have a read and familiarise yourselves with its contents will make life easier later. If you have a question about the course, please check the handbook: it should have the answer. Of course, if you think we have missed something, please let us know.

I wish you all the best during your time with us.

*Prof Andrew Horsfield*  
*Course Director*




## Academic and Administrative staff



 **Prof Andrew Horsfield**

MSc Course Director

 Room: B331

 +44 20 7594 6753

 [a.horsfield@imperial.ac.uk](mailto:a.horsfield@imperial.ac.uk)



 **Dr Fang Xie**

Deputy Course Director

 Room: 103

 +44 20 7594 9693


 [f.xie@imperial.ac.uk](mailto:f.xie@imperial.ac.uk)



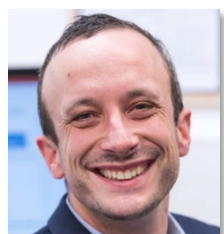
 **Prof Alexandra Porter**

MSc Senior Tutor

 Room: B341

 +44 20 7594 9691


 [a.porter@imperial.ac.uk](mailto:a.porter@imperial.ac.uk)




 **Dr Ifan Stephens**

Projects Coordinator

 Room: 2.03B

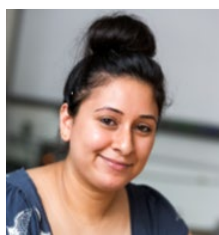
 +44 (0)20 7594 9523

 [i.stephens@imperial.ac.uk](mailto:i.stephens@imperial.ac.uk)

There are also a variety of other staff in charge of teaching who you might need to contact within the Department of Materials:

- **Dr Paul Franklyn:** Departmental Disabilities Officer/ Undergraduate Senior Tutor
- **Prof Luc Vandeperre:** Director of Undergraduate Studies (DUGS)

The Student Office administrative staff will be your first point of contact for any learning enquiries and day to day queries:



 **Mrs Raj Adcock**

**Teaching Operations Manager**

Oversees all administration of undergraduate (BEng/MEng) and taught postgraduate (MSc) programmes.



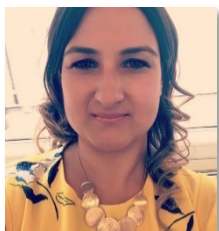
Room: G03A



+44 20 7594 6728



[materialsstudentoffice@imperial.ac.uk](mailto:materialsstudentoffice@imperial.ac.uk)



 **Miss Francesca Williams**

**Senior Student Office Administrator**

Based in the Student Office, supports the efficient administration of all taught programmes in the Department of Materials. Responsible for:

- Timetabling/Celcat Management
- Options management (internal and external)
- Exam organisation
- Panopto Management

Alongside other day-to-day administration including general student support.



Room: G03A



+44 20 7594 6726



[materialsstudentoffice@imperial.ac.uk](mailto:materialsstudentoffice@imperial.ac.uk)



 **Miss Harpreet Rajbans**

**Student Office Administrator**

Based in the Student Office, supports the efficient administration of all taught programmes in the Department of Materials. Responsible for:

- Coursework management
- Blackboard Learn Management
- Work Placements/UROPs
- Student exchange programmes (including Erasmus)
- Student laptop loan scheme

Alongside other day-to-day administration including general student support.



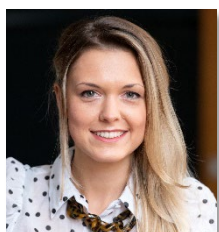
Room: G03A



+44 20 7594 6768



[materialsstudentoffice@imperial.ac.uk](mailto:materialsstudentoffice@imperial.ac.uk)



 **Miss Karolina Pielacha**

**Student Office Assistant**

Based in the Student Office, supports the efficient administration of all taught programmes in the Department of Materials. Responsible for:

- Locker Management
- Assist with attendance monitoring
- Assist with admissions applications
- Assist with exam organisation
- Assist with Student laptop loan scheme

Alongside other day-to-day administration including general student support.



Room: G03A



+44 20 7594 7277



[materialsstudentoffice@imperial.ac.uk](mailto:materialsstudentoffice@imperial.ac.uk)

## Attendance and absence

You must inform your MSc Senior Tutor if you are absent from the College for more than three days during term. If the absence is due to illness, you must produce a medical certificate after seven days. If you miss an examination or the deadline for any other assessment (including lab work, in class tests and all forms of coursework or presentation) due to illness or other reason you must follow procedure for claiming mitigating circumstances as described in the policy. Please note all claims for mitigation, for any reason must be submitted within 10 working days of the assessment deadline or examination. If you are unable to provide evidence at the time you must submit the claim and indicate what evidence will follow and when it can be provided. Claims without evidence will normally be rejected. Please see the section on mitigation below.

The Registry will be informed of all student non-attendances as the College is obliged to report the non-attendance of students on Tier 4/Student Route visas to the Home Office.

## Attendance monitoring

All small group exercises (laboratories etc.) are monitored for attendance. This is done through class list recording. If you miss any of these sessions, you will need to complete mitigation. For students attending remotely, we will monitor connection to the sessions via Teams and students missing sessions will still be required to file for mitigation.

Attendance will also be monitored through submissions on Blackboard and other systems.

## Key dates 2021–22

### Term dates

Autumn term:	2 October 2021 - 17 December 2021
Spring term:	8 January 2022 - 25 March 2022
Summer term:	30 April 2022 - 1 July 2022

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

### Closure dates

Christmas/New year:	24 December 2021 - 1 January 2022 (College reopens on 4 January 2022)
Easter Holiday:	12 April 2022 - 19 April 2022 (College reopens on 20 April 2022)
Early May Bank Holiday:	2 May 2022
Spring Bank Holiday:	2 June 2022
Platinum Jubilee Bank Holiday	3 June 2022
Summer Bank Holiday:	29 August 2022



### **Student Staff Committee dates**

Tuesday 2nd November 2021	12:30pm-14:00pm
Tuesday 7th December 2021	12:30pm-14:00pm
Tuesday 25th January 2022	12:30pm-14:00pm
Tuesday 1st March 2022	12:30pm-14:00pm
Tuesday 10th May 2022	12:30pm-14:00pm

### **Key events**

Great Exhibition Road Festival: 9 October 2021 – 15 October 2021



<http://www.imperial.ac.uk/whats-on/>



<http://www.imperial.ac.uk/admin-services/registry/term-dates/>



<https://www.imperial.ac.uk/graduation>

## Provisional Examination Timetable

For confirmed times/dates please refer **only** to your Celcat timetabled exam events which will be **released at the end of Spring term**. No travel should be booked based on these times nor should other commitments be agreed to. Mitigation due to assumed dates from this timetable will not be accepted for problems attending examinations that are moved for any reason.

## 2. Programme Information

The MSc is made up of a combination of taught modules and a research project. The optional taught modules are shared with the MEng and BEng students in Materials Science and Engineering, while the compulsory modules are specific to the MSc. There are three compulsory taught modules (Characterization of the Structure of Materials, Theory and Simulation of Materials, and Art of Research), in addition to which you must take five optional modules, four of which are examined. It is possible that some students (those who have graduated with a BEng in Materials Science and Engineering from our Department) will already have taken one or two of the compulsory modules and some of the options: in this case they must talk with the Director before making option choices and may need to take alternative versions of the compulsory modules. The research is organised in stages. The Art of Research module provides some training and includes the creation of the research project plan and attendance at research seminars, three of which need to be written up as reports. After the summer exams, the research project is carried out, for which you need to write a thesis and give a presentation. The available modules are listed below, with the number of European Transfer Credits (ECTS) given in parentheses.

Note that if you select all 5 options from the nuclear strand and carry out a nuclear related project, you can transfer over to the programme "MSc in Advanced Materials Science and Engineering: Specialising in Nuclear Engineering"

The **compulsory modules** are:

- (C1) MATE70001: Characterization of the Structure of Materials (7.5)
- (C2) MATE70002: Theory and Simulation of Materials (7.5)
- (C3) MATE70003: The Art of Research (15)
- (C4) MATE70004: Research Project (40)

In addition to the **compulsory modules 5 optional** courses must be taken from the following list. **Note that you will only be examined on 4 modules and will be asked to confirm the 4 options in the Spring Term (please refer to the deadline planner for the exact date):**

- (O01) MATE70006: Biomaterials (5)
- (O02) MATE70007: Engineering Alloys (5)
- (O03) MATE70008: Ceramic and Glass (5)
- (O04) MATE70010: Optoelectronic Properties (5)
- (O05) MATE70011: Surfaces and Interfaces (5)
- (O06) MATE70012: Nanomaterials (5)
- (O07) MATE70013: Advanced Engineering Alloys (5)
- (O08) MATE70014: Advanced Nanomaterials (5)
- (O09) MATE70015: Advanced Structural Ceramics (5)
- (O10) MATE70016: Advanced Tissue Engineering (5)
- (O11) MATE70017: Electroceramics (5)
- (O12) MATE70018: Advanced Biomaterials (5)
- (O13) MATE70019: Nuclear Materials (5)
- (O14) MATE70020: Modelling Materials with Density Functional Theory (5)

- (O15) MATE70021: Advanced Thin Film Manufacturing Technologies (5)
- (O16) MATE70022: Fusion and Advanced Reactors (5)
- (O17) MECH97057: Nuclear thermal Hydraulics (5)
- (O18) MECH97058: Nuclear Reactor Physics (5)
- (O19) CENG97031: Nuclear Chemical Engineering (5)

As part of *The Art of Research* course you will attend research seminars (producing reports on three of them) and transferable skills seminars offered by the graduate school. You will also meet regularly with your project supervisor in the autumn term to discuss your project and to write your project proposal. A full-time independent research project will run from the end of the exam period beginning of September; there is a research ethics course at the beginning. Projects will be assessed by a final written report and oral presentation.

### **ECTS summary**

Compulsory modules (not project related) = 15 ECTS  
 Compulsory modules (project related) = 55 ECTS  
 4 x Assessed options = 20 ECTS  
 Total = 90 ECTS

### **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.

MATE70001: Characterization of the Structure of Materials  
 MATE70002: Theory and Simulation of Materials  
 MATE70003: The Art of Research  
 MATE70004: Research Project

#### Ceramics and Glasses

MATE70008: Ceramic and Glass  
 MATE70015: Advanced Structural Ceramics  
 MATE70017: Electroceramics

#### Metals

MATE70007: Engineering Alloys  
 MATE70013: Advanced Engineering Alloys

#### Functional Materials

MATE70010: Electronic Structures and Opto-Electronic Properties  
 MATE70011: Surfaces and Interfaces  
 MATE70020: Modelling Materials with Density Functional Theory

#### Nanotechnology

MATE70012: Nanomaterials  
 MATE70014: Advanced Nanomaterials  
 MATE70021: Advanced Thin Film Manufacturing Technologies



Biomaterials Survey  
MATE70006: Biomaterials  
MATE70016: Advanced Tissue Engineering  
MATE70018: Advanced Biomaterials

Nuclear  
MATE70019: Nuclear Materials  
MATE70022: Fusion and Advanced Reactors  
MECH97057: Nuclear Thermal Hydraulics \*  
MECH97058: Nuclear Reactor Physics \*  
CENG97031: Nuclear Chemical Engineering \*

*\*These modules are run by other engineering department not materials*

*Students who have graduated (on the BEng) already from the Department of Materials are forbidden from repeating courses that they have previously completed. They should speak with the Director before choosing their options.*

## Study Groups

Learning can be greatly enhanced by talking with your fellow students about ideas being taught, and problems being solved for coursework. We thus assign you to study groups with about 10 students each. They will be set up once you have selected your options, so that we can put people with similar interests in the same group. Each group will have a representative, chosen by the group, who will help coordinate group activity, and will be a link to the Department for that group.

To help support the study groups the Department offers lunch vouchers for each group to go to lunch on campus twice in the first and second terms. The group team leader is responsible for collecting the vouchers from the student office. You will be able to collect these from the student office on the **Monday before each date** below:

### Term 1:

Tuesday 26th October 2021  
Tuesday 23rd November 2021

### Term 2:

Tuesday 1st February 2022  
Tuesday 1st March 2022

## Timetable

You will 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/>.

## Preparing for the courses: reviewing background material

The courses you take as part of your MSc may assume knowledge that you do not yet have. We provide lectures covering four areas (crystallography, microstructure, waves, and MATLAB) as part of the Art of Research. In addition, we provide you material to fill any gaps in your existing knowledge. The assumed knowledge is what is taught by the Department during the first two years of the undergraduate programme.

We have organised much of the course material from our Years 1 and 2 (old curriculum) into convenient learning packages that you can find on Blackboard (2021-2022 Materials General

Information, MSc Advanced Materials and Engineering (J2U3T)). Each learning package has a description of the module, a set of notes, example problems, and an old exam paper so you can estimate the level of knowledge expected. Where available, recordings of the lectures have been made available through Panopto. The learning packs will be available throughout your time studying for the MSc: you can refer to them whenever needed.

To provide structure to your study, we provide a comprehensive paper taken by our undergraduates in Year 3 that covers material from across Years 1 and 2.

While much of the study may be done alone, we strongly encourage meeting with your colleagues to discuss what you are doing: that way you can help each other learn.

### **Topics covered in Year 1 (old curriculum)**

MSE 101 Maths and computing

MSE 102 Materials Chemistry

MSE 103 Mechanics

MSE 104 Microstructure and Properties of Materials

MSE 105 Materials Physics

MSE 106 Materials Engineering [not available as not a prerequisite]

### **Topics covered in Year 2 (old curriculum)**

MSE 201 Maths and computing

MSE 202 Materials Chemistry

MSE 203 Mechanical Behaviour

MSE 204 Microstructure

MSE 205 Electronic Properties of Materials

MSE 206 Materials Engineering

## **Research Project**

You will learn what your project will be in week 1 of the Autumn Term. You can start on the project plan (part of Art of Research) immediately after you have spoken with your supervisor. The plan must be submitted for assessment by the end of the Autumn Term. You are encouraged to work on the literature review of the final thesis in the Spring Term: this keeps you engaged with your project and gives you more time at the end of the summer to work on other parts of the thesis. The research is mostly carried out once you have finished your exams, after which you need to write it up as a thesis (submitted in early September) and present a talk about it to the other MSc students and some academics (end of September): see below for more information about the thesis and presentation. Before you start your research in the Summer, you will be **required to attend a course on Research Ethics**, to be scheduled in term 2.

## **Art of Research**

This module is **compulsory** and includes a minimum of three elements:

1. Research project plan
2. Reports on research seminars
3. Taught courses

## **Research Project Plan**

During the Autumn Term you will need to write a project plan. This gives the information you need to plan the project in advance, and to enable the Department to assess the suitability of

the project. It forms part of the assessment for this module and is marked by the research project marking panel.

Below is the format of the project plan with a description of the information requested. Note that preparation of the plan will require reading and understanding of the literature, as well as an appreciation of what the project will aim to achieve. Please refer to the deadline planner for the exact deadline date on page 25.

### **Track Record [No marks]**

One paragraph describing what your UG degree covered.

- Note any previous research work you have done
- Note any experimental equipment you have learned to use
- Note any computational methods you have learned to use

### **Project Summary [85 marks] [approx. 4 pages]**

Background [40]

- Introduce the project topic and explain its context
- Review the state of scientific understanding in the field
- Describe the gap in our knowledge that the work will address

Research hypothesis and objectives [20]

- Set out your research idea or hypothesis
- Identify the overall aims of the project

Programme and methodology [25]

- Describe your research methodology
- Describe the work programme, indicating what research is to be undertaken, and the order in which the work will be done

### **Research Impact [5 marks]**

One paragraph to describe how your research may be of benefit to society and the state of scientific knowledge.

### **Work plan [5 marks]**

Provide a diagrammatic work plan (Gantt chart).

### **Resources Needed [No marks]**

List the resources you will require, and what equipment training you will need. Indicate what assistance you will require from other people. Indicate how you will use the £750 allocated to your project by the department. Please confirm this with your supervisor.

### **References [5 marks]**

Provide a list of your references here; around 20 would be typical.

This project proposal can be up to six A4 sides, including references. The minimum allowed font size is 11pt, the minimum margin width is 1.5 cm, and the minimum line spacing is single spaced.

### **Some other things to remember when submitting:**

- Electronic copy submitted through Blackboard Learn (for marking)
- Electronic copy submitted through Turnitin (plagiarism check)
- Style of font is Calibri or Arial (or similar)
- A4 size

For the references you can either use a numerical scheme:

- [1] Jonathan D. Breeze, Xavi Aupi and Neil McN. Alford. "Ultra-Low Loss Polycrystalline Alumina" Appl Phys Lett vol 81 p 5021 (2002)
- [2] Alan Templeton, Xiaoru Wang, Stuart J Penn, Stephen J Webb, Lesley F Cohen and Neil McN Alford "Microwave Dielectric Loss of Titanium Oxide" J Amer Ceram Soc 83 (1) 95-100 (2000)

or the Harvard scheme (recommended if you are not using reference management software):

[Brookes-2007] Brookes, J. C.; Hartoutsiou, F.; Horsfield, A. & Stoneham, A., "Could humans recognize odor by phonon assisted tunneling?" Physical Review Letters, 2007, 98, 038101

[Dreuw-2004] Dreuw, A. & Head-Gordon, M., "Failure of time-dependent density functional theory for long-range charge-transfer excited states: The zincbacteriochlorin-bacteriochlorin and bacteriochloro phyll-spheroidene complexes", Journal of the American Chemical Society, 2004, 126, 4007-4016

## Seminar Reports

You need to attend research seminars regularly, and then write summaries on 3 of your choice. The summary of a seminar should be one A4 page and should give the general background and key conclusions of the talk, and also your personal perspective on the research presented. See the template and coursework description for more details. Please refer to the deadline planner for the exact deadline date on page 25. We suggest you do a summary as soon as you hear a talk that inspires you. You will receive emails about LCN and TYC seminars and other talks too. There will be a lot of these throughout the year. Be proactive about getting information on more specialised talks from our research groups when you are assigned a supervisor. The reports are marked by your project supervisor and form part of the assessment for this module.

## Taught Components

- Basics of materials. This takes place at the start of the first term, and covers crystallography, microstructure, waves, and MATLAB
- Attendance at the compulsory course 'Writing for Masters 2: Literature Review' which you need to complete online in week 1.
- Attendance at one other course from the graduate school (see link: <https://www.imperial.ac.uk/study/pg/graduate-school/students/masters/professional-development/>). More information is provided below. Please try to get this done in Term 1 (classes only run from October to June) and then you can use the skills you have learnt for your research and study.

## Lab Equipment

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 by the College, departmental and local safety rules.

**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.**

## 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 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.
- Literature review. This must not be a copy of what you wrote for the project plan, but rather a review of the literature relevant to the project; it will generally be rather more extensive than what was done for the plan.
- 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: This is optional and will not be marked.

Writing concisely is a skill that you should be developing throughout the degree. It is easier to write a high-quality short document than a long one, and this is easier to mark in a robust



fashion. Therefore, the project report is limited to **35 pages of A4 in length** (excluding any appendices for the supervisor, etc). This includes the cover page and references.

A template (in LaTeX and MSWord) is provided on Blackboard learn and should be respected – **11pt Arial/Calibri for the main text, with 1.5cm margins, single spaced. Pages should be numbered, with the cover page being page 1.**

Further guidance is provided in the templates provided and the marking rubrics on Blackboard learn.

**Some other things to remember when submitting your thesis:**

- Electronic copy submitted through Blackboard Learn (for marking)
- Electronic copy submitted through Turnitin (plagiarism check)

Please refer to the deadline planner for the exact deadline date on page 25.

## Final Presentation (Research Project)

You will need to give a PowerPoint presentation that summarizes your research project. You have a total of 15 minutes: 12 minutes for the talk plus 3 minutes for questions. Your presentation should:

1. Introduce the aims of the project and situate it in the context of the research literature
2. Show the main results and findings
3. Discuss those results and present your conclusions.

You need to express yourself confidently when discussing the work and answering questions. The presentation should have a logical structure and high-quality slides, figures and graphs.

Please refer to the deadline planner for the exact deadline date on page 25.

The following links are reminder of what is expected from you and your supervisor during your project:

[What master's students and their project supervisors might mutually expect from each other \(MSc, MEd, MPH, MRes & PG Dip\)](#) – this document is intended to facilitate conversations between project supervisors and their students to establish effective partnerships.

The document can be found in the [Effective Partnerships](#) section of the Graduate School's Supervisors' Guide website

[Roles and responsibilities of the Master's Main Project Supervisor](#) - this document is intended to help clarify expectations as well as giving definition to the role of project supervisor.

The document can be found on the [Roles & Responsibilities](#) page of Registry's Quality Assurance & Enhancement website.

Please refer to them thought out your projects for reference.

## 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](mailto: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: <https://www.imperial.ac.uk/academic-english/current-students/master's/>

## 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 <https://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.

## The Graduate School

The Imperial College Graduate School supports 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: <https://www.imperial.ac.uk/study/pg/graduate-school/>.

## 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 <https://www.imperial.ac.uk/study/pg/graduate-school/students/masters/>.

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

## Imperial Mobile app

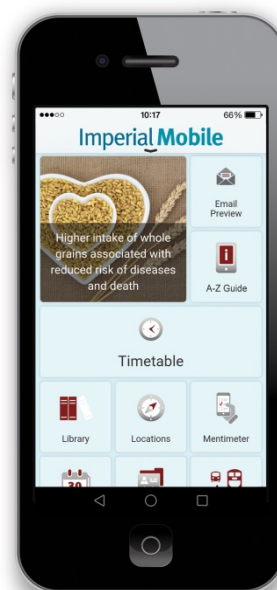
Don't forget to download the free Imperial Mobile app for access to College information and services anytime, anywhere, including your programme timetable, College emails and a library catalogue search tool.

 [www.imperial.ac.uk/imperialmobile](http://www.imperial.ac.uk/imperialmobile)

## Welcome to Imperial app

The College has a Welcome to Imperial app which contains important information about campus operations, aspects of student life, a schedule of welcome activities and information about life in halls. All new students should download this guide to ensure they have the most up to date information and event schedule for the start of term.

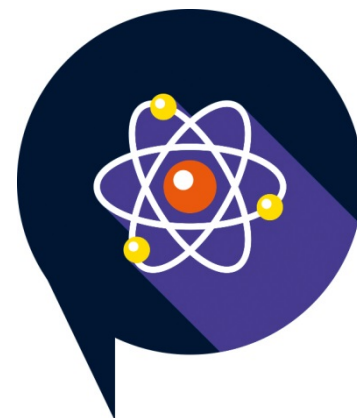
You can download the App from the Apple or Google App Stores.



## Imperial Success Guide

The Imperial Success Guide is an online resource with advice and tips on the transition to university level study. More than just a study guide, it is packed with advice created especially for undergraduate students, including information on support, health and well-being and ideas to help you make the most of London.

 [www.imperial.ac.uk/success-guide](http://www.imperial.ac.uk/success-guide)



## 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 'My Imperial' account as that is where we will look for your personal information.

## Official documents

To avoid queues at the Student Hub (throughout the year), you can request certificates via the on-line system (<http://www.imperial.ac.uk/student-hub/our-services/>). Due to the extremely high volume of requests at registration time, they may take slightly longer. Student Records 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.

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

- *Standard Statement*
- *Letters for Banks*
- *Council Tax Certificates*
- *Police Letter/Statement with Address*
- *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/>)*

## 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.

## Lockers

You will be allocated a locker for the duration of your degree which you can use to store your personal belongings and resources needed for your studies. \*

Please ensure you do not keep anything unsafe in your lockers and you abide by the points highlighted in the locker policy below.

### **Locker Policy**

- Please only use the locker allocated to you.
- Secure your allocated locker with a padlock.
- Please ensure any items you may have borrowed from Academics, PhD students, or Technicians for your projects or lab work are returned to them before the deadline for lockers to be emptied.
- Lockers must be emptied by **Friday, 9<sup>th</sup> of September 2022** (MSc Students). All personal items and rubbish must be disposed of, and anything left in lockers after this date will be thrown away by the Student Office.
- Any items stored in lockers that have been taken from or created in labs must be returned, recycled, or disposed of appropriately when you clear out your locker.

## Departmental laptops

### **Short-Term Loan Pool Scheme:**

All taught students in the department are permitted to borrow a laptop from the short-term loan pool scheme if their own laptop requires repair. Loan pool laptops can be borrowed for a maximum of four weeks, and extensions cannot be provided for the scheduled date of return\*. The short-term loan pool scheme policy can be found in the [2021-2022 Materials General Information](#) folder on Blackboard Learn.

\* Please note that owing to COVID-19 the short-term laptop scheme will not be available during the 2020-21 Autumn term. This policy will be reviewed later in the academic year.

## 3. Assessment

For assessments that take place in the autumn term, or at the start of the spring term of the 2021-22 academic year, where there was to be an in-person on-campus written examination, these will be assessed by timed remote assessments, irrespective of whether there are restrictions in place or not. We may continue to deliver examinations by timed remote assessments where these are deemed the most appropriate method of assessment.

## Examination of Compulsory and Optional Courses

The examination of the compulsory and optional taught courses is solely by written examination with the exception of MATE70001, MATE70002, MATE70006, MATE70007, MATE70011, MATE70014, MATE70018, MATE70020, and MATE70021 which have both a coursework and an exam component. MATE70003 and MATE70022 are assessed entirely by coursework.

### **Project**

The project is assessed as follows:

- A final presentation (in late September) accounts for 12.5% of the overall mark
- A written research report (submitted in early September) accounts for 87.5% of the overall mark.



Two members of a panel of assessors will mark your final report independently. 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 average of the two marks, following moderation by the course director if needed.

## Term breakdown

### Term One:

- Materials characterisation lectures (MATE70001)
- Theory and Simulations lectures and Workshops (MATE70002) – Part I Finite Elements
- Choose a project supervisor
- Research Project Plan (more detail on page 14)
- 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).

### Term Two:

- Materials characterisation labs (MATE70001)
- Theory and Simulation of Materials (MATE70002) – Part II Atomistic methods
- Art of Research
  - Attend a scientific seminar once a week
  - Write a report on three seminars
- Write literature review for Research Project thesis

### Term Three:

- Exams early in the term
- Research Project
  - Research Ethics lecture
  - Carry out Research Project for the remainder of the term and carry on until mid-August. By the start of September, you will have written a dissertation (more detail on page 17), and at the end of September you will give a final oral presentation.

## Coursework

You will be asked to write various pieces of coursework marked by your project supervisor, research assessor panel or lecturer/GTA. All coursework is submitted electronically via Blackboard, and must be submitted before the deadline. We recommend submitting 24 hours before the deadline in case there are problems. You should definitely leave **at least one hour**. For all reports the **deadline for submission of your work is 3pm** of the stipulated deadline date.

Blackboard will keep a record of the submission time of all work submitted electronically. Late receipt of work may be penalised. Where the deadline falls outside the term dates, it is replaced by the first Monday of the next term.

When submitting any coursework, please ensure you provide all of the information required on the front cover page (of your electronic documents):

- Full Name (registered name)
- CID Number
- Title subject of coursework you are submitting
- Course Programme

We can't allocate you marks if we don't know **who you are!** So, it's very important the above information is inputted on the front of any coursework submitted.

## Late work

Link to Late Submissions Policy and Penalties for late submission:



[www.imperial.ac.uk/media/imperial-college/administration-and-support-services/registry/academic-governance/public/academic-policy/marking-and-moderation/Late-submission-Policy.pdf](http://www.imperial.ac.uk/media/imperial-college/administration-and-support-services/registry/academic-governance/public/academic-policy/marking-and-moderation/Late-submission-Policy.pdf)

## Coursework Deadline Planner

The table gives you important coursework dates that you should remember. Coursework should always be handed in by **3pm** via Blackboard Learn.

Please note that these dates are **preliminary and may change throughout the year**. The dates below also depend on what options you pick so you may not be doing everything listed below. You will be notified of changes by the Student Office by email.

Term	Module	Assignment/Event	Due Date	Format	Feedback/Marks
	MATE70004	Choice of research project title	11:00am 7/10/21	Online selection	End of week 1
Autumn	Module options	Final module options selection	11:00am 12/10/21	Online via MS forms	End of week 2
	MATE70020	Homework problem 1	15:00 25/10/2021	Electronically via Blackboard Learn	1 week
	MATE70003	Art of Research - Assignment 3 - MATLAB program	15:00 26/10/2021	Electronically via Blackboard Learn	2 weeks*
	MATE70001	XRD Classwork assignment	At the end of your scheduled session (between weeks 4-6)	BB Learn Test	2 weeks (after all sessions have been held) *
	MATE70001	Equipment Demonstration Sessions	At the end of your scheduled session (between weeks 4-6)	BB Learn Test	2 weeks*
	MATE70020	Homework problem 2	15:00 01/11/2021	Electronically via Blackboard	1 week

			Learn	
MATE70022	Fusion Advanced Reactors - Coursework 1	15:00 04/11/2021	Electronically via Blackboard Learn	2 weeks*
MATE70020	Homework problem 3	15:00 08/11/2021	Electronically via Blackboard Learn	1 week
MATE70020	Homework problem 4	15:00 15/11/2021	Electronically via Blackboard Learn	1 week
MATE70022	Fusion Advanced Reactors - Coursework 2	15:00 18/11/2021	Electronically via Blackboard Learn	2 weeks*
MATE70020	Homework problem 5	15:00 22/11/2021	Electronically via Blackboard Learn	1 week
MATE70022	Fusion Advanced Reactors - Coursework 3	15:00 23/11/2021	Electronically via Blackboard Learn	2 weeks*
MATE70001	Characterisation Exercise Report Draft	15:00 <b>Group A:</b> 02/12/2021 <b>Group B:</b> 09/12/2021	Electronically via Blackboard Learn	Feedback on all drafts will be returned on 16th December 2021*
MATE70020	Homework problem 6	15:00 29/11/2021	Electronically via Blackboard Learn	1 week
MATE70002	Theory and Sim of Materials - Coursework 1 (Finite Elements)	15:00 30/11/2021	Electronically via Blackboard Learn	2 weeks*
MATE70020	Homework problem 7	15:00 06/12/2021	Electronically via Blackboard Learn	1 week

	MATE70022	Fusion Advanced Reactors - Coursework 4 (Advanced Reactors 1)	15:00 09/12/2021	Electronically via Blackboard Learn	2 weeks*
	MATE70020	Homework problem 8	15:00 13/12/2021	Electronically via Blackboard Learn	1 week
	MATE70003	Art of Research - Assignment 2 - Project Plan	15:00 16/12/2021	Electronically via Blackboard Learn	2 weeks*
Spring	MATE70007	Engineering Alloys Coursework	15:00 10/01/2022	Electronically via Blackboard Learn	2 weeks*
	MATE70021	Device manufacturing route report and workshops	15:00 11/01/2022	Electronically via Blackboard Learn	2 weeks*
	MATE70001	Characterisation Exercise Report	15:00 13/01/2022	Electronically via Blackboard Learn	4 weeks*
	MATE70022	Fusion Advanced Reactors - Coursework 5 (Advanced Reactors 2)	15:00 17/01/2022	Electronically via Blackboard Learn	2 weeks*
	MATE70022	Fusion Advanced Reactors - Coursework 6 (Advanced Reactors 3)	15:00 24/01/2022	Electronically via Blackboard Learn	2 weeks*
	MATE70014	Nanomaterials Presentation abstract	15:00 15/02/2022	Electronically via Blackboard Learn	2 weeks*
	MATE70011	Essay paper	15:00 17/02/2022	Electronically via Blackboard Learn	1 week (no marks, only feedback)

MATE70002	Theory and Sim of Materials - Coursework 2 (Atomistic assignments 1 & 2)	15:00 22/02/2022	Electronically via Blackboard Learn	2 weeks*
MATE70002	Theory and Sim of Materials - Coursework 2 (Atomistic assignment 3)	15:00 01/03/2022	Electronically via Blackboard Learn	2 weeks*
MATE70002	Theory and Sim of Materials - Coursework 3 (Research Project)	15:00 03/03/2022	Electronically via Blackboard Learn	2 weeks*
MATE70003	Art of Research - Assignment 1 - Seminar Reports	15:00 10/03/2022	Electronically via Blackboard Learn	2 weeks*
Module options	Final module options selections for summer exams	11am 10/03/2022	Online form via My Department	N/A
MATE70011	"Pecha-Kucha" presentation slides	15:00 14/03/2022	Electronically via Blackboard Learn	2 weeks*
MATE70014	Nanomaterials presentation slides	15:00 15/03/2022	Electronically via Blackboard Learn	2 weeks*
<b>Summer</b>				
MATE70004	Research Project Supervisor assessment (no student submission)	August 2022	MS Forms by project supervisor	N/A
MATE70004	Research Project Thesis	15:00 30/08/2022	Blackboard Learn and Turnitin	N/A
MATE70004	Final Project Presentation	19th-21st Sept 2022	No submission	No marks provided, only oral feedback from the panel during the presentations.



## Marking

Once the coursework has been marked and the mark recorded will be returned to you via Blackboard Learn by the Student Office. The mark scheme is set out below:


70-100%	60-69%	50-59%	0-49%
Distinction	Merit	Pass	Fail

## Departmental policy on failures

The Materials Department does not offer students the opportunity to repeat the programme 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 MSc Administrator with any relevant information concerning mitigating circumstances.

## Module failures

We follow the College Regulations for Taught Programmes of Study for both marginal and other module failures. The regulations can be found here in the sections headed **Compensation** and **Module Failure**:

 [www.imperial.ac.uk/student-records-and-data/for-current-students/undergraduate-and-taught-postgraduate/exams-assessments-and-regulations/](http://www.imperial.ac.uk/student-records-and-data/for-current-students/undergraduate-and-taught-postgraduate/exams-assessments-and-regulations/)

## Overall performance

We follow the College Regulations for Taught Programmes of Study for awarding degrees. The regulations can be found here in the sections headed **Award of a Postgraduate Degree and Classification of Postgraduate Taught Awards**:


 [www.imperial.ac.uk/student-records-and-data/for-current-students/undergraduate-and-taught-postgraduate/exams-assessments-and-regulations/](http://www.imperial.ac.uk/student-records-and-data/for-current-students/undergraduate-and-taught-postgraduate/exams-assessments-and-regulations/)

## Instruction to Candidates for Examinations

Students who are candidates for examinations are asked to note that all examinations are conducted in accordance with the College Regulations. The relevant set of regulations will depend on your programme and year of entry, please see our Regulations webpage to determine which apply to you:

 [www.imperial.ac.uk/about/governance/academic-governance/regulations/](http://www.imperial.ac.uk/about/governance/academic-governance/regulations/)

Instructions for exam candidates can be found here:

 [www.imperial.ac.uk/media/imperial-college/administration-and-support-services/registry/academic-governance/public/academic-policy/exam-arrangements-and-re-sits/Instructions-to-candidates-for-examinations.pdf](http://www.imperial.ac.uk/media/imperial-college/administration-and-support-services/registry/academic-governance/public/academic-policy/exam-arrangements-and-re-sits/Instructions-to-candidates-for-examinations.pdf)

## Academic Integrity and Academic Misconduct

As your programme of study continues, you will be taught the concept of academic integrity and how you can ensure that any work that you complete now, or in the future, conforms to these principles. This means that your work acknowledges the ideas and results of others, that it is conducted in an ethical way and that it is free from plagiarism. Academic integrity is fundamental to learning, teaching and research and it is important to understand what it means you and the international community of research that you are joining.

Academic misconduct is the attempt to gain an academic advantage, whether intentionally or unintentionally, in any piece of assessment submitted to the College. This includes plagiarism, self-plagiarism, collusion, exam offences or dishonest practice. Full details of the policy can be found at:



[www.imperial.ac.uk/student-records-and-data/for-current-students/undergraduate-and-taught-postgraduate/exams-assessments-and-regulations/plagiarism-academic-integrity--exam-offences/](http://www.imperial.ac.uk/student-records-and-data/for-current-students/undergraduate-and-taught-postgraduate/exams-assessments-and-regulations/plagiarism-academic-integrity--exam-offences/)

Definitions of the main forms of academic misconduct can be found below:

### 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 is the presentation of another person's thoughts, words, images or diagrams as though they were your own. Another form of plagiarism is self-plagiarism, which involves using your own prior work without acknowledging its reuse. Plagiarism may be intentional, by deliberately trying to use another person's work by disguising it or not citing the source, or unintentional where citation and/or referencing is incorrect.

Plagiarism must be avoided, with particular care on coursework, essays, reports and projects written in your own time but also in open and closed book written examinations. You can support your understanding of proper referencing and citation by using the resources available from the College such as the Library learning support webpages at:



[www.imperial.ac.uk/admin-services/library/learning-support/plagiarism-awareness/](http://www.imperial.ac.uk/admin-services/library/learning-support/plagiarism-awareness/)

Where plagiarism is detected in group work, members of that group may be deemed to have collective responsibility for the integrity of work submitted by that group and may be liable for any penalty imposed, proportionate to their contribution.

TurnitinUK is an online text matching service which assists staff in detecting possible plagiarism. The system enables institutions and staff to compare students' work with a vast database of electronic sources. Your programme team will explain how it is used in your programme



[www.imperial.ac.uk/admin-services/ict/self-service/teaching-learning/turnitin/](http://www.imperial.ac.uk/admin-services/ict/self-service/teaching-learning/turnitin/)

Link to the College's mandatory online training for Plagiarism for Master's students can be found here:



[www.imperial.ac.uk/study/pg/graduate-school/students/masters/professional-development/plagiarism-online/](http://www.imperial.ac.uk/study/pg/graduate-school/students/masters/professional-development/plagiarism-online/)

This course was developed by the Graduate School, in conjunction with the Library. It aims to equip all Imperial postgraduate students with a working knowledge of the concept of plagiarism and how to avoid it.

You are required to achieve a threshold level of understanding which will be tested through a final exam. **Instructions on how to obtain a certificate as proof of completion can be found in the course in the section 'Course Info.'**

On completion of this online workshop you will be able to:

1. **Explain** what plagiarism is
2. **Identify** incorrect referencing and possible potential cases of plagiarism
3. **Apply** techniques to avoid the different types of plagiarism
4. **Reference** properly someone else's work as well as your own work
5. **Evaluate** and relate the impact of academic integrity to your own work as researcher and in your career

**If you do not find the course on your Blackboard, please follow the instructions self-enrol onto the course: [Plagiarism Awareness \(Masters Students\) 2020-2021](#)**

Master's programme administrators 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.

## Collusion

This is the term used for work that has been conducted by more than one individual, in contravention of the assessment brief. Where it is alleged that there has been collusion, all parties will be investigated under the Academic Misconduct procedure.

You should note that whilst the College encourages students to support each other in their studies you should be careful to ensure that you do not exceed the assessment brief with regards to individual work, always acknowledge the contributions of others in your work, and do not leave yourself open to allegations that you have supplied answers to enable another student to commit academic misconduct.

## Exam offences

Exam offences fall into two categories. These are offences that may be disruptive in the exam venue or are considered an attempt to cheat. This can include behaviour such as bringing unauthorised material into an exam, attempting to communicate with others apart from the invigilator, trying to remove examination material without permission, taking an exam for someone else or getting someone else to take an exam for you. It would also include having an electronic device that has not been fully turned off or failing to follow a reasonable instruction of the invigilators.

## Dishonest practice

This is the most serious category under the procedure. Examples of dishonest practice include bribery, contact cheating (buying work from an essay mill or other individual to submit as your own), attempting to access exam papers before the exam, making a false claim for mitigating circumstances or providing fraudulent evidence, falsifying documentation or signatures in relation to assessment or a claim for mitigating circumstances.

## Preparing yourself for the exam

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:

- Gather together, read, and understand all the lecture notes, classwork and worked solutions.
- Try past papers – papers for the last 2 years are available on Blackboard Learn (where possible).
- Know what is going to be covered in the exam and the format of the examination paper.
- Know when and where the exam will take place.
- If you are registered dyslexic, you should inform the Disability Officer (see page 46) 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

## Just before the start of the exam

**Note that this advice applies only to exams held in person on campus. For timed remote assessments, advice will be provided by the Department closer to the time of the assessment.**

- 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.

## During the exam

**Note that this advice applies only to exams held in person on campus. For timed remote assessments, advice will be provided by the Department closer to the time of the assessment.**

- 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.
- 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.

**Please note this may not apply this year due to COVID.**

## 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.

## 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 June for the results from the taught courses, and the end of September for the Research Project, and degree outcomes). This is also true for coursework. After the results have been approved by Registry you can download all your marks from your 'My Imperial' student account (exams and coursework).

In the unlikely event that you are unable to sit an exam through serious medical reasons you may be able to take the exam at a later date if this is agreed by the exam board.

## Re-sits

You may find out that you have to take some re-sits in order to pass the degree program. You will be notified either after the exam board at the end of June. 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 abroad. 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**.

## Re-sit Timetable

If you are required to re-sit the following summer, then please note the Exam timetable will not be published until Spring term and you will receive an email from the Student Office in March with details for the re-sits you are doing.

## Marking Schemes for postgraduate taught programmes:

The pass mark for **all** postgraduate taught course modules is **50%**. Students must pass all modules in order to be awarded a degree.

## 4. Board of Examiners

### Board of Examiners

Members of the Board of Examiners are members of the academic staff of the Department of Materials and those from other departments in College who are involved in teaching and assessment in the Department of Materials. This list can be determined from your academic timetable. Also see the Appendix B (page 111) for a list of all academic staff involved in teaching.

### External Examiners

 Prof Alessandro Mottura, Birmingham University

External examining acts as an essential part of the College's quality assurance and enhancement process, serving to ensure that academic standards are maintained. The knowledgeable and independent views of external examiners are invaluable in certifying that the College's awards are appropriate and comparable as well as highlighting good practice and potential areas of enhancement.

During your programme you may be invited to meet your external examiners to discuss how you have found the programme. It is not appropriate however, for you to seek to submit complaints or representations directly to external examiners or to seek to influence them other than by giving feedback in a meeting. Inappropriate communication towards an examiner would make you liable for disciplinary action.

A summary of External examiners reports from the previous academic year can be found here:

 [www.imperial.ac.uk/about/governance/academic-governance/academic-policy/external-examining/](http://www.imperial.ac.uk/about/governance/academic-governance/academic-policy/external-examining/)


## 5. Location and Facilities

Imperial has a number of campuses in London and the South East. All have excellent travel links and are easily accessible via public transport.

### Your main location of study will be:

 South Kensington Campus  
Department of Materials  
Royal School of Mines  
Exhibition Road  
London, SW7 2AZ – UK

View a map of South Kensington Campus:

 <https://www.imperial.ac.uk/media/imperial-college/faculty-of-engineering/department-of-materials/internal/SouthKensingtonCampus.pdf>

The Royal School of Mines is building number 12 on the map. The best entrance to the building is via Prince Consort Road.

Closest Tube Stations: South Kensington and Gloucester Road.

## 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 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) 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.

## Departmental Common Rooms

You have access to a common room G10. G10 is only accessible to MSc Student and 3/4th year undergraduate students. These rooms are for you to study in, in both groups and individually. You should not misuse the departmental rooms and be respectful of other students when using the room. This room is for Materials student **ONLY**, do not let in any other authorised students in the room. Any misbehaviour will not be tolerated.

## 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.

## Library Services

The Central Library at South Kensington is open around the clock for study space pretty much all year. Make sure you find out who your departmental librarian is as they'll be able to help you find resources for your subject area. Also, don't forget to check out the Library's range of training workshops and our other campus libraries for access to specialist medicine and life sciences resources. Alongside these physical spaces and resources, the Library provides over 300,000 electronic books, journals and databases available both on and off campus and a free document delivery service to help you source books and articles from around the UK and the rest of the world. In order to keep you safe many of our services are operating remotely and we will be controlling the numbers who can visit our libraries. Services may be slightly reduced but you can keep up to date with the latest developments on our website and on Twitter @imperiallibrary.

 [www.imperial.ac.uk/library](http://www.imperial.ac.uk/library)

## Maps

Campus maps and travel directions are available at:

 [www.imperial.ac.uk/visit/campuses](http://www.imperial.ac.uk/visit/campuses)

## Accessibility

Information about the accessibility of our South Kensington Campus is available online through the AccessAble access guides:

 [www.accessable.co.uk/organisations/imperial-college-london](http://www.accessable.co.uk/organisations/imperial-college-london)

## Smoke-Free Policy

All Imperial campuses and properties are smoke-free. This means that smoking by staff, students or visitors is not permitted on or within 20 metres of College land. The policy covers all College properties, including student accommodation and sports grounds.

 [www.imperial.ac.uk/smoke-free](http://www.imperial.ac.uk/smoke-free)

## SafeZone

SafeZone is a College app through which you can quickly and directly contact the Security team whenever you need them. Whether you're in an emergency situation, in need of First Aid or want to report an incident on campus, SafeZone allows you to be immediately put in touch with a member of our Security team and, at the touch of a button, can share your location and personal profile so that they can respond quickly and effectively to your specific needs. It also allows the entire College community to stay informed in the event of a major incident in London or wherever you may be in the world. Safezone also provides information on other services, such as real-time updates on the College shuttle bus.



SafeZone is optional to register for and is now available to download on the Apple and Android App stores. Visit [www.imperial.ac.uk/campus-security](http://www.imperial.ac.uk/campus-security) for more details about SafeZone.

All existing phone numbers for the Security team are still operational. In the event of an emergency, you can still call 4444 from any internal College phone. In the event of a wider incident in London, you can now also call 0300 131 4444, Imperial's Emergency Recorded Message Line, which will point you in the direction of up-to-date information and advice.

## Changes due to Coronavirus (COVID-19)

The College will keep you informed about any further changes that may affect you due to the impact of coronavirus (COVID-19). The COVID-19 FAQs on the website are a repository of helpful information and the latest guidance can be found at:

 <https://www.imperial.ac.uk/about/covid-19/students/>

## 6. Working While Studying

If you are studying full-time, the College recommends that you do not work part-time during term time. If this is unavoidable, we advise you to work no more than 10–15 hours per week, which should be principally at weekends and not within normal College working hours.

Working in excess of these hours could impact adversely on your studies or health.

If you are here on a Tier 4/Student Route visa you can work no more than 20 hours a week during term time. Some sponsors may not permit you to take up work outside your studies and others may specify a limit.

If you are considering part-time work during term time you are strongly advised to discuss this issue with your Personal Tutor. If you are on a Tier 4/Student Route visa you should also seek advice from the International Student Support team regarding visa limitations on employment.

The College's examination boards will not normally consider as mitigating circumstances any negative impact that part-time work during term-time may have had on your performance in examinations or in other assessed work. Examinations or vivas cannot be rescheduled to accommodate your part-time working arrangements.

## 7. Health and Safety

Keeping you safe is a top priority for us. We continue to be guided by the latest official government guidance. At Imperial, we also have some of the world's leading researchers of the coronavirus (COVID-19) pandemic who are advising governments around the world on the most effective measures to take to protect people from the virus as well as developing and testing a new vaccine.

You will be required to follow the safety requirements put in place on campus and in all College buildings (including halls) to ensure we keep the campuses and the Imperial community safe and to mitigate the impact of the pandemic, particularly in our ability to deliver your degree programme and to offer you a full student experience.

You can find the latest guidance on the measures we are taking for your safety, plus information about the healthcare support available to you at:

 [www.imperial.ac.uk/about/covid-19/students/keeping-you-safe/](http://www.imperial.ac.uk/about/covid-19/students/keeping-you-safe/)

The College's Health and Safety Policy can be found at:

 [www.imperial.ac.uk/safety/safety-by-topic/safety-management/health-and-safety-policy-statement/](http://www.imperial.ac.uk/safety/safety-by-topic/safety-management/health-and-safety-policy-statement/)



**Your Departmental safety contact is:**

-  **Dr Peter Petrov**
-  Room: B333 (LCN Corridor)
-  +44 20 7594 8156 or +44 20 7595 0321
-  p.petrov@imperial.ac.uk

### The College Safety Department

The Safety Department offers a range of specialist advice on all aspects of safety. This includes anything which you feel might affect you directly, or which may be associated with teaching, research or support service activities.

The College's activities range from the use of hazardous materials (biological, chemical and radiological substances) to field work, heavy or awkward lifting, driving, and working alone or late.

All College activities are covered by general health and safety regulations, but higher risk activities will have additional requirements.

The Safety Department helps departments and individuals ensure effective safety management systems are in place throughout the College to comply with specific legal requirements.

Sometimes the management systems fail, and an accident or a near-miss incident arises; it is important that we learn lessons from such situations to prevent recurrence and the Safety Department can support such investigations. All accidents and incidents should be reported online at:

 [www.imperial.ac.uk/safety](http://www.imperial.ac.uk/safety)

To report concerns or to ask for advice you should contact your programme director, academic supervisor or departmental safety officer in the first instance. You may also contact the Safety Department directly.

Please familiarise yourself with the Departmental Safety Policy and important useful safety personnel in the department which you can find on our website:

 <https://www.imperial.ac.uk/materials/internal/hsgdom/>

## Occupational Health requirements

The College Occupational Health Service provides services to:

- protect health at work
- assess and advise on fitness for work
- ensure that health issues are effectively managed

The Service promotes and supports a culture where the physical and psychological health of staff, students and others involved in the College is respected, protected and improved whilst at work.

 [www.imperial.ac.uk/occupational-health](http://www.imperial.ac.uk/occupational-health)

## 8. College Policies and Procedures

### Regulations for Students

All registered students of the College are subject to the College Regulations. The relevant set of regulations will depend on your programme and year of entry, please see our Regulations webpage to determine which apply to you:

 [www.imperial.ac.uk/about/governance/academic-governance/regulations](http://www.imperial.ac.uk/about/governance/academic-governance/regulations)

 [www.imperial.ac.uk/students/terms-and-conditions](http://www.imperial.ac.uk/students/terms-and-conditions)

### Academic Feedback Policy

We are committed in providing you with timely and appropriate feedback on your academic progress and achievement, enabling you to reflect on your academic progress. During your study you will receive different methods of feedback according to assessment type, discipline,



level of study and your individual need. Further guidance on the Policy of Academic Feedback can be found on the Academic Governance website:



[www.imperial.ac.uk/media/imperial-college/administration-and-support-services/registry/academic-governance/public/academic-policy/academic-feedback/Academic-feedback-policy-for-taught-programmes.pdf](http://www.imperial.ac.uk/media/imperial-college/administration-and-support-services/registry/academic-governance/public/academic-policy/academic-feedback/Academic-feedback-policy-for-taught-programmes.pdf)

Please review each individual coursework item to see the specific feedback policy relating to that item. Please note that feedback can take multiple forms in the Department, from verbal interaction with a GTA through to formal written assessed commentary on a submitted paper. Any interaction with a GTA, lecturer, tutor or other member of staff related to a learning process, should therefore be considered as part of your feedback on coursework.

Please note that your examination scripts once completed belong to the College under the GDPR legislation. Please see the College GDPR webpages for further information at:



[www.imperial.ac.uk/admin-services/secretariat/information-governance/data-protection/internal-guidance/guide-2---exam-records/](http://www.imperial.ac.uk/admin-services/secretariat/information-governance/data-protection/internal-guidance/guide-2---exam-records/)

## Provisional Marks Guidance

Provisional marks are agreed marks that have yet to be ratified by the Board of Examiners. These results are provisional and are subject to change by the Board of Examiners. The release of provisional marks is permitted except in certain circumstances. Further information can be found in the Guidelines for Issuing Provisional Marks to Students on Taught Programmes:



[www.imperial.ac.uk/media/imperial-college/administration-and-support-services/registry/academic-governance/public/academic-policy/markings-and-moderation/Guidelines-for-issuing-provisional-marks-to-students-on-taught-programmes.pdf](http://www.imperial.ac.uk/media/imperial-college/administration-and-support-services/registry/academic-governance/public/academic-policy/markings-and-moderation/Guidelines-for-issuing-provisional-marks-to-students-on-taught-programmes.pdf)

## Late Submission Policy

You are responsible for ensuring that you submit your coursework assessments in the correct format and by the published deadline (date and time). Any piece of assessed work which is submitted beyond the published deadline (date and time) would be classed as a late submission and will incur a penalty (a cap at the pass mark, or it is classed as a fail). Further guidance on Late Submission of Assessments can be found on the Academic Governance website:



[www.imperial.ac.uk/media/imperial-college/administration-and-support-services/registry/academic-governance/public/academic-policy/markings-and-moderation/Late-submission-Policy.pdf](http://www.imperial.ac.uk/media/imperial-college/administration-and-support-services/registry/academic-governance/public/academic-policy/markings-and-moderation/Late-submission-Policy.pdf)

If you submit late due to mitigating circumstances, you may be able to make a claim that means that the cap on your mark is lifted. Please see below and the policy document.

## Mitigating Circumstances

During your studies you may be affected by sudden or unforeseen circumstances. You should always contact your personal tutor for advice and support. If this happens at the time of, or immediately preceding your assessments you may be able to make a claim for mitigating circumstances. If successful this claim enables the Board of Examiners when reviewing your marks at the end of the year to have greater discretion with regards to offering repeat attempts

(either capped or uncapped), a repeat year, or with your progression or final classification. Please note, the Board are not permitted to amend the marks that you were awarded, only to take your claim into account making decisions.

All claims must be supported by independent evidence and submitted within 10 working days of the assessment deadline. Any claim made after this deadline is likely to be rejected unless there is a good reason (such as you were still unwell) until the point of submitting the claim. Details of the College's Mitigating Circumstances procedure can be found under the Mitigating Circumstances tab on the page below:



[www.imperial.ac.uk/about/governance/academic-governance/academic-policy/exams-and-assessment/](http://www.imperial.ac.uk/about/governance/academic-governance/academic-policy/exams-and-assessment/)

Through the procedure you may also be able to request an extension deadline to some forms of assessment. Wherever possible it is expected that this is used as it will enable to you complete your studies within the same College year (rather than over the summer holiday or in the next year).

Mitigation is submitted in the Department by completing the mitigating circumstances form directly at [MyDepartment](#) app. The link to MyDepartment can also be found in the General Information folder on Blackboard or on your year's MS Team.

Mitigating panels will meet regularly through the year (at approximately 2 week intervals). You will normally be given written feedback regarding your mitigation after the panel has met, and you are expected to act on the feedback you receive appropriately. Outcomes of mitigation submissions will be provided back to you through MyDepartment or on email.

Support for ongoing or long-term conditions, or for registered disabilities would not normally fall under the remit of mitigating circumstances and students should be supported through their studies with Additional Examination Arrangements. More details can be found at:



[www.imperial.ac.uk/disability-advisory-service/support/exams/](http://www.imperial.ac.uk/disability-advisory-service/support/exams/)

## Academic Misconduct Policy and Procedures

As has been highlighted under the Academic Integrity section, it is important that you learn how to properly attribute and acknowledge the work, data and ideas of others. Any proven form of academic misconduct is subject to penalties as outlined in the College's Misconduct Policy and Procedures.



[www.imperial.ac.uk/about/governance/academic-governance/academic-policy/exams-and-assessment/](http://www.imperial.ac.uk/about/governance/academic-governance/academic-policy/exams-and-assessment/)

## Unsatisfactory Progress

Unfortunately, sometimes students struggle to make satisfactory progress in their study or their engagement with their studies falls below our expectations. The College has a process to identify and support students by reaffirming these expectations with an action plan. The full details of this process, and the appeals procedure relating to it can be found at:



[www.imperial.ac.uk/about/governance/academic-governance/academic-policy/complaints-appeals-and-discipline](http://www.imperial.ac.uk/about/governance/academic-governance/academic-policy/complaints-appeals-and-discipline)

## Academic Appeals Procedure

We have rigorous regulations in place to ensure assessments are conducted with fairness and consistency, claims for mitigating circumstances have been considered reasonably and in line with the regulations of the College, and that the decisions of the Boards of Examiners maintain the integrity of our academic awards. In the event that you believe that you have grounds to appeal these decisions, we have laid out clear and consistent procedures through which appeals can be investigated and considered:



[www.imperial.ac.uk/about/governance/academic-governance/academic-policy/complaints-appeals-and-discipline](http://www.imperial.ac.uk/about/governance/academic-governance/academic-policy/complaints-appeals-and-discipline)

## Arithmetic Marks Check (Examinations and year results)

If you consider that there may have been an error in the adding up of your marks, you may request an arithmetic mark check. Please note that this must be requested within 10 working days of the official notification of your results from the Results team in Registry. You may not request a marks check for a previous year of study.

Mark queries are submitted through the [MyDepartment](#) app which can also be accessed in the General Information folder on Blackboard or in your year's MS Team.

## Marks Query Check (coursework and test marks)

If you consider that a coursework assignment you have submitted or a test you have sat may have been unfairly marked against the rubric published, you may be able to request a check on the marks you have been awarded.

Mark query checks are submitted through the [MyDepartment](#) app by completing the Mark Query Check form. The link can also be found in the General Information folder on Blackboard or in your year's MS Team.

Mark Query Checks will only be considered when submitted within 10 working days after receiving your test or coursework mark, and any requests after 10 working days will only be considered with mitigating circumstances.

Outcomes of Mark Query Check requests will be published to you through MyDepartment within 15 working days.

## Student Complaints

The College strives to ensure that all students are well supported in their studies and receive a good experience of their programme and the wider College activities. If you feel that your experience has not lived up to these expectations the College has an agreed Students Complaints process through which your concern can be investigated and considered.

If you have any concerns about your experience at the College and have been unable to address these informally, you should contact Student Complaints who can provide advice about what is the appropriate way to seek to resolve this at:




[student.complaints@imperial.ac.uk](mailto:student.complaints@imperial.ac.uk)



[www.imperial.ac.uk/about/governance/academic-governance/academic-policy/complaints-appeals-and-discipline](http://www.imperial.ac.uk/about/governance/academic-governance/academic-policy/complaints-appeals-and-discipline)

## Student Disciplinary Procedure

The College has the right to investigate any allegation of misconduct against a student and may take disciplinary action where it decides, on the balance of probabilities, that a breach of discipline has been committed. The general principles of the Student Disciplinary Procedure are available on the College website:

 [www.imperial.ac.uk/admin-services/secretariat/college-governance/charters/ordinances/students/](http://www.imperial.ac.uk/admin-services/secretariat/college-governance/charters/ordinances/students/)

## Intellectual Property Rights Policy

For further guidance on the College's Intellectual Property Rights Policy is available on the College website:

 [www.imperial.ac.uk/students/enterprising-students/intellectual-property/](http://www.imperial.ac.uk/students/enterprising-students/intellectual-property/)

Further information about the Imperial Enterprise Lab can be found at:

 [www.imperial.ac.uk/students/enterprising-students/](http://www.imperial.ac.uk/students/enterprising-students/)  
 [www.imperialenterpriselab.com/support/experts-in-residence](http://www.imperialenterpriselab.com/support/experts-in-residence)

## Use of IT Facilities


View the Conditions of Use of IT Facilities:

 [www.imperial.ac.uk/admin-services/ict/self-service/computers-printing/staff-computers/conditions-of-use-for-it-facilities/](http://www.imperial.ac.uk/admin-services/ict/self-service/computers-printing/staff-computers/conditions-of-use-for-it-facilities/)

## General Data Protection Regulation (GDPR)

All staff and students who work with personal data are responsible for complying with GDPR. The College will provide support and guidance, but you do have a personal responsibility to comply.

In line with the above please see the College's privacy notice for students which form part of the terms and conditions of registration with the College.

 <https://www.imperial.ac.uk/media/imperial-college/administration-and-support-services/registry/academic-governance/public/academic-policy/admissions/ICL---Privacy--Notice-for-Students-and-prospective-students.pdf>

## 9. Wellbeing, Support and Advice

### In your department

Your department has a system of academic and pastoral care in place to make sure you have access to the appropriate support throughout your time at Imperial.

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 MSc Senior Tutor

Your Senior Tutor acts as your personal tutor (if required) and will remain the same person throughout your time here at the Department. They would be the first point of contact if you need help or guidance alongside the Student Office.

Your Senior Tutor will therefore get to know you better than most other members of staff and is best placed to advise you on study skills, progression, and professional development. You can talk to your Senior Tutor in confidence on any matter that is affecting you. Your Senior Tutor 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.

## Your Course Director/Deputy Course Director

Your Course Director/Deputy Course Director also acts as your personal tutor if the Senior Tutor is not available (if required). They can be contacted about course matters that you think need to be raised and addressed.

Your Course Director is also well 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. 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 of this you will also have two Class Representatives who you can raise any concerns on your behalf to both Senior Tutor/Course Director (more information on page 47).

## The Materials Student Office team Emails: queries etc.

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

### Letter request

If you need the Student Office to provide you with a letter, please give the us at **least a week's notice** (more if possible). At busy times in the term it can take up to 2 weeks for a 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 from the Course Director, please could you email and discuss this in advance of your need with them directly.

### **Student Office**

The Student Office is in G.03a and is open to students. There will almost always be someone there to help you if you need it. 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. If that is the case then please email us at [materialsstudentoffice@imperial.ac.uk](mailto:materialsstudentoffice@imperial.ac.uk) and we will get back to you as soon as possible.

### **Departmental Disability Officers**

Departmental Disability Officers are the first point of contact in your department for issues around disability. They can apply for additional exam arrangements on your behalf and will facilitate support within your department.

#### **Your Departmental Disability Officer: Dr Paul Franklyn**

Email: [p.franklyn@imperial.ac.uk](mailto:p.franklyn@imperial.ac.uk)

Telephone: 44 (0)20 7594 6725

More information on Departmental Disability Officers is available at:



[www.imperial.ac.uk/disability-advisory-service/support/ddos](http://www.imperial.ac.uk/disability-advisory-service/support/ddos)

More information about how to request additional arrangements for exams if you have a disability is available at:



[www.imperial.ac.uk/student-records-and-data/for-current-students/undergraduate-and-taught-postgraduate/exams-assessments-and-regulations/additional-exam-arrangements-in-respect-of-disability](http://www.imperial.ac.uk/student-records-and-data/for-current-students/undergraduate-and-taught-postgraduate/exams-assessments-and-regulations/additional-exam-arrangements-in-respect-of-disability)

### **In your hall of residence**

If you're staying in College accommodation you will have access to a range of support within your hall.

All halls have a Hall Warden team who are on call 24/7 to look after your wellbeing and maintain a friendly living environment so that all residents can study, sleep, relax and enjoy themselves.

They also play an important part in the social life of the hall, organising a rolling programme of events to bring everyone together. Your rent includes a contribution towards your halls activity fund.

The team includes returning students, known as Hall Seniors, who can offer first-hand advice about making the most of life at Imperial.



Each hall also has a Hall Supervisor or a Reception team who oversee the day-to-day running of the residence. So, if you have any enquiries or want to report a maintenance issue there are people on hand to help you.

Your health, safety and wellbeing are our top priority in halls of residence. We have made a number of changes in response to COVID-19, so that we can ensure our residents are safe, secure and comfortable and can comfortably adhere to social distancing guidelines. This will include staggered arrival times, clear self-isolation procedures, and amendments to corridor and communal space usage.

More information and the latest guidance around accommodation can be found at:

 [www.imperial.ac.uk/study/campus-life/accommodation](http://www.imperial.ac.uk/study/campus-life/accommodation)

## Your Union

All Imperial students automatically become members of Imperial College Union when they register at the College. The Union provides a range of independent support.

### Imperial College Union Advice Centre

The Union's advisers are on hand to provide free, confidential, independent advice on a wide range of welfare issues including housing, money and debt, employment and consumer rights, and personal safety.

 [www.imperialcollegeunion.org/advice](http://www.imperialcollegeunion.org/advice)

### Student representatives

Imperial College Union operates two Representation Networks of over 600 elected student representatives – the Academic Representation Network and the Wellbeing Representation Network. Reps represent the voice of students and can direct you to internal and external support services. The Union's Liberation Officers also work to make sure that the views of under-represented and interest groups are heard at the College.

If you have any feedback about issues in your department relating to academic or wellbeing issues, you can speak to one of your student representatives.

 [www.imperialcollegeunion.org/your-union/your-representatives/a-to-z](http://www.imperialcollegeunion.org/your-union/your-representatives/a-to-z)

### Officer Trustees

The Union is led by a team of Officer Trustees who are elected every year by the students of Imperial College. They take a year out of their studies and work full-time at the Union, representing the voices of students in the Union, the College and the wider community.

The Officer Trustees represent students in a variety of roles, including Education, Welfare, Finance & Service and Clubs & Societies. These elected students are here to represent your views as a student body do make sure you get in touch with them if there's something you would like to discuss or change.

## Student Hub

At the Student Hub, you can access advice about accommodation, admissions and financial support and get help with international student enquiries, questions about student records, and exams.

 [www.imperial.ac.uk/student-hub](http://www.imperial.ac.uk/student-hub)

## Student Support Zone

If you have moved home to take up your place at Imperial you will need to register with a new doctor (also known as a General Practitioner or GP) so that you can access NHS healthcare. It's important that you register with a doctor soon after you arrive – don't wait until you are sick, as this could delay your access to treatment.

Student Support Zone has lots of information about the resources available at Imperial and beyond to help you to stay healthy and happy. It's a great place to start when you're looking for some support – it covers advice about housing and money, health, wellbeing and maintaining a good work-life balance, and provides the details of who you can contact if you need some extra support.

 [www.imperial.ac.uk/student-support-zone](http://www.imperial.ac.uk/student-support-zone)




## Useful support contacts

### Registry




 <http://www.imperial.ac.uk/admin-services/registry/>

### Health and wellbeing

Imperial College Health Centre

 40 Prince's Gardens, South Kensington Campus  
 020 7584 6301  
 [imperialcollege.hc@nhs.net](mailto:imperialcollege.hc@nhs.net)  
 [www.imperialcollegehealthcentre.co.uk](http://www.imperialcollegehealthcentre.co.uk)

Imperial College Dental Centre

 Prince's Gardens, South Kensington Campus  
 020 7589 6623  
 [imperialcollegedental.co.uk](http://imperialcollegedental.co.uk)



Student Counselling and Mental Health Advice Service

 020 7594 9637  
 [counselling@imperial.ac.uk](mailto:counselling@imperial.ac.uk)  
 [www.imperial.ac.uk/counselling](http://www.imperial.ac.uk/counselling)

Multi-Faith Chaplaincy Service

 Chemistry Building, South Kensington Campus  
 [chaplaincy@imperial.ac.uk](mailto:chaplaincy@imperial.ac.uk)  
 [www.imperial.ac.uk/chaplaincy](http://www.imperial.ac.uk/chaplaincy)




Disability Advisory Service

 Room 566, Level 5, Sherfield Building, South Kensington Campus  
 020 7594 9755

 [disabilities@imperial.ac.uk](mailto:disabilities@imperial.ac.uk)  
 [www.imperial.ac.uk/disability-advisory-service](http://www.imperial.ac.uk/disability-advisory-service)

## International students' support

Centre for Academic English

 Level 3, Sherfield Building, South Kensington Campus  
 [english@imperial.ac.uk](mailto:english@imperial.ac.uk)  
 [www.imperial.ac.uk/academic-english](http://www.imperial.ac.uk/academic-english)

## International Student Support team

 020 7594 8040  
 [www.imperial.ac.uk/study/international-students](http://www.imperial.ac.uk/study/international-students)

## Accommodation





 <http://www.imperial.ac.uk/study/campus-life/accommodation/>

## Student Finance

 <http://www.imperial.ac.uk/fees-and-funding/>




## Careers

Careers Service

 Level 5, Sherfield Building, South Kensington Campus  
 020 7594 8024  
 [careers@imperial.ac.uk](mailto:careers@imperial.ac.uk)  
 [www.imperial.ac.uk/careers](http://www.imperial.ac.uk/careers)

## ICT and software

ICT Service Desk

 Central Library, South Kensington Campus  
 020 7594 9000  
 [www.imperial.ac.uk/ict/service-desk](http://www.imperial.ac.uk/ict/service-desk)


## Software shop

 [www.imperial.ac.uk/admin-services/ict/self-service/computers-printing/devices-and-software/](http://www.imperial.ac.uk/admin-services/ict/self-service/computers-printing/devices-and-software/)

## Sport Imperial

 <http://www.imperial.ac.uk/sport/>

## Student Online Services

 <https://www.imperial.ac.uk/student-records-and-data/for-current-students/undergraduate-and-taught-postgraduate/>

## Alumni Service

 <http://www.imperial.ac.uk/alumni/>


## 10. Student Administration

The Student Administration Team are responsible for the administration and maintenance of the student records for all students studying at the College. This includes enrolments, programme transfers, interruption of studies, withdrawals and processing of examination entry for research degree students. The team also use this information to fulfil reporting duties to the Student Loans Company, Transport for London and the UKVI, as well as other external bodies.

The Team is responsible for the processing of student results and awards on the student record system as well as the production and distribution of academic transcripts and certificates of award.


The Student Administration Team produce a variety of standard document requests for both current and previous students including council tax letters, standard statements of attendance and confirmation of degree letters.

### Student Records

 +44 (0)20 7594 7268

 [student.records@imperial.ac.uk](mailto:student.records@imperial.ac.uk)

### Degree Certificates

 +44 (0)20 7594 7267

 [certificates@imperial.ac.uk](mailto:certificates@imperial.ac.uk)

## 11. Work-life Balance

The pace and intensity of study at Imperial can be demanding so it's important to find time for outside interests.

### Imperial College Union

The Union's range of 360+ student-led clubs, societies and projects is one of the largest of any UK university, opening up lots of ways for you to enjoy your downtime.

 [www.imperialcollegeunion.org/about-us](http://www.imperialcollegeunion.org/about-us)

## Move Imperial

Imperial College has a wide range of sports and activities on offer that cater for all standards and abilities. We have a recreational activity offer, competitive sports teams and an elite sport programme. We are dedicated to ensuring we have a diverse, inclusive and exciting offer for all.

More information about Imperial student memberships and updates to our services can be found at:

 [www.imperial.ac.uk/ethos/memberships/students/](http://www.imperial.ac.uk/ethos/memberships/students/)

With an annual fee of £30 you will get use of the gym and swimming facilities on our campuses.

 [www.imperial.ac.uk/sport](http://www.imperial.ac.uk/sport)

We have a huge collection of online resources, home workout videos, healthy recipes and playlists available to all as part of our MoveFromHome campaign, more information can be found at:

 [www.imperial.ac.uk/sport/movefromhome](http://www.imperial.ac.uk/sport/movefromhome)

## 12. Student feedback and representation

### Feedback from students

The College and Union is committed to continually improving your education and wider experience and a key part of this is your feedback. Feedback is thoroughly discussed by your student representatives and staff.

### Student representation

Student Representatives are recruited from every department to gather feedback from students to discuss with staff. More information about the role, and instructions on how to become an academic representative, are available on the Imperial College Union website.

 [www.imperialcollegeunion.org/your-union/your-representatives/academic-representatives/overview](http://www.imperialcollegeunion.org/your-union/your-representatives/academic-representatives/overview)

We have two representatives for this MSc programme, who will also be invited to a meeting once every two weeks in term time with the key staff members who are involved in the organising of the MSc to address any matters of concern. This is in addition to the Staff-student Committee.

### Staff-Student Committee

Staff-Student Committees are designed to strengthen understanding and improve the flow of communication between staff and students and, through open dialogue, promote high standards

of education and training, in a co-operative and constructive atmosphere. College good practice guidelines for staff-student committees are available here:

 [www.imperial.ac.uk/about/governance/academic-governance/academic-policy/student-feedback](http://www.imperial.ac.uk/about/governance/academic-governance/academic-policy/student-feedback)

## 13. Student Surveys

Your feedback is important to your department, the College and Imperial College Union.

Whilst there are a variety of ways to give your feedback on your Imperial experience, the following College-wide surveys give you regular opportunities to make your voice heard:

- PG Student Online Evaluation (SOLE) module survey or departmental equivalent
- Student Experience Survey (SES)

The PG SOLE module survey (or equivalent for your department) runs at the end of the autumn and spring terms. This survey is your chance to tell us about the modules you have attended.

The Student Experience Survey (SES) is an opportunity to give your views on your experience beyond the lecture theatres or labs. This survey will cover a range of College services and on the Imperial College Union.

All these surveys are confidential and the more students that take part the more representative the results so please take a few minutes to give your views.

The Union's "You Said, We Did" campaign shows you some of the changes made as a result of survey feedback:

 [www.imperialcollegeunion.org/you-said-we-did](http://www.imperialcollegeunion.org/you-said-we-did)

The Union's response to surveys can be found here:

 [www.imperialcollegeunion.org/your-union/your-representatives/responses](http://www.imperialcollegeunion.org/your-union/your-representatives/responses)

If you would like to know more about any of these surveys or see the results from previous surveys, please visit:

 [www.imperial.ac.uk/students/academic-support/student-surveys/pg-student-surveys](http://www.imperial.ac.uk/students/academic-support/student-surveys/pg-student-surveys)

For further information on surveys, please contact the Registry's Surveys Team at:

 [surveys.registrysupport@imperial.ac.uk](mailto:surveys.registrysupport@imperial.ac.uk)

## 14. And finally...

### Alumni Services

When you graduate you will be part of a lifelong community of over 190,000 alumni, with access to a range of alumni benefits including:

- discounts on further study at the College and at Imperial College Business School
- alumni email service
- networking events



- access to the Library and online resources
- access to the full range of careers support offered to current students for up to three years after you graduate
- access to our Alumni Visitor Centre at the South Kensington Campus, with free Wi-Fi, complimentary drinks, newspapers and magazines, and daytime left luggage facility

Visit the Alumni website to find out more about your new community, including case studies of other alumni and a directory of local alumni groups in countries across the world.

 [www.imperial.ac.uk/alumni](http://www.imperial.ac.uk/alumni)

## 15. Appendices

### Appendix A – Indicative Module Content

*Unless otherwise stated the pass mark for each module is 50% for MSc Advanced Students*

#### (C1) MATE70001: Characterization of the Structure of Materials

**For all BEng/MEng/MSc programmes**

**Module Leader:** Prof. Stephen Skinner

**Teaching Staff:** Dr Sarah Fearn

Mr Richard Sweeney

Prof. Alexandra Porter

Dr Jonathan Rackham

#### Brief description of the Module

This course is designed to give you a firm foundation in the fundamentals of the characterisation of the structure of materials. It provides practical experience of key techniques, as well as a grounding in the theory of a wider range of techniques.

#### Learning Outcomes

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

- Select an appropriate technique to measure a specified property
- Apply the theory of key techniques used to characterise the structure of materials
- Explain how to prepare samples for each technique in a manner useful for technical reports
- Analyse and interpret the output from each technique
- Critique measurements based on the limitations of the technique used

## Module Content

### *Diffraction*

- What X-rays are and their importance in structure determination.
- The components contributing to the formation of a diffraction pattern.
- Bragg's Law, the Laue equations, reflecting sphere construction and a reciprocal lattice.
- The experimental challenges of obtaining a useful diffraction pattern.
- The importance of diffraction maxima for structure determination.
- The atomic structure factor
- Systematic absences.
- Index powder diffraction patterns for cubic systems.
- Neutron and electron diffraction compared with X-ray diffraction.
- Le Bail and Rietveld analysis techniques for diffraction analysis.

### *Electron Microscopy*

- Wave-particle duality and the wave properties of electrons.
- Resolution.
- The design and operation of scanning electron microscopes (SEM) and transmission electron microscopes (TEM), with particular reference to electron sources, electrostatic lenses and electromagnetic lenses.
- Specimen preparation techniques for SEM.
- Specimen preparation for TEM.
- Types of aberration that can arise and current practical resolution limits for SEM and TEM.
- Contrast mechanisms in SEM.
- Secondary electron imaging and backscattered electron imaging in SEM.
- Contrast mechanisms in TEM.
- Bright-field imaging, dark-field imaging and diffraction pattern formation in TEM.
- Energy dispersive X-ray analysis and electron energy loss spectroscopy.
- Scanning transmission electron microscope and the use of high-angle annular detectors for imaging.

### *Scanning Probe Microscopies*

- Scanning probe microscopy.
- Lateral imaging range and sensitivity to structure and properties.
- The theory use and operation of the scanning tunnelling microscope and atomic force microscope including strengths and weaknesses of each technique.
- Applications of scanning probe microscopies to materials characterisation.

### *Thermal analysis*

- Types of thermal analysis techniques.
- Limitations and challenges of the various techniques.
- The most appropriate thermal analysis technique for a variety of characterisation investigations.
- Interpretation of thermal analysis data for simple materials.

### *X-ray Photoelectron Spectroscopy*

- Theory of how XPS operates
- How XPS is used

### *Nuclear Magnetic Resonance*

- Theory of how NMR operates
- How NMR is used

### Learning and Teaching Approach

Lectures are used to communicate the main body of the theory and to introduce the practical aspects of using the characterization techniques. Practical sessions allow some use of the equipment, and the workshop provides experience with analysing results. The open-ended exercise enables students to connect the techniques they have learned with a practical application.

- 25 lectures: Autumn term
- 4 group teaching
- 4 introductory laboratory sessions

### Assessment Strategy

The exam assesses the level of understanding of the theory behind the techniques used. The report from the open-ended exercise assesses the ability to apply the techniques to a practical problem. The coursework from the workshop and the practical sessions assesses the ability to use and interpret data from a specific technique. Peer review is included in the open-ended characterisation exercise.

### Feedback

Written summative feedback is provided for each piece of coursework. Coursework is marked within two weeks of the assessment being submitted and the feedback is provided through Blackboard. Summative feedback for the exam is provided through a commentary on the main themes found in the answers. Verbal formative feedback is provided during the practical exercises and the workshop.

### Reading List

#### Optional reading:

- *Microstructural Characterisation of Materials*, David Brandon & Wayne D Kaplan, 2nd edition, Wiley (2008)
- *Fundamentals of Powder Diffraction and Structural Characterisation of Materials*, V.K. Pecharsky and P.Y. Zavalij, Kluwer (2003)
- *Surface Analysis: the principle techniques*, J.C. Vickerman and I. Gilmore, Wiley (2009)
- *Structure from Diffraction Methods*, D.W. Bruce, D. O'Hare and R.I. Walton, Wiley

(2014)

- *Characterization of Materials, E. N. Kaufmann, (2nd edition, Wiley (2012))*

## MATE70001 Characterization of the Structure of Materials – Characterisation Exercise Report Coursework Information

Assessment Name:	Characterisation Exercise Report
Academic:	Dr Jonathan Rackham
Submission:	Blackboard Learn only
Self-study hours:	35 hrs
Assignment details:	<p>The cohort will be split into three groups, each starting their exercise a week apart from each other. Deadlines for each group are set accordingly.</p> <p>Each group is further broken down so that students work in teams of four to characterise a pair of related samples with unknown identities. The identities of the samples, and the relationship between them, should be determined and the findings presented as a report written and submitted individually. The following characterisation techniques will be made available to the groups in a free-form style, with support from GTAs. Some of these may be conducted in person if procedures allow, otherwise GTAs will assist.</p> <ul style="list-style-type: none"><li>- Visible light microscopy</li><li>- Scanning electron microscopy (including energy dispersive X-ray spectroscopy)</li><li>- X-ray diffraction</li><li>- Atomic force microscopy</li><li>- FTIR spectroscopy</li><li>- UV-Vis spectroscopy</li><li>- Densimetry</li></ul> <p>In addition to these techniques, transmission electron micrographs will be available where relevant.</p> <p>Students will receive feedback from several sources,</p> <ul style="list-style-type: none"><li>- verbally from GTAs during their time using equipment,</li><li>- verbally from academic staff during the office hours,</li><li>- in written form on their report draft.</li></ul>
Other requirements:	<p>The report should be written in the style of a short paper with a focus on presentation and discussion of results. A short introduction may be included for context but an extended introduction of the techniques used should be avoided.</p> <p>Report to be submitted as a PDF, maximum 6 pages in length. Formatting requirements for this are set out in the briefing document provided at the beginning of the exercise. A document template is provided (MS Word and LaTeX) and should be used.</p>

### Rubric:

Item name/number	Value	Description of marking
Abstract	10	<p>0% Not present within the page limit.</p> <p>25% Does not provide context or present conclusions drawn. No reference to numerical results. Would not inspire further reading of the report.</p>

		<p>45% Describes experiments performed and conclusions drawn in isolation with no context or reference to numerical results. Would not inspire further reading of the report.</p> <p>65% Provides context, describes experiments performed and conclusions drawn. Overly brief/long and does not quote any relevant numerical results. May inspire further reading of the report.</p> <p>85% Provides context, a concise description of the experiments performed and conclusions drawn. May have reference to numerical results, but not necessarily appropriate. Would inspire further reading of the report.</p> <p>100% Provides context, a concise description of the experiments performed and the conclusions drawn. Makes reference to relevant numerical results. Would inspire further reading of the report.</p>
Expt Details	15	<p>0% Not present within the page limit.</p> <p>25% Some, but not all, of the techniques used are mentioned.</p> <p>45% Appropriate techniques are mentioned. Some details are provided but some important details (e.g. instrument model) are missing. Unlikely to show meaningful mention of relevant analysis tools (e.g. software or databases).</p> <p>65% Appropriate techniques are mentioned with most important details provided. Some minor errors may be present and some unnecessary details are included. Relevant analysis tools (e.g. software or databases) may be mentioned, but may be incomplete/inaccurate.</p> <p>85% Appropriate techniques are mentioned and all important details are provided with some minor errors. Relevant analysis tools (e.g. software or databases) used are detailed.</p> <p>100% Appropriate techniques are mentioned and all key details are correctly provided in appropriate detail. All relevant analysis tools are described and referenced with an appropriate level of detail.</p>
Results	25	<p>0% Not present within the page limit.</p> <p>25% Not all techniques used are appropriate and several major misunderstandings of techniques are present. No primary analysis has been performed (indexing patterns or assigned spectra). Results presented without any appropriate accompanying text in an unusable format or with items missing.</p> <p>45% All techniques used are appropriate but some major misunderstandings may be present. Some primary analysis performed (e.g. indexing patterns, assigning spectra dimensional measurements) but this may not be done completely or competently. Results are ambiguously presented in a poor format and show no evidence of further processing (e.g. cropping, brightness/contrast correction, annotation). Some, but not all, of the results are presented appropriately in the accompanying text with no comments made about reliability of particular results.</p> <p>55% All techniques used are appropriate with several minor misunderstandings present. Some primary analysis competently performed (e.g. indexing patterns, assigning spectra, dimensional measurements) but this may not be done completely. Results are ambiguously presented in a basic format but shows some evidence of further processing (e.g. cropping, brightness/contrast correction, annotation). May show some evidence of advanced composition techniques (e.g. stacking, insets, overlays,</p>

		<p>annotations and labels) although this may not be successfully be applied. Accompanying text describes some but not all of the results presented. Some limited comments may be made about reliability of particular results.</p> <p>65% All techniques used are appropriate with limited minor misunderstandings of any particular technique. Primary analysis competently performed (e.g. indexing patterns, assigning spectra, dimensional measurements) but this may not be done completely. Results unambiguously presented in a basic format but shows evidence of further processing (e.g. cropping, brightness/contrast correction, annotation). May show some evidence of advanced composition techniques (e.g. stacking, insets, overlays, annotations and labels) although this may not be successfully employed. Accompanying text describes all of the results presented but not all are described appropriately. Some comments may be made about reliability of particular results, but may not be explored sufficiently</p> <p>85% All techniques used are appropriate with clear understanding of each technique. Primary analysis (e.g. indexing patterns, assigning spectra or taking dimensional measurements from micrographs) performed competently and completely. Results presented in a clear format with appropriate application of further processing (e.g. cropping, brightness/contrast correction, annotation). Shows evidence of advanced composition techniques (e.g. stacking, insets, overlays, annotations and labels) although this may not be successfully employed. Accompanying text appropriately describes all of the results presented with some comments made about reliability of individual results.</p> <p>100% All techniques used are appropriate with clear understanding of each technique. Primary analysis (e.g. indexing patterns, assigning spectra or taking dimensional measurements from micrographs) performed competently and completely. Results presented in a clear and engaging format with appropriate application of further processing (e.g. cropping, brightness/contrast correction, annotation). Successfully employs advanced composition techniques (e.g. stacking, insets, overlays, annotations and labels). Accompanying text appropriately describes all of the results presented with comprehensive comments made about reliability of individual results.</p>
Discussion	20	<p>0% Not present within the page limit.</p> <p>25% Individual results are commented upon but no comparisons are made between techniques or samples. No evidence of narrative development nor of abstract analysis to support comparisons (e.g. calculation of lattice parameters, crystallite size, statistical analysis of dimensional measurements). No relevant references to literature.</p> <p>45% Individual results are commented upon and some limited comparisons are made between techniques or samples. No evidence of narrative development nor of abstract analysis to support comparisons (e.g. calculation of lattice parameters, crystallite size, statistical analysis of dimensional measurements). No narrative developed and limited references to literature, not all are appropriate.</p> <p>55% Individual results are commented upon and some limited comparisons are made between techniques or samples</p>



		<p>presented as a partly developed narrative. Limited evidence of abstract analysis to support the presented narrative (e.g. calculation of lattice parameters, crystallite size, statistical analysis of dimensional measurements) but not performed competently or completely. Limited references to literature, most are appropriate.</p> <p>65% Comparisons are made between results from different techniques and between samples, presented as part of a partly-developed narrative. Evidence of abstract analysis to support the presented narrative (e.g. calculation of lattice parameters, crystallite size, statistical analysis of dimensional measurements) but not necessarily all performed competently or completely. Limited reference to literature, most are appropriate.</p> <p>85% Comparisons are routinely made between results from different techniques and between samples, presented as a developed narrative. Extensive evidence of abstract analysis competently performed to support the presented narrative. Regular reference to literature, most are appropriate.</p> <p>100% Strong comparisons are made between results, presented as a well developed narrative with extensive insightful abstract analysis performed competently and completely to support these comparisons. Regular and appropriate reference to literature.</p>
Further Work	5	<p>0% Not present within the page limit.</p> <p>25% Limited suggestions for further work are made, none are appropriate</p> <p>45% Limited suggestions for further work are made, some are appropriate but none are supported by specific details (e.g. hypotheses to test, techniques to apply) or references to literature.</p> <p>65% Appropriate general suggestions for further work are made, some are supported by specific details (e.g. hypotheses to test, techniques to apply) or references to literature although not all details/references are appropriate.</p> <p>85% Several appropriate suggestions for further work are made. All are supported by relevant details (e.g. hypotheses to test, techniques to apply) and some reference to literature.</p> <p>100% Several appropriate suggestions for further work are made, some are insightful. All are supported by relevant details (e.g. hypotheses to test, techniques to apply) and some reference to literature.</p>
Conclusions	10	<p>0% Not present within the page limit.</p> <p>25% Inappropriate conclusions unrelated to the body of the report and unsupported by points in the discussion. May be overly brief or verbose.</p> <p>45% Inappropriate conclusions related to the body of the report and partly supported by points in the discussion. May be overly brief or verbose.</p> <p>65% Superficial conclusions but without specific statements made. Mostly supported by points made in the discussion. May be overly brief or verbose.</p> <p>85% Concise conclusions with specific statements, summarising any insights drawn. Mostly supported by points made within the discussion.</p> <p>100% Concise conclusions with specific statement, summarising any insights drawn. Entirely supported by points made within the discussion.</p>

Written Presentation	5	<p>0% Unacceptable presentation. Major elements of the report inappropriately formatted (e.g. spacing, margin).</p> <p>25% Unacceptable presentation with poor structure. Prose is difficult to understand with regular grammatical/typographical errors. Some minor elements of the report are inappropriately formatted (e.g. lacking page numbers, unreferenced figures). Figure captions give no context.</p> <p>45% Poor presentation with poor structure. Prose is sometimes ambiguous or difficult to parse with repeated grammatical/typographical errors. All report elements are appropriately formatted. Figure captions give little to no context.</p> <p>65% Good presentation. Prose is generally well written with a reasonable structure, but marred by repeated grammatical/typographical errors. Some areas are ambiguous or excessively verbose. Figure captions give some context, although this may be limited in some place.</p> <p>85% Excellent presentation. Prose is generally well written with a good structure, but marred by repeated grammatical/typographical errors. Some areas are ambiguous or excessively verbose. Figure captions give context and guide the reader to important features.</p> <p>100% Journal-level presentation, ready to publish. Prose is well written and easy to read with clear structure and explanations. No/minimal grammatical/typographical errors. Figure captions give context and guide the reader to important features.</p>
References	5	<p>0% None present.</p> <p>25% References are incomplete; many items are uncited. Some sources are inappropriate. Bibliography formatting is poor and most entries are ambiguous.</p> <p>45% References are mostly complete; a few items are uncited. Some sources are inappropriate. Bibliography formatting is poor in places and several entries are ambiguous.</p> <p>65% References are mostly complete; a few items are uncited. All sources are appropriate. Bibliography entries are well formatted but some may be ambiguous.</p> <p>85% References are complete, but some inappropriate sources have been used. Most are well formatted but some may be ambiguous.</p> <p>100% References are complete and all are appropriate. Bibliography is well formatted and unambiguous.</p>
Acting on Feedback	5	<p>0% Did not act on any feedback given.</p> <p>25% Partially acted on some of the points of improvement.</p> <p>45% Partially acted on most points of improvement.</p> <p>65% Acted thoroughly on some points for improvement.</p> <p>85% Acted thoroughly on most points for improvement.</p> <p>100% Acted thoroughly on all points for improvement.</p>

## MATE70001 Characterization of the Structure of Materials – Equipment Demonstration Sessions Coursework Information

Assessment Name:	Equipment Demonstration Sessions
Academic:	Dr Jonathan Rackham
Submission:	Blackboard Learn tests
Self-study hours:	2

Assignment details:	<p>Students will attend four lab sessions in groups. Each session will introduce them to a different instrument(s):</p> <ol style="list-style-type: none"> <li>1. Scanning electron microscope</li> <li>2. Transmission electron microscope</li> <li>3. Atomic force microscope and thermal analysis (dilatometer and calorimeter)</li> <li>4. X-ray diffractometers</li> </ol> <p>Students will be guided through each session by a worksheet (conducted via BlackBoard Learn) with practical guidance provided by a tutor. The worksheet will pose various questions about the instrument and associated sample preparation. Students will receive feedback during the session from the GTA and on their marked worksheets.</p>
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## MATE70001 Characterization of the Structure of Materials – XRD Class Work Assignment Coursework Information

Assessment Name:	XRD Class work assignment
Academic:	Dr Jonathan Rackham and Dr Andrey Berenov
Submission:	Blackboard Learn test
Self-study hours:	1 hour of revision– a recap will be given during the lesson.
Assignment details:	<p>This is a highly interactive session designed to reinforce and enhance understanding of some of the concepts covered in the XRD lectures.</p> <p>During this exercise the students will process some example data to determine the structure type, lattice parameter and composition of a brass specimen.</p> <p>This will be achieved by following a step by step process explained in the booklet provided.</p> <p>Staff and GTAs will be on hand to help and to answer any questions.</p> <p>Tables, graphs and answers to questions must be entered into the booklet where indicated. The booklet must then be handed in before the end of the session through Blackboard Learn.</p>
Other requirements:	All questions must be entered into the assignment booklet where indicated. Graphs must include labelled axes with a suitable choice of range.

### Rubric:

Item name/number	Value
Data Table (p6)	1.5
Structure	1
Indexing	2
Structure Factor	3
Data Table (p12)	1.5
Graph	2
Lattice Parameter value	1
Composition	2

Doublet explanation	2
Separation increase explanation	2
Presentation and clarity	2

## (C2) MATE70002: Theory and Simulation of Materials

**Core: MSc in Advanced MSE**

**Module Leader: Andrew Horsfield**

**Teaching Staff: Paul Tangney**

### Brief description of the Module

This module introduces you 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. You will have an opportunity to use these methods by performing simulations using a combination of a commercial finite element package and code written for the course that will be provided

### Learning Outcomes

On successful completion of this module you will be able to:

- Apply the finite element method
- Analyse a range of materials related properties using finite elements
- Interpret the energy landscape of a molecule or crystal
- Analyse the time dependent behaviour of materials using Molecular Dynamics
- Analyse the equilibrium properties of materials using Metropolis Monte Carlo
- Synthesise the ideas in the course and apply them to a problem

### Module Content

#### *Finite Element Theory*

- The continuum assumption and examples
- The fundamentals of finite elements
- Linear elements in 1D, 2D and 3D
- Quadratic elements in 2D
- Worked example: Poisson's equation

#### *Introduction to commercial finite element software*

- Basic ideas underpinning the program
- Introduction to the interface
- Model building
- Adding physics
- Running simulations
- Analysing the results

### *Crystal Elasticity*

- Why we must consider the crystal structure
- Common crystal structures
- Anisotropic elastic responses
- Stiffness matrix and compliance matrix
- Modelling anisotropic single crystal response using elastic finite elements
- Application to a piezoelectric actuator

### *Electrochemistry*

- The nature of the problem
- Butler-Volmer equation
- Nernst-Planck equation
- Analytic solutions for simple cases
- Application to a simple battery

### *Electromagnetism*

- Maxwell's equations
- Wave equation and solution
- Analytic solution for simple cases
- Application to scattering of light from a metal particle

### *Energy landscapes*

- Potential energy surface in the context of aggregates of atoms
- How real potential energy surfaces may be approximated
- How different types of bonding (ionic, covalent, metallic, van der Waals) are modelled
- Minimum-energy structure of a molecule or crystal.

### *Molecular Dynamics*

- Molecular dynamics method for calculating finite temperature properties
- How to perform a Molecular Dynamics simulation (velocity Verlet)
- Simple way to introduce the effect of a surrounding medium (Langevin dynamics)

### *Metropolis Monte Carlo*

- Review of statistical mechanics; computing averages
- The Metropolis algorithm
- Extensions to other ensembles
- Free energy calculations

### *Short project*

- Overview of the context of the short project

### Learning and Teaching Approach

New material will be introduced to you in lectures. You will gain experience using the techniques in exercise sessions.

### Assessment Strategy

Assessment is through two problem sets, a mini project, and a one hour exam. The problem sets assess the outcome of the exercises, and thus support the learning process. The mini project allows the taught content to be used to answer a question, thus developing problem solving skills and independent learning. The exam tests the ability to apply the theory learned to small problems.

### Feedback

Written summative feedback on the problem sets and mini project will be provided within two weeks of submission. Verbal formative feedback will be provided during the exercise sessions.

### Reading List

#### Optional reading:

- *Numerical Recipes, W.H. Press et al, Cambridge University Press 1989*
- *Understanding Molecular Simulation, Second Edition: From Algorithms to Applications, D. Frenkel and B. Smit, Academic Press (2002)*
- *Statistical Mechanics. N. Davidson, Dover Publications (2003)*
- *First Course in Finite Elements, Jacob Fish and Ted Belytschko, Wiley (2007)*

## MATE70002 Theory and Simulation of Materials – Coursework 1 (Finite Elements) Coursework Information

Assessment Name:	Coursework 1 (Finite Elements)
Academic:	Professor Andrew Horsfield
Submission:	Blackboard Learn as a PDF
Self-study hours:	15 hours
Assignment details:	The notes for each lecture conclude with exercises to be performed (5 exercises in all). The sections titled Assessed Coursework at the end of each of the exercises indicate for each topic which results are to be reported and what discussion is expected for the assessed work.
Other requirements:	The provided Word template must be used. The maximum allowed length of the report is 6 A4 pages including the template front cover. Each exercise should be on a separate page, with a maximum of one page per exercise. The font and margins of the template are already the correct ones for the coursework (11 point font, 1.5 cm margins and single spacing).

### Rubric:

Item name/number	Value	Description of marking
Finite Elements	10	



Introduction to COMSOL	10	Marks are given for clear and correct presentation of results obtained from the exercises, and for well-presented and accurate discussions.
Crystal Elasticity	10	
Electrochemistry	10	
Electromagnetism	10	

## MATE70002 Theory and Simulation of Materials –Coursework 2 (Atomistic) Coursework Information

Assessment Name:	Coursework 2 (Atomistic)
Academic:	Paul Tangney
Submission:	Blackboard Learn as a PDF
Self-study hours:	15 hours
Assignment details:	The assignment is in three parts and each part involves using a different method of simulating materials atomistically. Notes explaining one part of the assignment will be provided before each of the three lectures. One part uses kinetic Monte Carlo (kMC), another uses structural relaxation (also known as energy minimization), and the third uses molecular dynamics (MD). Each plays a different role and provides different information. You will be required to perform simulations, analyse and interpret the data produced, and present your results in a specified format. For each of the three parts you will be asked for specific numbers calculated, one or two publication-quality graphics or plots, and one or two sentences of explanation and interpretation
Other requirements:	Minimum 11pt font for all text, including figure labels and captions. When the number of sentences of explanation is specified, only that number will be marked, e.g., if the assignment asks for one or two sentences and you write three, only the first two will be marked or read

### Rubric:

Item name/number	Value	Description of marking
kinetic Monte Carlo	20	Quality of simulations performed. Analysis of data produced. Presentation of simulation results. Interpretation of simulation results.
Energy landscapes	20	
Molecular dynamics	20	

## MATE70002 Theory and Simulation of Materials – Coursework 3 (Research Topic) Coursework Information

Assessment Name:	Coursework 3 (Research Topic)
Academic:	Professor Andrew Horsfield
Submission:	Blackboard Learn as a PDF

Self-study hours:	15 hours
Assignment details:	Answer questions provided that are based on the research topic discussed in the lecture
Other requirements:	The maximum allowed length of the report is 3 A4 pages. The minimum size font, spacing and margins are: 11 point font, 1.5 cm margins, and single spacing.

### Rubric:

Item name/number	Value	Description of marking
Exercises 3 (Research Topic)	20	Marks are given for clearly presented correct answers to research related questions

## (R1) MATE70003: The Art of Research

<b>Core: MSc in Advanced MSE</b>	
<b>Module Leader:</b>	<b>Andrew Horsfield</b>
<b>Topic Leader:</b>	<b>Luc Vandepierre Ifan Stephens</b>
<b>Brief description of the Module</b>	
<p>This module provides you with knowledge and skills that support your research project. It includes lectures on key topics in the science and engineering of materials, opportunities to attend and report on current research seminars, and support in planning your own research project.</p>	
<b>Learning Outcomes</b>	
<p>On successful completion of this module you will be able to:</p> <ul style="list-style-type: none"> <li>• Synthesise fundamental concepts from across Materials Science and Engineering</li> <li>• Create small computer programs</li> <li>• Analyse research seminars</li> <li>• Plan a research project</li> </ul>	
<b>Module Content</b>	
<i>Review of background material: crystallography</i>	
<ul style="list-style-type: none"> <li>• Crystal structures in terms of their 2D and 3D lattices</li> <li>• Planes and directions in lattices to real materials</li> <li>• Packing sequences</li> </ul>	
<i>Review of background material: defects and microstructure</i>	
<ul style="list-style-type: none"> <li>• Stress and strain in deformable materials</li> </ul>	

- Point defects and how they influence the properties of materials
- Dislocations and how they influence the plastic behaviour of materials
- Fundamental properties of surfaces and interfaces
- Phases, and how phase changes influence the formation of microstructure

*Review of background material: waves*

- Mathematical description of waves
- Interference
- Diffraction

*Review of background material: MATLAB*

- Introduction to the MATLAB interface
- Simple command line operations to perform calculations
- Running scripts and functions
- Plotting graphs

*Writing for Masters 2: Literature Review*

- How to write a properly organized literature review

*One other course from the graduate school*

- Learn about a transferable skill

*Research seminars*

- Attend and participate in research seminars throughout the first two terms

*Research Plan*

- Critically read the scientific literature
- Assess the state of current knowledge and identify a research question
- Plan a set of experiments or calculations to address the research question
- Explain the importance of the research for society
- Write a clear report

**Learning and Teaching Approach**

Lectures are used to review fundamental background material. This is supported by learning packages you can consult in your own time. Exercises are provided for the MATLAB class to allow practice of the skills needed: these are opportunities for formative assessment and feedback. The writing of the reports on research seminars is supported by project supervisors and provides an opportunity to demonstrate familiarity with broad materials knowledge.

You will select a project from a list offered by the academics. In discussion with your supervisor, you will identify key literature to read and understand. From this a research question is formulated, and a strategy (experimental or computational) is designed to address

it. You will write up your findings and decisions as a report, with support from your supervisor, and possibly PhD students and PDRAs. The lecture on writing a literature review supports this.

### Assessment Strategy

There are three assessments designed to show the learning outcomes are met and to support the learning process. The MATLAB assessment is to write a short program and show it works; this is pass/fail. The writing of three one page reports on research seminars provides a structured way to learn how to engage with research seminars as well as providing an opportunity to use knowledge about materials in an integrated way. The Graduate School course on writing literature reviews supports the project plan, and is assessed through the writing of the plan. The plan also gives you an opportunity to develop a variety of skills.

### Feedback

Written summative feedback is provided with the marked seminar reports and the project plan. Verbal formative feedback is also provided by the project supervisors during the writing of these reports. Summative feedback on the MATLAB program is provided verbally at the time of assessment, with formative feedback being provided during the exercise sessions.

### Reading List

#### Optional reading:

- *Getting Started with MATLAB: A quick introduction for scientists and engineers*, Rudra Pratap, OUP
- *Materials Science and Engineering*, William D. Callister and David G. Rethwisch, Wiley

## MATE70003 The Art of Research – Seminar Reports Coursework Information

Assessment Name:	Seminar Reports
Academic:	Andrew Horsfield
Submission:	Blackboard Learn only
Self-study hours:	12 (about 4 hours per report)
Assignment details:	<p>You need to write summaries on 3 research seminars of your choice. Each summary and should contain three sections:</p> <p>General background [10]</p> <p>This section should provide information about the background to the research. This should be based on what is learned from the seminar but could also include information from additional reading (e.g. papers written by the speaker). It should show understanding of the scientific or engineering ideas underpinning the talk, how they connect, and why they are relevant now.</p> <p>Marks are given for:</p> <ul style="list-style-type: none"> <li>• Grammatically correct writing</li> <li>• Clear and precise presentation of information (good style)</li> <li>• Accuracy of the content</li> <li>• The level of understanding shown</li> </ul> <p>The key conclusions of the talk [10]</p>

	<p>Here should be reported the key conclusions of the talk, making clear what the main new findings the speaker wants to get across are. It should show understanding of the scientific or engineering ideas underpinning the findings, how they connect, and how they advance the field.</p> <p>Marks are given for:</p> <ul style="list-style-type: none"> <li>• Grammatically correct writing</li> <li>• Clear and precise presentation of information (good style)</li> <li>• Accuracy of the content</li> <li>• The level of understanding shown</li> </ul> <p>Your personal perspective on the research presented [5]</p> <p>A personal assessment of the work described and the presentation given. Was the work significant? Why? What new work might arise from this? What will the impact on society be? Any other points that are considered important.</p> <p>Marks are given for:</p> <ul style="list-style-type: none"> <li>• The correctness of the argument for the significance of the work</li> <li>• The correctness of the argument for the proposed future work</li> </ul>
Other requirements:	<p>Each summary should be one A4 page, with references allowed on a second page if needed. The margins must be no smaller than 1.5 cm, and the font no smaller than 11pt. The report should be written using the provided template, with the title being a hyperlink to the recording of the seminar (if available).</p>

### Rubric:

Item name/number	Value	Description of marking
Report 1 -- background	10	<p>This section should provide information about the background to the research. This should be based on what is learned from the seminar but could also include information from additional reading (e.g. papers written by the speaker). It should show understanding of the scientific or engineering ideas underpinning the talk, how they connect, and why they are relevant now.</p> <ul style="list-style-type: none"> <li>◦ Marks are given for: <ul style="list-style-type: none"> <li>▪ Grammatically correct writing</li> <li>▪ Clear and precise presentation of information (good style)</li> <li>▪ Accuracy of the content</li> <li>▪ The level of understanding shown</li> </ul> </li> <li>◦ Breakdown of marks: <ul style="list-style-type: none"> <li>▪ 0-2: Not grammatically correct, very little content</li> <li>▪ 3-4: Mostly grammatically correct, but difficult to determine the main messages</li> <li>▪ 5-6: Grammatically correct, and key ideas are correctly described</li> <li>▪ 7-8: Clear writing and correct presentation of the ideas, showing good understanding</li> <li>▪ 9-10: Clear writing and correct presentation of the ideas, showing a very high level of understanding</li> </ul> </li> </ul>
Report 2 -- background	10	
Report 3 -- background	10	

Report 1 -- conclusions	10	<p>Here should be reported the key conclusions of the talk, making clear what the main new findings the speaker wants to get across are. It should show understanding of the scientific or engineering ideas underpinning the findings, how they connect, and how they advance the field.</p> <ul style="list-style-type: none"> <li>◦ Marks are given for: <ul style="list-style-type: none"> <li>▪ Grammatically correct writing</li> <li>▪ Clear and precise presentation of information (good style)</li> </ul> </li> <li>▪ Accuracy of the content</li> <li>▪ The level of understanding shown</li> </ul>
Report 2 -- conclusions	10	
Report 3 -- conclusions	10	
Report 1 -- personal perspective	5	<p>A personal assessment of the work described and the presentation given. Was the work significant? Why? What new work might arise from this? What will the impact on society be? Any other points that are considered important.</p> <ul style="list-style-type: none"> <li>◦ Marks are given for: <ul style="list-style-type: none"> <li>▪ The correctness of the argument for the significance of the work</li> <li>▪ The correctness of the argument for the proposed future work</li> </ul> </li> <li>◦ Breakdown of marks: <ul style="list-style-type: none"> <li>▪ 0-1: The arguments are not based on a clear understanding</li> <li>▪ 2-3: Good arguments based on the content of the seminar (as described above)</li> <li>▪ 4-5: Good arguments that employ information beyond that provided in the seminar</li> </ul> </li> </ul>
Report 2 -- personal perspective	5	
Report 3 -- personal perspective	5	

## MATE70003 The Art of Research – Research Project Plan Coursework Information

Assessment Name:	Project Plan
Academic:	Ifan Stephens
Submission:	Blackboard Learn only
Self-study hours:	100
Assignment details:	<p>During the Autumn Term you will need to write a project proposal. This gives the information you need to plan the project in advance, and to enable the Department to assess the suitability of the project.</p> <p>Below is the format of the project proposal with a description of the information requested. Note that preparation of the proposal will require reading and understanding of the literature, as well as an appreciation of what the project will aim to achieve. Please refer to the deadline planner for the exact deadline date.</p> <p>Track Record [No marks]</p>



	<p>One paragraph describing what your UG degree covered.</p> <ul style="list-style-type: none"> <li>• Note any previous research work you have done</li> <li>• Note any experimental equipment you have learned to use</li> <li>• Note any computational methods you have learned to use</li> </ul> <p>Project Summary [85 marks] [approx. 4 pages]</p> <p>Background [40]</p> <ul style="list-style-type: none"> <li>• Introduce the project topic and explain its context</li> <li>• Review the state of scientific understanding in the field</li> <li>• Describe the gap in our knowledge that the work will address</li> </ul> <p>Research hypothesis and objectives [20]</p> <ul style="list-style-type: none"> <li>• Set out your research idea or hypothesis</li> <li>• Identify the overall aims of the project</li> </ul> <p>Programme and methodology [25]</p> <ul style="list-style-type: none"> <li>• Describe your research methodology</li> <li>• Describe the work programme, indicating what research is to be undertaken, and the order in which the work will be done</li> </ul> <p>Research Impact [5 marks]</p> <p>One paragraph to describe how your research may be of benefit to society and the state of scientific knowledge.</p> <p>Work plan [5 marks]</p> <p>Provide a diagrammatic work plan (Gantt chart).</p> <p>Resources Needed [No marks]</p> <p>List the resources you will require, and what equipment training you will need. Indicate what assistance you will require from other people. Indicate how you will use the £750 allocated to your project by the department. Please confirm this with your supervisor.</p> <p>References [5 marks]</p> <p>Provide a list of your references here; around 20 would be typical.</p>
Other requirements:	<p>This project proposal can be up to six A4 sides, including references. The minimum allowed font size is 11pt, the minimum margin width is 1.5 cm, and the minimum line spacing is single spaced. Some other things to remember when submitting:</p> <ul style="list-style-type: none"> <li>• Electronic copy submitted through Blackboard Learn (for marking)</li> <li>• Electronic copy submitted through Turnitin (plagiarism check)</li> <li>• Style of font is Calibri or Arial (or similar)</li> <li>• A4 size</li> </ul>

### Rubric:

Item name/number	Value	Description of marking
Track Record	0	<p>One paragraph describing what your UG degree covered.</p> <p>-Note any previous research work you have done</p> <p>-Note any experimental equipment you have learned to use</p> <p>-Note any computational methods you have learned to use</p>
Project Summary (Background)	40	<p>Background</p> <p>-Introduce the project topic and explain its context</p> <p>-Review the state of scientific understanding in the field</p> <p>-Describe the gap in our knowledge that the work will address</p> <p>This will be assessed on:</p>

		<ul style="list-style-type: none"> <li>-Clarity of the writing</li> <li>-Demonstration of knowledge of the field</li> <li>-Accuracy of the reasoning used to identify the gap in our knowledge</li> </ul>
Project Summary (Objectives)	20	<p>Research hypothesis and objectives</p> <ul style="list-style-type: none"> <li>-Set out your research idea or hypothesis</li> <li>-Identify the overall aims of the project</li> </ul> <p>This will be assessed on:</p> <ul style="list-style-type: none"> <li>-Clarity of the writing</li> <li>-Accuracy of the technical content</li> </ul>
Project Summary (Programme)	25	<p>Programme and methodology</p> <ul style="list-style-type: none"> <li>-Describe your research methodology</li> <li>-Describe the work programme, indicating what research is to be undertaken, and the order in which the work will be done.</li> </ul> <p>This will be assessed on:</p> <ul style="list-style-type: none"> <li>-Clarity of the writing</li> <li>-Accuracy of the technical content</li> </ul>
Research Impact	5	<p>One paragraph to describe how your research may be of benefit to society and the state of scientific knowledge.</p> <p>This will be assessed on:</p> <ul style="list-style-type: none"> <li>-Clarity of the writing</li> <li>-How understandable the text is to a non-specialist reader</li> </ul>
Workplan	5	<p>Provide a diagrammatic work plan (Gantt chart).</p> <p>This will be assessed on:</p> <ul style="list-style-type: none"> <li>-Does the plan look achievable?</li> <li>-Does the plan cover all the steps in the project?</li> </ul>
Resources Needed	0	<p>List the resources you will require, and what equipment training you will need. Indicate what assistance you will require from other people. Indicate how you will use the £500 allocated to your project by the department. Please confirm this with your supervisor.</p>
References	5	<p>Provide a list of your references here</p> <p>This will be assessed on:</p> <ul style="list-style-type: none"> <li>-Proper formatting of the references</li> <li>-Appropriateness of the references</li> </ul>

## MATE70003 The Art of Research – MATLAB program Coursework Information

Assessment Name:	MATLAB program
Academic:	Andrew Horsfield
Submission:	Blackboard Learn only (program plus screen shot of its output)
Self-study hours:	10
Assignment details:	Write a program in MATLAB to find the day of the week for a given date.
Other requirements:	Put a copy of your program into a Word document. After the code, paste a screen shot of the output of the program showing that it works. Upload this to Blackboard.

## Rubric:

Item name/number	Value	Description of marking
MATLAB program	Pass/Fail	Write a working program in MATLAB to determine the day of the week from the date

## (R2) MATE70004 - Advanced Materials Science and Engineering Research Project

<b>Core: MSc in Advanced MSE</b>	
<b>Module Leader:</b>	<b>Ifan Stephens</b>
<b>Topic Leader:</b>	<b>Greg Artus</b>
<b>Brief description of the Module</b>	
<p>In this module you will undertake a significant independent investigation of a research topic and present the results in a report and talk. Research topics are offered by staff across all the Department's Research Themes and you will have freedom to guide the project direction. Although you will be working independently you will work closely with your supervisor and potentially with others within their research group. You will also receive training in ethics for research.</p>	
<b>Learning Outcomes</b>	
<p>On successful completion of this module you will be able to:</p> <ul style="list-style-type: none"><li>• Critically review the current scientific literature relating to the research project</li><li>• Explain and justify the experimental or computational methods and techniques that were applied in the research</li><li>• Evaluate the results obtained and describe the evaluation in an accurate and concise manner</li><li>• Interpret the results and discuss their broader implications</li><li>• Identify additional investigations that are able to further advance the research field</li><li>• Synthesise data and literature to create a unique scientific report to a professional standard, and clearly communicate the results in different professional formats (oral presentation, poster presentation)</li><li>• Plan and manage a significant research project in an ethical manner</li></ul>	
<b>Module Content</b>	
<i>Research Ethics course</i>	
<ul style="list-style-type: none"><li>• Learn about the ethics of research</li></ul>	
<i>Research and reporting</i>	
<ul style="list-style-type: none"><li>• critical synthesis of a scientific problem</li><li>• generation of original laboratory or computational data</li></ul>	

- independent and creative thinking to solve problems and interpret results
- working in a systematic manner
- recording results in a retrievable format
- acting independently to plan and implement a work programme
- specialised training in research methods
- communication skills, both orally and by dissertation, to both a specialist and non-specialist audience
- independent study and time management

### Learning and Teaching Approach

Students have the opportunity to select a research project from a list of topics offered by academics from across the department. Students spend the summer working independently (under staff supervision, with possible support from PDRA and PhD researchers) on their projects to meet the research aims and objectives. Where appropriate students will be trained in experimental methods, use of analytical techniques, specialist software and computational tools.

### Assessment Strategy

Assessment is 100% coursework.

Your research project supervisor is not directly involved in marking your final report but will provide feedback on a draft and will provide a commentary for the assessors on difficulties encountered, and the extent of PhD and PDRA involvement in the project. The final written report will be marked by two assessors (87.5%), and you will give a presentation of your results (12.5%). The research ethics course supports the project and is assessed through the project.

### Feedback

You will meet your supervisor regularly throughout the project to discuss progress. Your supervisor will provide formative feedback on a draft of the final report and a draft of your presentation. You will get written summative feedback from the panel on the final report through Blackboard. After the presentation exercise the academic staff present will submit a joint assessment and provide you with summative feedback through Blackboard.

### Reading List

Reading will be assigned by your project supervisor.

## MATE70004 Advanced Materials Science and Engineering Research Project – Research Project Thesis Coursework Information

Assessment Name:	Research Project Thesis
Academic:	Dr Ifan Stephens
Submission:	Blackboard Learn and Turnitin
Self-study hours:	450 hours

<p>Assignment details:</p>	<p>Carry out research between the summer exams and the deadline date, under the supervision of an academic, and write it up as a thesis.</p> <p>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.</p> <p>The layout should be discussed with the supervisor, but the recommended general outline is as follows:</p> <p>Guidance on the Thesis</p> <p>Writing concisely is a skill that you should be developing throughout the degree. It is easier to write a high quality short document than a long one, and this is easier to mark in a robust fashion. Therefore the project report is limited to 35 pages in length (excluding any appendices for the supervisor, etc) including cover sheet and references. A template (in LaTeX and MSWord) is provided and should be respected – 11pt Arial/Calibri for the main text, with 1.5cm margins, single spaced. Pages should be numbered, with the cover page being page 1. It should include</p> <p>1pp Title Page and Abstract. To include project title, your name, supervisors incl PhDs and PDRAs and an abstract of up to 150 words.</p> <p>1pp Contents. Do not go beyond the first subheading level. If appropriate, here include a paragraph providing commentary, on industrial involvement in the project and its relationship to any prior work, e.g. in a UROP or summer placement. A paragraph of acknowledgements and thanks should also be included here.</p> <p>1pp Aims and Context. 1 paragraph on the aims of the project, and then a brief outline of the application context of the work and the relevance of the topic of study to society and industry.</p> <p>15pp Literature Review.</p> <p>3pp Methods.</p> <p>12-17pp Results. (Bear in mind that around 1/3rd of this might be figures)</p> <p>3-5pp Discussion.</p> <p>0.5pp Conclusions</p> <p>1-2.5pp References. Around 60 references would be normal.</p> <p>You may include additional material as an appendix, but this will not be marked.</p> <p>Further guidance is provided in the templates provided and the marking rubrics. To be clear: the 40 page limit is a hard limit. Many students can do a good job in fewer pages; markers are interested in the quality of the content, not in volume.</p>
<p>Other requirements:</p>	<ul style="list-style-type: none"> <li>An electronic copy should be submitted through Blackboard Learn for marking.</li> </ul>

	<ul style="list-style-type: none"> <li>An electronic copy should be submitted through TurnItIn for a plagiarism check.</li> </ul>
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**Rubric:**

Item name/number	Value	Description of marking
Aims and Motivation	5	Technological motivation for the work (socio-economic, technical and industrial), scientific context and clear articulation of the aims of the work and the research problem / question/ hypothesis.
Literature Review	25	The review should aim to identify what has been done in the research area, what knowledge gaps remain that might profitably be explored in the project and include a summary. Students are guided to avoid reworking standard textbooks and review articles and instead to synthesize the primary literature; copying and pasting of (appropriately referenced) figures is acceptable but should receive nil credit.
Results and Analysis	30	Copious results coherently presented and related to each other with the inferences drawn from different approaches discussed and contrasted. Methods and their limitations clearly well understood.
Discussion, Conclusions and Abstract	20	There is no requirement to separate the discussion from the results into separate sections. Whichever approach is taken, the learning outcomes being tested are the ability to interpret the results in the context of the literature and technological problem investigated, to draw appropriate conclusions (<1pp) and to summarise and extract the main findings in a coherent abstract (200 words).
Written Presentation, presentation of (original) figures and handing of data	20	Logical structure and overall presentation, correct English and grammar, quality of referencing (completeness and in a consistent and recognisable style). Overall effectiveness of the Thesis as a technical document. Bear in mind that a template is provided. At the upper end (8+/10) textbook/ publication quality would be expected. At the lower end of the scale (0-5) significant problems of English and style remain. Figures and Tables should meet scientific norms around error bars, units and axes, appropriateness of trend and fit lines, appropriate use of precision e.g. in tables, scale bars and relationship to sample axes, consideration of symmetry and crystallography. Captions should be descriptive and helpful to the reader. Use of colour should be appropriate and the presentation of data in graphs e.g. when compared to the literature or using multiple axes should aid clarity and insight. Again, a mark of 8+/10 would indicate uniformly publication-quality figures in leading journals.

**MATE70004 Advanced Materials Science and Engineering Research Project – Final Project Presentation Coursework Information**

Assessment Name:	Final Project Presentation
Academic:	Dr Ifan Stephens
Submission:	Oral



Self-study hours:	10h, incl supervisor assistance, plus half day attending presentations and presenting
Assignment details:	After submission and marking of the thesis you will present your results, analysis and findings to your peers. Submit this on blackboard beforehand. This will be a 15 minute presentation (including time for question-and-answer discussion). There will be a briefing note available on making scientific presentations. The staff present (your assessor pair, plus another assessor pair making a panel of four staff) will submit a joint assessment on blackboard. Your presentation should (i) introduce the aims of the project and situate it in the context of the research literature, (ii) show the main results and findings, (iii) discuss those results and present your conclusions.
Other requirements:	AV equipment and a PC will be available for the use of powerpoint or other visual aids software.

### Rubric:

Item name/number	Value	Description of marking
Background	20	Was the scientific and technological context and motivation for the work clearly exposted?
Methods and Results	20	Was it clear <i>what</i> was done, <i>how</i> it was done, and were errors/uncertainties handled properly?
Discussion and Conclusions	20	Were the results discussed in the context of the literature and appropriate conclusions drawn?
Oral Presentation	20	Was the oral presentation, including questions, handled well? Was the talk well organised and stayed within the time restriction?
Visual Aids: slides, figures and graphs	20	quality (including logical structure) of the visual aids used.

## (O01) MATE70006: Biomaterials

<b>Optional for MSc programmes</b>	
<b>Module Leader:</b>	<b>Julian Jones</b>
<b>Teaching Staff:</b>	<b>Stefano Angioletti-Uberti Priya Saravanapavan</b>
<b>Brief description of the Module</b>	
The missions of the Biomaterials module are to explain the types and properties of materials needed for various medical applications and how to synthesise and characterise these materials.	
<b>Learning Outcomes</b>	
On successful completion of this module you will be able to:	

- Distinguish various components in 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.
- Classify the major biomedical implant materials, their means of fixation, stability and advantages and disadvantages when used as implants devices and in artificial organs.
- Analyse reasons for failure in various clinical applications in terms of the types of failure of implants and device.
- Consider 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
- Review the literature for new developments in replacement of tissues and organs.
- Communicate alternative means to repair or replace parts of the body to both healthcare professionals and patients.

### Module Content

*The topics covered are:*

- Biomaterials Coatings
- Cartilage
- Tissue Engineering
- Bone
- Tissue response to biomaterials
- Joint Replacements
- Bone cement
- Biofilms
- Hydrogels
- Protein adsorption onto materials
- Antibacterial Surfaces
- Bioinert Polymer Devices
- Bioresorbable Polymers
- Bioactive Ceramics
- Bioactive Glass
- Scaffold materials
- Biomimetic adhesives
- Dental biomaterials
- Haemocompatibility
- Stents

### Learning and Teaching Approach

New material will be introduced to you in lectures. You will have an opportunity to test your understanding of the material through non-assessed problem sheets that will be reviewed in lectures. There will be an introductory lecture on a project to design a medical device, and a workshop to review the design part through the project.

### Assessment Strategy

The module is assessed by an end of module examination and a report on a project. For the exam, you need to answer three questions from five. For the project you will need to design a medical device for a scenario that requires comprehensive knowledge of the course, and then write up the design.

### Feedback

Feedback on written summative examinations is provided as a written commentary detailing where the cohort performed well and poorly.

### Reading List

#### Optional reading:

- *Biomaterials, Artificial Organs and Tissue Engineering*, LL Hench, JR Jones Eds, Woodhead Publishing, 2005
- *Biomaterials Science: An Introduction to Materials in Medicine, 4th Edition*, W Wagner, S Sakiyama-Elbert, G Zhang, M Yaszemski, Elsevier 2020

## (O02) MATE70007: Engineering Alloys

### Optional for MSc programmes

<b>Module Leader:</b>	<b>Fionn Dunne</b>
<b>Teaching Staff:</b>	<b>Minh-Son Pham</b> <b>Chris Gourlay</b> <b>Stella Pedrazzini</b> <b>Bat Gault</b>

### Brief description of the Module

You will draw together key concepts within the “processing-microstructure-properties-performance” domain to consider the opportunities and challenges of using engineering alloys in real components. This course is focussed around key case studies to translate theory and understanding into real-world applications.

### Learning Outcomes

On successful completion of this module you will be able to:

- Appraise engineering alloys, and evaluate multi-objective engineering design problems
- Apply approaches to engineering design and lifing, where failure and optimisation of alloys dominate function in solid stage metal components
- Apply the science of alloys as a microstructure system with an engineering goal
- Analyse and solve a problem using knowledge of texture and crystal plasticity

## Module Content

### *Steels, welding and additive manufacture*

- Overview of microstructure and properties of steels; phase transformation and deformation twinning in steels; thermo-mechanical processing; engineering steels for automotive applications (focus on car bodies); steels in energy applications with focus on power plant
- Intro to fusion-based welding and additive manufacturing with focus on classification and characteristics; applications (and challenges) of Welding and Additive manufacturing; processing defects: porosity (lack of fusion, keyholing, gas bubbles) and cracks (solidification, liquation, ductility loss cracking including strain age cracking); microstructure (solidification and effect of thermal cycles); properties (effects of defects, anisotropy, fatigue)

### *Magnesium for automotive applications*

- Automotive light-weighting: the case for Mg in automotive design.
- Cast magnesium: solidification paths in Mg-Al-X ternary phase diagrams; high pressure die casting
- Wrought Mg: texture and the origin of formability problems; case study on forged Mg wheels for F1 motor racing.
- Heat treatment of Mg alloys: continuous vs. discontinuous precipitation of Mg<sub>17</sub>Al<sub>12</sub>; the role of shape and orientation of precipitates on strengthening in HCP Mg; how good could Mg alloys be?

### *Advanced characterisation to understand structure-property relationships in engineering alloys*

- Considers complex architectures of metallic alloys across multiple scales ranging from a few atoms to several centimetres.
- Principles of microscopy and microanalysis techniques, including scanning and transmission electron microscopy, and associated spectroscopies, as well as atom probe tomography; use of these techniques to characterise Al-alloys and Ni-based alloys, amongst others, with a focus on phase transformation, segregation to grain boundaries and other crystalline imperfections; scale-bridging, multi-microscopy approaches helping to link microstructure to physical properties of interest of these alloys.

### *Alloys for aero applications*

- The Nickel superalloys: introduction, role in jet engine, alloying elements, brief history; strengthening mechanisms, yield stress anomaly, creep resistance. Turbine discs, powder metallurgy, heat treatment, fatigue, corrosion; turbine blades, casting, heat treatment, oxidation, coatings, corrosion.
- The Titanium alloys: introduction and role in aero-engines: a-b microstructures and the Burgers orientation relationship; processing and microstructure, including texture. Phase properties, and resulting behaviour in fatigue, creep and cold creep. Examples of manufacturing of wide-cord fan blades, superplastic forming, diffusion bonding, and discs.

### Deformation processing of Mg auto component

- Introduction to Mg crystallography, texture and slip through to bulk deformation
- Introduction to finite element crystal plasticity and texture modelling

### Learning and Teaching Approach

New material will be introduced to you in lectures. You will have an opportunity to test your understanding of the material through non-assessed problem sheets that will be reviewed in lectures. An assessed coursework exercise, led in lecture sessions, includes the development of a numerical model and exploration in the theme of deformation processing of Mg alloy components.

### Assessment Strategy

The module is assessed by:

- an end of module examination in which students answer 3 questions from 5
- a coursework based exercise on deformation processing of Mg alloy components

### Feedback

Summative feedback on the coursework activity will be provided within two weeks of submission. Feedback on the summative examination will be provided as a written commentary detailing where the cohort performed well and poorly. Formative feedback will be provided during the coursework exercise.

### Reading List

#### Optional reading:

#### Books:

- *H. K. D. H. Bhadeshia and R. Honeycombe, Steels: Microstructure and Properties, Butterworth-Heinemann; 4th edition*
- *George Krauss, Steels: Processing, Structure and Performance, ASM International; 2nd edition (30 May 2015)*
- *The Superalloys, RC Reed, CUP, 2007*
- *Titanium, Lutjering and Williams, Springer, 2003*
- *Light Alloys: Metallurgy of the Light Metals. IJ Polmear, 3rd Ed., Arnold, 1995*
- *The Jet Engine, Rolls Royce*
- *Metals Speciality Handbooks in Nickel and Titanium, ASM Int'l (Donachie)*
- *Welding Metallurgy, Second Edition, Sindo Kou*  
<http://onlinelibrary.wiley.com/book/10.1002/0471434027>

#### Journal articles:

- *Gu, D.D., Meiners, W., Wissenbach, K. and Poprawe, R., "Laser additive manufacturing of metallic components: materials, processes and mechanisms" International Materials Reviews (2012)*  
<http://dx.doi.org/10.1179/1743280411Y.0000000014>
- *Sames WJ, List FA, Pannala S, Dehoff RR, Babu SS. The metallurgy and processing*

## MATE70007 Engineering Alloys – Engineering Alloys Coursework Information

Assessment Name:	Engineering Alloys Coursework
Academic:	Fionn Dunne
Submission:	Blackboard Learn only
Self-study hours:	2 hours workshop for coursework exercise, 3 hours self study
Assignment details:	Students will carry out finite element crystal plasticity texture development in an HCP alloy (Mg or Zr) and will use MTEX to plot orientation distribution at varying strains, and examine intragranular residual stresses. Students will each be asked to prepare a short report to summarise their individual results which will be presented at a workshop session.

### Rubric:

Item name/number	Value	Description of marking
Q1: Model polycrystal deformation using crystal plasticity FE with a unique applied strain	4	Edit abaqus input deck for required applied strain and run. Include details of strain loading history in report.
Q2: Extract texture data and plot	4	Use provided software to extract texture information and plot using MTEX. Include ODs in report.
Q3: Examine examples of intragranular stresses developed in the polycrystal at peak applied strain	2	Use abaqus postprocessor to extract stress data within the polycrystal. Include stress results in report.
Q4: Write summary report to describe methods, results and conclusions	10	Summarise results (texture and intragranular stresses) in a short report. Submit report containing the above.



## (O03) MATE70008: Ceramics and Glass

### Optional for MSc programmes

**Module Leader:** Eduardo Saiz

**Teaching Staff:** Finn Giuliani  
Norbert Klein

### Brief description of the Module

This module discusses the main methods of processing for engineering ceramics (and, to a lesser degree, glasses and glass ceramics) and the fundamental principles underlying these methods. You will develop an understanding of the factors that influence their mechanical and electrical properties, in particular the correlation between these properties and the ceramic microstructure.

### Learning Outcomes

On successful completion of this module you will be able to:

- Compare different powder characterization techniques and assess their use in the selection of powders for ceramic processing
- Assess, with reference to interparticle forces, particle stability and powder flowability dry and wet processing approaches towards ceramic shaping.
- Appraise ceramic and glass sintering techniques
- Apply the fundamental concepts defining glass structure to glass processing.
- Explain and justify, in terms of the microstructure, the mechanical properties of ceramics and glasses
- Relate how the electronic properties of ceramics leads them to be the material of choice in microwave communications
- Synthesise information from the module and apply it to solving a complex problem in ceramics design and processing.

### Module Content

#### *Ceramics Processing*

- Powder characterization methods.
- Particle types
- Powder packing and the dry pressing of ceramic powders
- Origins and characteristics of different forces between particles (typical orders of magnitude)
- Types of colloids and stabilization of colloidal suspensions
- The zeta potential, isoelectric point, flocculation, coagulation and gelation
- Rheology in ceramic and glass processing
- Standard ceramic wet processing techniques
- Drying and de-binding of powder compacts.
- Structure of glasses and their formation.
- General concepts in solid-liquid-vapour systems and their relevance in ceramic and glass processing
- Stages of solid-state sintering and how they may be controlled

- Liquid phase and viscous glass sintering

#### *Mechanical properties of ceramics and glasses*

- Fracture strength, Young's modulus and fracture toughness of ceramics
- Elastic constants of two-phase ceramics by analytical methods
- Effect of microcracking on Young's modulus
- Griffith's energy balance criterion in a crack brittle solid
- The link between cracks and stress concentrations
- Griffith's flaw in determining fracture strength of ceramics
- Effect of porosity and other microstructural features on mechanical strength
- The statistical nature of the fracture strength of ceramics
- Weibull modulus of ceramics submitted to fracture strength tests
- Development of internal thermal stresses in ceramics
- Toughening mechanisms in ceramics
- Thermal and time aging effects in ceramics, including creep, subcritical crack growth and thermal shock
- The relationship between microstructural features, in particular porosity, and thermal shock resistance

#### *Electrodynamic properties and high-frequency applications of ceramics*

- The Clausius-Mossotti equation.
- The complex dielectric permittivity and its relation to the reflection and absorption of electromagnetic waves.
- Dielectric resonator and their applications in microwave communication technology
- The Q factor, its relation to the loss tangent and how it is being measured.
- The dielectric function of an ionic crystal in terms of the harmonic oscillator model and its relation to infrared absorption by phonons
- Intrinsic and extrinsic microwave losses of ceramics

#### **Learning and Teaching Approach**

New material will be introduced to you in lectures. You will have an opportunity to test your understanding of the material through non-assessed problem sheets that will be reviewed in lectures.

#### **Assessment Strategy**

The module is assessed by an end of module examination. Students answer three questions from five that test individual topics. The exam also included a compulsory question that requires the student to solve a problem by synthesising the knowledge gained in the course.

#### **Feedback**

Feedback on written summative examinations is provided as a written commentary detailing where the cohort performed well and poorly. Formative feedback is provided with the non-assessed problem sheets.

## Reading List

### Optional reading:

- *Introduction to Ceramics*, W. D. Kingery, J. Wiley & Sons (1976).
- *Mechanical Behaviour of Ceramics*, R. W. Davidge, Cambridge University Press (1979).
- *Fundamentals of Ceramics*, M. W. Barsoum, Taylor & Francis (2003).
- *Ceramic Materials, Science and Engineering*, C Barry Carter, M. Grant Norton, Springer (2013).
- *An Introduction to the Mechanical Properties of Ceramics*, D. J. Green, Cambridge University Press (1998).
- *Ceramic processing and sintering*, M.N. Rahaman, Marcel Dekker (1995)
- *Physical Ceramics*, Y-M Chang, D.P. Birnie and W.D. Kingery, John Wiley (1997)
- *Concise Encyclopedia of Advanced Ceramic Materials*, ed. R. J. Brook.
- *What Every Engineer Should Know about Ceramics*, Solomon Musikant, Marcel Dekker Publishers (ISBN 0-8247-8498-7).
- *Mechanical Properties of Ceramics and Composites. Grain Size and Particle Effect*, R. W. Rice, Marcel Dekker (1999).
- *Modern Ceramic Engineering*, D. W. Richerson, Marcel Dekker
- *Glasses and the Vitreous State*, J. Zarzycki, Cambridge U.P.
- *Principles of Ceramic Processing*, James S. Reed, Wiley. H. K. D. H. Bhadeshia and R. Honeycombe, *Steels: Microstructure and Properties*, Butterworth-Heinemann; 4th edition

## (O04) MATE70010: Optoelectronic Materials

### Optional for MSc programmes

**Module Leader:** Jason Riley

**Teaching Staff:** Mark Oxborrow  
Martyn McLachlan

### Brief description of the Module

This module explores the materials in electronic devices used to emit light, transmit light and detect light and shows you how these elements can be combined to create integrated systems for fibre optic communications, solar energy conversion and displays.

### Learning Outcomes

On successful completion of this module you will be able to:

- Interpret optical device behaviour based on the different mechanisms by which visible light interacts with matter
- Select materials to fabricate a Light Emitting Diode that operates at a specified wavelength
- Justify the design and materials selected in a semiconductor laser
- Apply knowledge of the principles of operation and the components of a liquid crystal display to interpret the behaviour of a device

- Critique first, second and third generation photovoltaic devices
- Explain the mechanisms and uses of organic electronics

### Module Content

- Reflection and refraction
- Microstructure on colour (scattering and diffraction)
- Absorption and luminescence of light from a material
- Band edge tuning
- Emission by phosphors
- Fibre optic communication links
- Light emitting diodes (LEDs) working in the visible and infra-red parts of the electromagnetic spectrum
- Materials requirements of a LED and the materials selection criteria
- Population inversion in an semiconducting laser - a homojunction laser, a single heterojunction laser and a double heterojunction laser
- Band gap and refractive index engineering as well as optical feedback in semiconductor lasers
- Passive and active solar energy and direct and indirect solar devices
- Economic and environmental viability of photovoltaic cells
- Fill factor, open circuit voltage, short circuit current and solar cell efficiency
- Silicon as a photovoltaic material
- Hetero-junctions in solar cells
- Excitonic solar cells
- Phases of a liquid crystal
- Chiral liquid crystal as a waveguide
- Orientation of liquid crystals in a field; the Fréedericksz transition
- The components of a liquid crystal display
- Electronic structure, hybridisation, bonding in organic semiconductors;
- Properties of organic semiconductors compared with classical semiconductors;
- Mechanism of conductivity and semiconducting behaviour in organic polymers and small molecules;
- Charge generation and stabilisation in organic materials;
- Types of organic semiconductors;
- C94 of organic semiconductors ;
- Absorption and emission processes in organic semiconductors;
- Operational principles, market space and design considerations of organic photovoltaic and organic light emitting diode devices.

### Learning and Teaching Approach

New material will be introduced to you in lectures. You will have an opportunity to test your understanding of the material through non-assessed problem sheets that will be reviewed in lectures.

### Assessment Strategy

The module is assessed by an end of module examination. You answer three questions

from five, plus one compulsory question.

### Feedback

Feedback on written summative examinations is provided as a written commentary detailing where the cohort performed well and poorly. Formative feedback is provided with the non-assessed problem sheets.

### Reading List

#### Optional reading:

- *Optoelectronics, An Introduction. J.H. Wilson and J.F.B. Hawkes, Prentice Hall International Series in Optoelectronics, ISBN 0-13-638495-1*
- *Optoelectronics, An Introduction. J.C.A. Chaimowicz, Butterworth Heinemann, ISBN 0-7506-0803-X*
- *Colour and the Optical Properties of Materials, R.J.D. Tilley, Wiley, ISBN 978-0-470-74695-0*
- *Physics Of Semiconductor Devices. S.M.Sze, John Wiley and Sons, ISBN 0-471-09837-X*
- *Lectures On The Electrical Properties Of Materials. L. Solymar and D. Walsh, Oxford Science Publications, ISBN 0-19-856280-2*
- *The Physics of Solar Cells, J. Nelson, Imperial College Press, ISBN 1-86094-340-3*
- *Introduction to Liquid Crystals: Chemistry and Physics. P.J. Collings, ISBN-10:074840483X Principles of Ceramic Processing, James S. Reed, Wiley. H. K. D. H. Bhadeshia and R. Honeycombe, Steels: Microstructure and Properties, Butterworth-Heinemann; 4th edition*

## (O05) MATE70011: Surfaces and Interfaces

### Optional for MSc programmes

<b>Module Leader:</b>	<b>Sandrine Heutz</b>
<b>Teaching Staff:</b>	<b>David Payne, Katharina Marquardt</b>

### Brief description of the Module

This module is designed to provide you with 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 module will provide a thorough overview of the typical analytical techniques used to characterise surfaces and buried interfaces.

## Learning Outcomes

On successful completion of this module you will be able to:

- critique different techniques for investigating interfaces
- discriminate electronic and chemical bonding at interfaces and in the bulk
- compare and contrast heterogeneous and homogeneous processes
- explain the importance of interfaces in magnetic, plastic electronic and energy devices
- synthesise knowledge from a range of scientific papers

## Module Content

### *Structure of surfaces*

- Nomenclature
- Defects
- Techniques: *LEED, RHEED, STM/SPM, GIXD*

### *Energy of surfaces*

- Surface free energy, surface tension
- Curved interfaces

### *Electronics and chemical bonding at interfaces*

- Charge distribution at surfaces and interfaces
- Electronic states at surfaces
- Techniques: *XPS, HAXPES, UPS*

### *Reactions at surfaces*

- Adsorption: chemisorption vs physisorption
- Diffusion
- Introduction to *film growth*

### *Characterising buried interfaces*

- *TEM, SIMS, EXAFS, neutron reflectivity*
- *Grain boundaries*

### *Case studies*

- *Topical examples chosen to reflect current challenges, e.g. in the areas of Energy, IT, health, nanotechnology.*

## Learning and Teaching Approach

New material will be introduced to you in lectures. You will have an opportunity to test your understanding of the material through non-assessed problem sheets that will be reviewed

in lectures. Student led research article discussion sessions will be held prior to the presentation exercise.

### Assessment Strategy

The module is assessed by an examination paper, duration 2.5 hours. It contains 5 long questions worth 20 marks each, of which you should answer three. There will be a presentation exercise related to a research article. The students will then form teams that will synthesise knowledge acquired from their papers and present their findings as a poster.

### Feedback

Summative feedback on the written summative examinations is provided as a written commentary detailing where the cohort performed well and poorly. Summative feedback on the presentation exercise and poster will be provided within 2 weeks of the events. Verbal formative feedback will be provided on the problem sheets.

### Reading List

#### Optional reading:

- *Surface Analysis - The Principal Techniques*, John C. Vickerman, Ian S. Gilmore
- *Gabor A. Somorjai, Introduction to Surface Chemistry*, Wiley, 1994
- *Physics of Surfaces and Interfaces*, Harald Ibach

## MATE70011 Surfaces and Interfaces – Essay Paper Coursework Information

Assessment Name:	Essay Paper
Academic:	Sandrine Heutz
Submission:	Blackboard Learn only
Self-study hours:	6
Assignment details:	Students will research a paper that includes at least one topic related to surface science and that relates to at least one theme of the department of Materials. They will then write an essay on the paper, developing a critical discussion of the surface science aspects presented in the paper, and giving suggestions for alternative surface science-based approaches to provide further insights into the research problem. They will then present the paper in a 3-minute “Pecha-Kucha” oral presentation to the rest of the class.
Other requirements	Essay- 1 page with minimum font size 11.

## MATE70011 Surfaces and Interfaces – “Pecha-Kucha” Presentation Coursework Information

Assessment Name:	“Pecha-Kucha” presentation
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Academic:	Sandrine Heutz
Submission:	Blackboard Learn only for slides.
Self-study hours:	6
Assignment details:	Students will present the paper from the literature related to surfaces and interfaces in a 3-minute oral presentation to the rest of the class.
Other requirements	Presentation: template provided, includes 9 slides scrolling every 20 seconds.

### Rubric:

Item name/number	Value	Description of marking
Overall structure and timekeeping	2	2 - excellent, perfect timing, logical structure, nothing missing 1- some vagueness, not quite to time, too long or too short 0 - no structure, no timing, poor effort
Use and quality of slides / figures / other media	2	2-No errors, well laid out, figures easily understood, perfectly applied into the talk 1- Generally good, some errors/poor layout, most figures useful 0 - unreadable, figures do not help
Technical & scientific content	5	5 - perfect, very high level and high engagement at that level 4 - very good, could have been more detailed 2/3- acceptable, some understanding demonstrated, no depth 0/1 -no understanding, no content
Quality of explanations and answers to questions	4	4 - perfect, very high level and high engagement at that level 3- very good, could have been more detailed 2 - acceptable, some understanding demonstrated, no depth 0/1 -no understanding, no content
Overall communication / engagement and interest	2	2 - Excellent, enthusiastic, genuine investment in the work 1- Very good, decent interest shown, some areas lacking 0- Poor, limited engagement, task based on requirement

## (O06) MATE70012: Nanomaterials

<b>Optional for MSc programmes</b>	
<b>Module Leader:</b>	<b>Jason Riley</b>
<b>Teaching Staff:</b>	<b>David Payne</b> <b>Peter Petrov</b>
<b>Brief description of the Module</b>	
<p>In this module you will investigate the fundamentals of nanoscience and how it can be applied in technological devices. A mechanistic description of the structure/property relationships for each class of material will be discussed with a focus on the specific advantages that nanoscale materials can provide. You will gain an understanding of the processing routes to produce controlled nanostructures.</p>	
<b>Learning Outcomes</b>	
On successful completion of this module you will be able to:	

- critique the different routes of nanoparticle synthesis
- recommend a procedure for fabricating a transistor of given dimensions
- compare and contrast the electronic properties of bulk and nanomaterials
- relate the ethics, environmental and social, of utilising nanomaterials to specific use cases
- synthesise ideas from across the course and apply to some challenges

## Module Content

### *Processing of Nanostructured Materials:*

- Surface energy in the thermodynamics of nanoscale systems
- Bottom-up versus top-down routes of nanomaterial processing
- Nucleation and growth of nanostructures
- Chemical and physical methods of thin film deposition
- Architecture of the CMOS transistor
- Manufacturing and device design challenges related to transistors at 22nm, 14nm and below.
- The manufacturing process of 2D and 3D CMOS devices.
- “Post-CMOS” nanomaterials and devices

### *Properties of Nanostructured materials*

- The effect of nanoscale structure on the mechanical properties of materials
- Electrical testing of nanomaterials and thin film devices
- Surface plasmon resonance in metals
- Colour of metal nanoparticles
- Bohr radius of an exciton
- Quantum confinement in semiconductor quantum dots
- Coulomb blockade in nanoparticles arrays
- Nanowires in sensor applications
- Band-edge tuning in charge transfer between nanoparticles

### *Ethics and social impact of Nanomaterials:*

- responsible development
- impact of nanomaterials on human health and the environment

### *Four challenges*

- explain clouds as collections of nanoparticles
- investigate a zeolite
- discover an object with nanomaterial content at the V&A
- discover where nanomaterials have been used for their mechanical properties

## Learning and Teaching Approach

New material will be introduced to you in lectures. You will have an opportunity to test your understanding of the material through non-assessed problem sheets that will be reviewed in lectures. There are challenges provided to encourage further exploration of the material.

### Assessment Strategy

The module is assessed by an end of module examination. You answer three questions from five that assess individual topics. There is an additional compulsory question that assesses the synthesis of knowledge achieved - formulated via specific topical challenges.

### Feedback

A session is held to provide formative feedback on the challenges. Feedback on written summative examinations is provided as a written commentary detailing where the cohort performed well and poorly.

### Reading List

#### Optional reading:

- *Nanostructures and Nanomaterials - Synthesis, Properties and Applications;* Guozhong Cao, Imperial College Press.
- *Metal Nanoparticles – Synthesis, Characterization and Applications;* D. Feldheim and C. Foss, Marcel Decker

## (O07) MATE70013: Advanced Engineering Alloys

### Optional for MSc programmes

<b>Module Leader:</b>	<b>Fionn Dunne</b>
<b>Teaching Staff:</b>	<b>Chris Gourlay</b>

### Brief description of the Module

This module builds on knowledge acquired from 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

On successful completion of this module you will be able to:

- relate cooling regimes and microstructure
- design a processing route to obtain a particular microstructure
- justify how a material's microstructure is related to its performance
- summarise how processing-structure-property-performance paradigm is employed in engineering practice

## Module Content

### *Microstructure formation during solidification:*

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

### *Microstructure and performance:*

- generalized crystal deformation – stretch, slip and rigid body rotation
- slip in fcc, bcc, and hcp crystal lattices and slip systems, Schmid rule, strain from slip, strain and rotation rates
- slip rules and slip by dislocation glide and thermally-activated climb; self and latent hardening
- 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

## Learning and Teaching Approach

New material will be introduced to you in lectures. You will have an opportunity to test your understanding of the material through non-assessed problem sheets that will be reviewed in lectures.

## Assessment Strategy

The module 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.

## Feedback

Summative feedback on the written summative examination will be provided as a written commentary detailing where the cohort performed well and poorly. Formative feedback on problems will be provided during lectures.

## Reading List

### Optional reading:

- Dantzig, J.A. & M. Rappaz. *Solidification*. EPFL press, 2016.
- Roters, F, Eisenlohr, P, Bieler, TR, Raabe, D, *Crystal Plasticity Finite Element Methods*, Wiley-VCH, 2010.
- Hertzberg RW, *Deformation & Fracture Mechanics of Engineering Materials*, John Wiley, 2012.

Links to underpinning scientific journal papers are provided on Blackboard

## (O08) MATE70014: Advanced Nanomaterials

### Optional for MSc programmes

<b>Module Leader:</b>	<b>Alexandra Porter</b>
<b>Teaching Staff:</b>	<b>Ifan Stephens Cecilia Mattevi Fang Xie Michelle Conroy</b>

### Brief description of the Module

This module is designed to provide you with an insight into the emerging applications of nanotechnology through a series of topically relevant case studies. The underlying nanoscience as well as the engineering aspects of material and device operation is given. The broader societal impacts of nanotechnology and its impact on human health are explored.

### Learning Outcomes

On successful completion of this module you will be able to:

- Synthesise arguments on the advantages and disadvantages of nanomaterials in a specified application.
- Discover, through reading journal articles, how nanomaterials are used in an application.
- Summarise a particular nanotechnology and present it in a talk.
- Defend the content of your talk to an audience of researchers who specialise in the field.

### Module Content

At the end of this module, you will be able to:

- Describe the electronic band structure of graphene and of monolayered transition metal (group VI) disulphide and diselenide (e.g. MoS<sub>2</sub>).

- Discuss the optical, electrical and catalytic properties of these materials.
- Discuss the liquid phase synthesis method for these materials.
- Discuss their applications.
- Quantify the scalability of different energy conversion technologies for our future energy needs.
- Explain the role of the electrocatalyst in controlling the efficiency of low temperature fuel cells and water electrolysis.
- Describe trends in catalytic activity due to (i) particle size (ii) alloying.
- Identify fundamental bottlenecks in emerging electrochemical reactions: N<sub>2</sub> reduction and CO<sub>2</sub> reduction.
- To be able to describe plasmonic materials: synthesis and fabrication.
- To be able to describe and understand optical properties of plasmonic materials.
- To be able to describe and understand Biosensing and bioimaging
- To be able to describe and understand Solar energy enhancing for water splitting and solar cells.
- Discuss multiferroic domain wall nano-interfaces and their dynamic magnetoelectric applications
- Discuss the energetics that contribute to the multiferroic domain wall structure and formation
- Discuss synthetic routes to forming these functional magnetoelectric domain walls
- Discuss the dynamics of multiferroic domain walls
- 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.

### Learning and Teaching Approach

New material will be introduced to you in lectures. You will have an opportunity to test your understanding of the material through non-assessed problem sheets that will be reviewed in lectures.

You are also required to present on a general theme related to “Nano”. Themes are deliberately broad and change every year. Students are required to focus on a topic not directly related to their research project and lectures but use some of the knowledge acquired on the course. This work is presented as a group of 5-6 students and students are free to organise their groups as they wish. An abstract should be submitted by week 4. Presentations should be fully referenced and of a standard expected in a research symposium. Presentations will be presented at the annual Nano II symposium, which is

attended by other academics in the department, as well as senior researchers. Students are marked on both the oral and written (design, clarity, remit of the poster) presentation.

### Assessment Strategy

The course is examined in the summer term. The examination paper, duration 2.5 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).

### Feedback

Summative feedback on the written summative examination will be provided as a written commentary detailing where the cohort performed well and poorly. Formative feedback on problems will be provided during lectures. Formative feedback (non-assessed) is given on the abstract on the suitability of the topic students have chosen to focus on. Summative feedback is provided to all students on the presentation within two weeks.

### Reading List

A list of suitable research papers will be provided on Blackboard.

## MATE70014 Advanced Nanomaterials – Presentation Abstract Coursework Information

Assessment Name:	Presentation Abstract
Academic:	Alex Porter
Submission:	Blackboard Learn only
Self-study hours:	15-18 hours
Assignment details:	Group of 3-5 students are required to prepare a presentation on a topic provided by the course leader. Students should first perform an in-depth literature search on the topic, select a subtopic on which to focus their presentation and read more in specific on that. Students should first formulate an abstract of their presentation content on which to receive feedback from the course leader. The abstract is not assessed.

## MATE70014 Advanced Nanomaterials – Presentation Slides Coursework Information

Assessment Name:	Presentation using slides (power point)
Academic:	Alex Porter
Submission:	Blackboard Learn for submission of slides
Self-study hours:	15-18 hours



Assignment details:	Group of 3-5 students are required to prepare a power point slide-based presentation on a topic provided by the course leader. Students should first perform an in-depth literature search on the topic, select a subtopic on which to focus their presentation and read more in specific on that. After receiving feedback on the abstract, students can prepare a presentation in the form of slides to be presented in 12 minutes. The presentation will be assessed.
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### Rubric:

Item name/number	Value
Presentation skills	10
The scientific quality of slides content	10
Answers to questions	10

## (O09) MATE70015: Advanced Structural Ceramics

<b>Optional for MSc programmes</b>	
<b>Module Leader:</b>	<b>Luc Vandeperre</b>
<b>Teaching Staff:</b>	<b>Finn Giuliani</b>
<b>Brief description of the Module</b>	
<p>In this module you will consider microstructural aspects of the behaviour of the major ceramic families, contrasting microstructural control aimed at increases in strength with microstructural approaches aiming to improve toughness. Compare the properties of ceramic composites with monoliths and learn how to use fractography in ceramics. The module will look at the performance of ceramics in various service conditions.</p>	
<b>Learning Outcomes</b>	
<p>On successful completion of this module you will be able to:</p> <ul style="list-style-type: none"> <li>• Review microstructural aspects of the behaviour of major ceramic families</li> <li>• Contrast microstructural control aimed at increased strength and improved toughness</li> <li>• Justify the need for composites and to contrast the mechanical response of ceramic composites with that of monoliths</li> <li>• 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</li> <li>• Explain the concepts underpinning the state-of-the-art methodologies, which can be used to design monolithic ceramic components with confidence</li> <li>• Summarise the fractography of ceramics</li> <li>• Discuss high temperature ceramics, including the various forms in which these materials are used such as coatings, fibres and composites and how they are made.</li> <li>• Document the fundamental quantitative factors that control stability, mechanical performance and damage accumulation under service conditions.</li> </ul>	

## Module Content

### *Design implications of reliability and fracture of ceramics*

- Classical families of advanced structural ceramics including alumina, zirconia, silicon nitride, silicon carbide and ceramic matrix composites
- Approaches to improve the strength of these materials
- Approaches to improve the toughness of these materials
- Ceramic composite approaches and their failure modes
- Inherent toughness, apparent toughness, and fracture energy
- Crack progression for stable cracking and for materials with R-curve behaviour
- Driving force for cracking under mixed mode loading and for published crack configurations
- Failure criteria for mixed mode loading and their limitations
- Possible fatigue effects in ceramics
- How a ceramic fracture surface yields information on failure origin, and failure type
- Mechanism of slow crack growth (subcritical crack growth)
- Expected life-time accounting for slow crack growth.
- Weibull distributions; choice of probability estimator; fitting methodology and link to defect distributions
- Calculation of material Weibull parameters and test Weibull parameters and relationship
- Probability of failure for simple loading cases
- Proof testing or non-destructive evaluation in a reliability strategy
- Design methodology for complex ceramic components based on probability of failure

### *Deformation of ceramics*

- Deformation behaviour of ceramics compared to other materials
- Deformation mechanisms active in ceramics
- Schematic representation of the bounds on stress, temperature and strain rate; regions where the different mechanisms can be expected to operate
- Microstructural influences on transitions in deformation mechanisms
- Mechanical response from deformation mechanism maps
- Affect of scale in the deformation response
- How to investigate the different deformation mechanisms
- Strengths and weaknesses associated with different experimental approaches (both small scale measurements and microscopic measurements)

### *The Effect of High Temperature on Ceramics*

- Importance of thermo-mechanical properties at temperature
- 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
- Mechanical damage mechanisms in ceramics including from wear and impact/erosion.
- Local and global chemical equilibrium

- Applications of high temperature ceramics and why they are used in thermal protection systems, thermal barrier coatings in jet engines, and processing equipment in glass making, steel making and other industrial high temperature processes.
- Appropriate refractory materials for specific applications
- Limits of established material systems and underpinning principles in new developments

### Learning and Teaching Approach

New material will be introduced to you in lectures. You will have an opportunity to test your understanding of the material through non-assessed problem sheets that will be reviewed in lectures.

### Assessment Strategy

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.

### Feedback

Summative feedback on the written summative examination will be provided as a written commentary detailing where the cohort performed well and poorly. Formative feedback on problems will be provided during lectures.

### Reading List

#### Optional reading:

- *Materials for High Temperature Engineering Applications*, GW Meetham and MH Van de Voorde, (Springer 2000)
- *Ceramic Microstructures, Property Control by Processing*, WE Lee and WM Rainforth, (Chapman & Hall 1994)
- Hull, D. (1999). *Fractography*. Cambridge, Cambridge University Press.
- Lawn, B. R. and T. R. Wilshaw (1975). *Fracture of Brittle Solids*. Cambridge, Cambridge University Press.

Links to research papers are provided on Blackboard.

## (O10) MATE70016: Advanced Tissue Engineering

### Optional for MSc programmes

<b>Module Leader:</b>	<b>Iain Dunlop</b>
<b>Teaching Staff:</b>	<b>Theoni Georgiou Molly Stevens</b>

### Brief description of the Module

You will learn about modern developments in tissue engineering, and about the principles

on which they are based.

### Learning Outcomes

On successful completion of this module you will be able to:

- Specify the importance in tissue engineering of controlling the local environment to generate a specific cellular response
- Plan a synthetic strategy of a material for tissue engineering
- Consider the advantages and disadvantages of different scaffold materials in tissue engineering
- Recommend a strategy for taking a biomaterial through clinical trials.

### Module Content

#### *Cellular responses to the local environment*

- The role of cellular responses to the local environment in tissue engineering.
- Empirical and rational design approaches to tissue engineering.
- The principles and basic mechanisms of cellular signalling, in the abstract, and with reference to the examples given in the course.
- The principles and mechanisms of cellular mechanotransduction
- Surface chemistry and protein adsorption relevant to tissue engineering

#### *Materials synthesis for tissue engineering*

- Property requirements of scaffold materials for regenerative biological applications
- Strategies to fabricate porous materials
- Approaches to functionalisation of porous materials

#### *Clinical aspects of tissue engineering*

- The role and importance of the extracellular matrix in tissue engineering
- The advantages and disadvantages of hydrogels and other scaffolds for tissue engineering
- The applications of scaffolds for tissue engineering; tissues such as heart, bone, liver, kidney, nervous system.
- The application of polymers in drug delivery as a basis of polymer structure
- Clinical case studies

### Learning and Teaching Approach

New material will be introduced to you in lectures. You will have an opportunity to test your understanding of the material through non-assessed problem sheets that will be reviewed in lectures.

### Assessment Strategy

The course is examined in the summer term. The paper is 2.5 hours and students are required to answer 3 questions from the 5 set on the examination paper.

### Feedback

Summative feedback on the written summative examination will be provided as a written commentary detailing where the cohort performed well and poorly. Formative feedback on problems will be provided during lectures.

### Reading List

Links to journal papers will be published on Blackboard.

## (O11) MATE70017: Electroceramics

### Optional for MSc programmes

**Module Leader:** Stephen Skinner

**Teaching Staff:** TBC

### Brief description of the Module

In this module you will gain an understanding of the fundamental science governing the electronic and ionic conductivity of metal oxides and then use this knowledge to describe the operation of devices based on these properties, such as gas sensors, fuel cells, batteries and thermoelectrics.

### Learning Outcomes

On successful completion of this module you will be able to:

- Derive expressions that permit the construction of Brouwer diagrams and use the diagrams to predict conductivity variation with oxygen partial pressure for a simple binary oxide
- Compare and contrast the main battery types
- Derive an algebraic expression for the temperature dependence of the ionic conductivity of an oxide ion conductor
- Recommend electroceramic materials for a particular sensor application
- Identify novel materials for ceramic based devices.

### Module Content

*Defect chemistry, electrical conductivity and secondary batteries*

- Algebraic expressions for the point defect concentrations in pure and doped oxide materials
- Construction of a simple Brouwer diagram for a binary oxide
- Prediction of the conductivity variation with  $P_{O_2}$  for a simple binary oxide
- Extrinsic defects incorporated into the Brouwer diagram (constant and variable dopant concentrations)
- Types of conductivity and applicability to materials in electrochemical systems

- Secondary batteries: main battery types, and characteristics
- Electrode reaction mechanism in secondary batteries
- Electrochemical performance in terms of the band theory of solids
- Chemical and electrochemical stability of electrode and electrolyte materials
- Types of solid electrolytes and ionic conduction mechanisms for alkaline ions
- Relationships between crystal structure, composition and morphology to transport properties
- Novel materials for ceramic based devices

#### *Fuel cells, sensors and devices*

- Anionic, cationic and mixed conductors.
- Operation of a ceramic membrane device
- Selecting appropriate materials for the fabrication of devices such as a single SOFC cell
- Operation of a fuel cell; details of the four main types of cell
- The excess air factor  $\lambda$  and the variation of the PO<sub>2</sub>, and pollutant content, of the exhaust gasses of an internal combustion engine as a function of  $\lambda$
- Oxide based sensors to sense the changes in oxygen activity arising from the  $\lambda$  curve, the common zirconia based  $\lambda$  probe, and the semiconducting TiO<sub>2</sub> sensor
- Amperometric sensors for determining the PO<sub>2</sub> of the exhaust gasses in an internal combustion engine in the lean burn region of operation
- Sensors for the detection of flammable gasses
- Thermoelectric materials

#### **Learning and Teaching Approach**

New material will be introduced to you in lectures. You will have an opportunity to test your understanding of the material through non-assessed problem sheets that will be reviewed in lectures.

#### **Assessment Strategy**

The course is examined in the summer term. The examination paper, duration 2.5 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).

#### **Feedback**

Summative feedback on the written summative examination will be provided as a written commentary detailing where the cohort performed well and poorly. Formative feedback on problems will be provided during lectures.

## Reading List

### Optional reading:

- *Electroceramics*, A.J.Moulson and J.M.Herbert Chapman and Hall (1992). 2nd Edition John Wiley and Sons (2003)
- *Physical Ceramics*, Chiang, Birnie and Kingery, John Wiley and Sons (1997).
- *Ceramic Materials for Electronics*, R.C.Buchanan, Marcel Dekker (1991), 3rd Edition CRC press 2004
- *Electronic Ceramics Properties Devices and Applications* Lionel M. Levinson. Marcel Dekker (1988)
- *High-temperature solid oxide fuel cells: fundamentals, design and applications*, Edited by Subhash C. Singhal and Kevin Kendall, Elsevier, Oxford (2003)
- *Fuel Cell systems explained*, James Larminie and Andrew Dicks, Wiley (2003)
- *Solid oxide fuel cell technology: Principles, performance and operations*, Kevin Huang and John B. Goodenough, Woodhead Publishing Ltd (2009)

## (O12) MATE70018: Advanced Biomaterials

### Optional for MSc programmes

<b>Module Leader:</b>	<b>Julian Jones</b>
<b>Teaching Staff:</b>	<b>Alexandra Porter</b> <b>Stefano Angioletti-Uberti</b>

### Brief description of the Module

The module aims to introduce students to the latest developments in hard tissue biology. Emphasis is placed on synthetic scaffolds, bioactive nanoparticles, bioceramics, interactions in biomaterials and the challenges of characterising biological systems.

### Learning Outcomes

On successful completion of this module you will be able to:

- Consider the merits of different materials and processing routes for synthetic scaffolds
- Argue the advantages and disadvantages of non-conventional pharmaceuticals
- Explain cell uptake routes and nanotoxicity of both classes of nanomaterials
- Consider the different types of interactions in biomaterials
- Critique the various methods of characterising materials in the body
- Plan how to take a biomaterials device from concept to market.

### Module Content

#### *Synthetic scaffolds*

- The shortfalls of bone replacement materials to the biomaterials industry and investors
- Commercially available bone graft replacement materials; their benefits and shortfalls
- Alternative means to repair skeletal tissues



- Differences between melt and sol-gel derived bioactive glasses; mechanisms of bioactivity and application
- Bone replacement material criteria
- Processing methods for production of artificial bone grafts
- Challenges involved with transfer of laboratory inventions to a clinical product

#### *Bioactive nanoparticles*

- Production and application of hydroxyapatite and bioactive glass nanoparticles
- Cell uptake routes and nanotoxicity of both classes of nanoparticle
- Concepts of non-conventional pharmaceuticals

#### *Nanotoxicology, Nanotherapeutics*

- 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*

- The composition of hydroxyapatite and bone apatite
- Different routes for processing synthetic hydroxyapatite
- Mechanism of bioactivity of hydroxyapatite (HA) and the dissolution reprecipitation mechanism leading to bone formation around the implant surface.
- The limitations of HA and the need for and advantages of using substituted hydroxyapatites: Si-HA, CHA
- Different forms of HA used in bone grafting applications

#### *Interactions in biomaterials*

- The major types of microscopic interactions in biomaterials: ionic interactions, polymer-mediated and water-mediated interactions, ligand-receptor interactions
- The microscopic origins generating and controlling the aforementioned interactions.
- The effect of interactions in the development of applications, e.g. in drug-delivery, controlled protein adsorption or biosensing.

#### *Characterisation of material: biomaterial-tissue and biomaterial-cell interfaces*

- 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.
- SIMS, Raman spectroscopy and Zeta potential measurements on biological systems
- 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*

- Patenting
- Regulatory procedures and claims
- Clinical trials
- Good manufacturing practice

#### **Learning and Teaching Approach**

New material will be introduced to you in lectures. You will have an opportunity to test your understanding of the material through non-assessed problem sheets that will be reviewed in lectures.

To test students understanding of the mechanism and stages needed to take a new device from concept to clinic al Dragon's Den exercise will be performed in groups.

#### **Assessment Strategy**

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 coursework element of this module is the Dragon's Den exercise.

#### **Feedback**

Summative feedback on the written summative examination will be provided as a written commentary detailing where the cohort performed well and poorly. Formative feedback on problems will be provided during lectures. Written summative feedback on the Dragon's Den type exercise will be within two weeks.

#### **Reading List**

Journal articles will be recommended on Blackboard.

## **(O13) MATE70019: Nuclear Materials for Reactor Systems**

#### **Optional for MSc programmes**

<b>Module Leader:</b>	<b>Mark Wenman</b>
<b>Teaching Staff:</b>	<b>Robin Grimes</b> <b>Michele Conroy</b> <b>David Bowden (UKAEA/CCFE) guest lecturer</b>

#### **Brief description of the Module**

The aim is 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 consider 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.

### Learning Outcomes

On successful completion of this module you will be able to:

- Compare mechanisms of radiation damage in nuclear systems.
- Discuss the nuclear fuel cycle and fuel fabrication.
- Predict failure in nuclear components.
- Evaluate the use of stainless steels, nickel alloys and zirconium as nuclear materials.

### Module Content

- Radiation types, radioactive decay and dose units.
- Mechanisms of radiation damage of nuclear materials.
- The Kinchin-Pease Model to predict damage accumulation.
- Types of fuel and components for the Nuclear Fuel Assembly.
- The fuel cycle and fuel fabrication.
- Materials (stainless steels, Ni alloys) used in a pressurised water reactor (PWR) primary circuit.
- Microstructure and mechanical properties of ferritic steels used for reactor pressure vessels.
- The influence of stress on structural integrity assessments of nuclear plant.
- FAD and Weibull analysis methods to predict failure in nuclear components.
- Pellet-clad mechanical interactions (PCMI) in PWR and AGR systems.
- Zirconium as a cladding in PWR environments.
- Alloying of zirconium for cladding materials.
- Deformation modes in zirconium systems.
- Crystallographic texture and its importance in highly engineered systems.
- Measuring and describing texture using pole figures & Kearn's factors.
- Ageing and corrosion of zirconium in power plant systems.
- Engineering decisions for tube fabrication.

### Learning and Teaching Approach

New material will be introduced to you in lectures. You will have an opportunity to test your understanding of the material through non-assessed problem sheets that will be reviewed in lectures.

### Assessment Strategy

The module is assessed by an end of module examination. Students answer three questions from five.

### Feedback

Summative feedback on written summative examinations is provided as a written

commentary detailing where the cohort performed well and poorly. Formative feedback will be provided with the non-assessed problem sheets.

### Reading List

- *J G Collier and G F Hewitt "Introduction to Nuclear Power", Hemisphere Publishing Corporation, New York, 2000.*
- *C P D Wilson (Editor) "The Nuclear Fuel Cycle: From Ore to Waste" (0198565402W)*
- *B G S Was "Fundamentals of Radiation Materials Science" Springer (978-3-540-49471-3)*

## (O14) MATE70020: Modelling Materials with Density Functional Theory

### Optional for MSc programmes

**Module Leader:** Johannes Lischner

**Teaching Staff:** Eamonn Murray

### Brief description of the Module

This course will introduce you 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 you will learn to use a density-functional theory software package and compute the properties of real materials from first principles.

### Learning Outcomes

On successful completion of this module you will be able to:

- Explain the underlying concepts of DFT
- Consider the strengths and weaknesses of density functional theory
- Compute and interpret material properties using density functional theory
- Explain the limitations of Density Functional Theory

### Module Content

- Basic principles and capabilities of materials modeling with density functional theory (DFT)
- Quantum-mechanical basis of DFT and its limitations
- Use of DFT software package to compute:
  - 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.

### Learning and Teaching Approach

New material will be introduced to you in lectures and then embedded through use in computer workshops.

### Assessment Strategy

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

### Feedback

Summative feedback on the written summative examination will be provided as a written commentary detailing where the cohort performed well and poorly. Summative feedback on the weekly problem sets will be provided within two weeks of submission. Verbal formative feedback can be obtained in the workshops.

### Reading List

- *Materials modelling using Density-Functional Theory: Properties and Predictions*, F. Giustino, Oxford University Press, 2014.
- *Electronic Structure Calculations For Solids and Molecules: Theory and Computational Methods*, J. Kohanoff, Cambridge University Press, 2006.
- *Introduction to Quantum Mechanics*, D. J. Griffith, Pearson Education International, 1995.

## MATE70020 Modelling Materials with Density Functional Theory - Homework Problem 1 Coursework Information

Assessment Name:	Homework Problem 1
Academic:	Johannes Lischner
Submission:	Blackboard Learn
Self-study hours:	10-15 hours of self-study required
Assignment details:	Assignment details will be provided by the academic in charge.

## MATE70020 Modelling Materials with Density Functional Theory - Homework Problem 2 Coursework Information

Assessment Name:	Homework Problem 2
Academic:	Johannes Lischner
Submission:	Blackboard Learn
Self-study hours:	10-15 hours of self-study required
Assignment details:	Students will study the electronic structure of diatomic molecules. Further assignment details will be provided by the academic in charge.

### MATE70020 Modelling Materials with Density Functional Theory - Homework Problem 3 Coursework Information

Assessment Name:	Homework Problem 3
Academic:	Johannes Lischner
Submission:	Blackboard Learn
Self-study hours:	10-15 hours of self-study required
Assignment details:	Students will study the convergence of density functional theory calculations. Further assignment details will be provided by the academic in charge.

### MATE70020 Modelling Materials with Density Functional Theory - Homework Problem 4 Coursework Information

Assessment Name:	Homework Problem 4
Academic:	Johannes Lischner
Submission:	Blackboard Learn
Self-study hours:	10-15 hours of self-study required
Assignment details:	Students will study the electronic structure of two-dimensional boron nitride sheets. Further assignment details will be provided by the academic in charge.

### MATE70020 Modelling Materials with Density Functional Theory - Homework Problem 5 Coursework Information

Assessment Name:	Homework Problem 5
Academic:	Johannes Lischner
Submission:	Blackboard Learn
Self-study hours:	10-15 hours of self-study required
Assignment details:	Students will study the properties of a vacancy in silicon. Further assignment details will be provided by the academic in charge.

### MATE70020 Modelling Materials with Density Functional Theory - Homework Problem 6 Coursework Information

Assessment Name:	Homework Problem 6
Academic:	Johannes Lischner
Submission:	Blackboard Learn

Self-study hours:	10-15 hours of self-study required
Assignment details:	Students will study atomic vibrations in cumulene. Further assignment details will be provided by the academic in charge.

## MATE70020 Modelling Materials with Density Functional Theory - Homework Problem 7 Coursework Information

Assessment Name:	Homework Problem 7
Academic:	Johannes Lischner
Submission:	Blackboard Learn
Self-study hours:	10-15 hours of self-study required
Assignment details:	Students will study the specific heat of diamond. Further assignment details will be provided by the academic in charge.

## MATE70020 Modelling Materials with Density Functional Theory - Homework Problem 8 Coursework Information

Assessment Name:	Homework Problem 8
Academic:	Johannes Lischner
Submission:	Blackboard Learn
Self-study hours:	10-15 hours of self-study required
Assignment details:	Students will use DFT to search for perovskite materials with a favorable band gap for sunlight absorption. Further assignment details will be provided by the academic in charge.

## (O15) MATE70021: Advanced Thin Film Manufacturing Technologies

<b>Optional for MSc programmes</b>	
<b>Module Leader:</b>	<b>Peter Petrov</b>
<b>Teaching Staff:</b>	<b>Robert Hoyer</b>
<b>Brief description of the Module</b>	
<p>This course aims to familiarise you with the basic vacuum technologies, explain the essential concepts involved in using vapour and solution-based deposition techniques to develop thin films, provide a foundation required to successfully use lithographic and other microfabrication methods, and provide you with the basics for working in, and understanding the microfabrication production environment.</p>	
<b>Learning Outcomes</b>	
<p>On successful completion of this module you will be able to:</p> <ul style="list-style-type: none"> <li>• Explain the principles of vacuum production and its classification.</li> </ul>	



- Explain the deposition techniques used to grow thin films.
- Specify the most appropriate methods and equipment for a deposition process and discuss its advantages and disadvantages.
- Explain the basic principles for working in a hi-tech production environment.
- Explain the classification of cleanrooms, their design principles and control measures.
- Synthesise the contents of this module and apply this to the design of a manufacturing process.

### Module Content

- The principles of vacuum production and its classification.
- The working principles and limitations of the vacuum pumps and gauges.
- The essential concepts involved in using vapour and solution deposition techniques to grow thin films.
- The most common types of vapour deposition technologies (chemical vapour deposition (CVD), physical vapour deposition (PVD) and mixed deposition), as well as solution-based processing methods
- The three basic PVD techniques: vacuum evaporation (thermal/e-beam evaporation), sputter deposition (DC-, RF-, reactive- magnetron sputtering) and pulsed laser deposition.
- The connection between vapour and solution deposition parameters and thin film properties.
- The most appropriate methods/equipment for a deposition process and discuss its advantages and disadvantages.
- The characteristics and practical limitations of basic lithographic methods used for integrated circuit manufacturing.
- The etching methods used in a microfabrication process
- The methods and equipment used for a patterning process and their principles of operation and limitations.
- The basic principles for working in hi-tech (e.g. semiconductor) production environment.
- The classification of cleanrooms, their design principles and control measures.

### Learning and Teaching Approach

The material is taught through lectures and workshops. The workshops provide an opportunity for group discussion of the design of manufacturing processes and equipment.

### Assessment Strategy

There is an exam that tests knowledge of the whole course. The workshops are used to assess engagement. There is also a piece of coursework (report) based on the workshop discussions that assesses independent learning and problem solving skills.

### Feedback

Written summative feedback is provided on the report. Summative feedback in the form of a commentary is provided for the exam highlighting common points where answers were good and where they could be improved. In preparation for the report there are three workshops in which formative feedback can be provided.

## Reading List

### Optional reading:

- R.W. Berry, P.M. Hall & M.T. Harris: 'Thin Film Technology', published by D. Van Nostrand Company, 1968
- Krishna Seshan et al., 'Handbook of Thin Film Deposition Processes and Technologies', Second Edition, Noyes Publications, 2002
- K.L. Saenger, in: D.B. Chrisey and G.K. Hubler (Eds.), 'Pulsed laser deposition of thin films', Wiley Interscience, New York, 1994
- Fundamentals of Vacuum Technology (revised and compiled by W Umrath) Oerlikon Leybold Vacuum 00.200.02 Kat.-Nr. 199 90
- M. Ohring, 'The Materials Science of Thin Films' (Academic Press, 1992; 2nd edition 2002) 538.975 OHR
- M. Napari, T. N. Huq, J. L. MacManus-Driscoll, R. L. Z. Hoyer, 'Nickel oxide thin films grown by chemical deposition techniques: potential and challenges in next-generation rigid and flexible device applications', Infomat, 2020, Accepted. DOI: 10.1002/INF2.12146

## MATE70021 Advanced Thin Film Manufacturing Technologies – Device Manufacturing Route Report and Workshops Coursework Information

Assessment Name:	Device manufacturing route report and workshops
Academic:	Peter Petrov and Robert Hoyer
Submission:	Blackboard Learn
Self-study hours:	20 Hours
Assignment details:	To prepare for and attend 3x workshops and write a 10 page report
Other requirements:	Arial 11; all margins 2.5cm

### Rubric:

Item name/number	Value	Description of marking
<b>Performance at workshop (x3)</b>	9	1- attended; 2 - engaged with the discussion; 3 - exceptional contribution to the discussion
<b>Report:</b>		
i) Introduction	1	completeness and level of discussion
ii) Manufacturing workflow	3	
iii) The most challenging fabrication process	3	
iv) Equipment (for the most challenging fabrication process)	3	
v) Conclusions	1	

## (O16) MATE70022: Fusion and Advanced Reactors

### Optional for MSc programmes

**Module Leader:** Andrew Horsfield

**Teaching Staff:** Mark Wenman  
Mike Bluck  
Christos Markides  
Robin Grimes  
Christopher Ham  
Sergei Dudarev  
David Bowden

### Brief description of the Module

This module is designed to provide you with an introduction to next generation nuclear reactor concepts and ideas, including hydrogen fusion and advanced fission (e.g. GenIV) reactors.

### Learning Outcomes

On successful completion of this module you will be able to:

- Justify need for new energy sources
- Analyse quantitatively the principles of hydrogen fusion power generation, including the materials used, and the practicalities of producing a power plant.
- Synthesise information about new technologies being developed for the next generation of nuclear power generation
- Synthesise information about fuels for the next generation of nuclear power plants

### Module Content

#### *Fusion reactions: cross sections and reactivity*

- The origin of fusion energy in terms of the nuclear forces and the energy yield from a given fusion reaction.
- The requirements for fusion reactors.
- Fusion cross-sections and reactivity for the most promising fusion reactions i.e. DT, DD, DHe3 and pB.
- Magnetic and inertial approaches to fusion.
- The  $nTt$  formula.
- Fusion triple product and link to energy gain.

#### *Magnetic confinement systems*

- Particle motion in electromagnetic fields and drifts in tokamak plasmas.
- Magnetic configuration required for confinement
- Stationary equilibrium.
- Heating mechanisms
- Modes of plasma operation

### *Physics and fusion reactor systems*

- Instability
- MHD equations and stability calculations.
- Confinement time, specifically classical and turbulent confinement.
- Plasma diagnostics
- The main challenges for ITER.

### *Materials for Fusion*

- The choice of fusion materials, fusion and fission needs, and the key differences.
- Transmutation effects, low activation materials, and technological constraints associated with fusion irradiation environment.
- Structural, plasma-facing, and functional materials.
- Materials for fusion applications, and implications for power plant design and economics
- Current status of fusion materials development and its future objectives

### *Fusion materials and engineering*

- The primary requirements of a fusion breeder blanket.
- How we achieve tritium self-sufficiency
- How to extract energy from a fusion power plant
- Breeder blanket concepts and designs (primary focus on ITER-TBM and DEMO programmes)
- Structural materials for a fusion power plant – design considerations, performance and optimisation
- Neutron multiplier and breeder materials
- Coolant material selection and corrosion protection

### *Advanced reactors*

- The current fleet, new build, and next generation scenarios
- The benefits of advanced reactor designs, including modular technologies and next generation manufacturing
- The benefits, problems and opportunities for each of GenIV reactor technologies (thermal reactors and fast reactors)

### *Options for Nuclear Power Generation*

- Fundamentals of different power conversion/generation cycles
- The advantages and disadvantages of related power-generation options, and their ranges of applicability with an emphasis on scale and temperature
- The performance of different power-conversion technologies

### *Small and Advanced Modular Reactors*

- The range of small reactor types
- The economic case for modularity in nuclear engineering
- The social, political and licensing implications of modular nuclear reactors in a global landscape

#### *Accident tolerant fuels for the future*

- Current fuel and cladding for PWR and BWR and their behavior under severe accident conditions such as that at Fukushima
- The near term cladding solutions such as Cr coated Zr cladding or FeCrAl cladding
- The future fuel cladding concepts such as SiC/SiC, its manufacture, performance under both accident and normal operational conditions
- The advantages/disadvantages of fuel designs for high temperature Gen IV reactors such as those for pebble bed reactors.

### Learning and Teaching Approach

Lectures are combined with independent reading and problem classes to learn about fusion and next generation fission power generation. The assessments encourage independent learning through problem solving and learning and synthesising of new information.

### Assessment Strategy

Quantitative understanding of fusion power generation is assessed by means of coursework composed of a set of mathematical problems. Integrated knowledge of components of a fusion power plant is assessed through an infographic and short essay. Integrated knowledge about next generation fission technology is assessed through three pieces of coursework: two combine one infographic and an accompanying short essay (500 words), while the third consists of two short essays of 800 words. In each case reading of additional information is required, together with synthesis of the information found.

### Feedback

Written summative feedback is provided with the four written pieces of coursework. Verbal formative feedback is provided in workshops.

### Reading List

#### Optional reading:

- *Physics of Plasmas* by Boyd and Sanderson CUP
- K. Linga Murty and Indrajit Charit, *An introduction to nuclear materials*, Wiley, 2013
- *Fusion, the Energy of the Universe*, McCracken, Stott, Academic Press.
- *Tokamaks*, Wesson, OUP.
- Judd, A. M. "An Introduction to the Engineering of Fast Nuclear Reactors", CUP, Cambridge 2014
- Waltar, A. E., D. R. Todd & P. V. Tsvetkov "Fast Spectrum Reactors", Springer, New York 2012

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

## MATE70022 Fusion and Advanced Reactors – Fusion problem sheet 1 Coursework Information

Assessment Name:	Fusion problem sheet 1
Academic:	Dr Chris Ham
Submission:	Blackboard Learn
Self-study hours:	5 hours
Assignment details:	Solve the five problems related to plasma physics using the material given in the lectures as well as information in the literature sources and standard textbooks on electromagnetism. The solutions are expected to be as detailed as possible and should provide the mathematical details of the derivations

### Rubric:

Item name/number	Value	Description of marking
Fusion problem sheet 1 (C. Ham)	34	Marks are awarded with the breakdown as indicated on the question sheet

## MATE70022 Fusion Advanced Reactors – Fusion problem sheet 2 Coursework Information

Assessment Name:	Fusion problem sheet 2
Academic:	Prof. Sergei Dudarev
Submission:	Blackboard Learn
Self-study hours:	5 hours
Assignment details:	Solve the three problems given after the lectures, using the material given in the lectures as well as information in the literature sources also mentioned in the lectures. The solutions are expected to be as detailed as possible and should provide the mathematical details of the derivations. The originality of the solutions, including the clear difference in the line of thought and approach from the solutions given by other students in the group, is going to be treated as an additional positive factor in the assessment.

### Rubric:

Item name/number	Value	Description of marking
Fusion problem sheet 2 (S Dudarev)	33	Marks are awarded with the breakdown as indicated on the question sheet

## MATE70022 Fusion and Advanced Reactors – Fusion problem sheet 3 Coursework Information

Item name/number	Value	Description of marking
Fusion problem sheet 3 (D. Bowden) -- Infographic	60	Produce an infographic of your favourite breeder blanket concept
Fusion problem sheet 3 (D. Bowden) -- Text	40	Write a short essay (up to 500 words) on a material of your choice from this concept. Highlight the performance of the chosen material in its environment, covering the pros, cons, and opportunity for development.

### Rubric:

Assessment Name:	Fusion problem sheet 3
Academic:	David Bowden
Submission:	Blackboard Learn
Self-study hours:	5 hours
Assignment details:	Produce an infographic of your favourite breeder blanket concept and write a short essay (up to 500 words) on a material of your choice from this concept. Highlight the performance of the chosen material in its environment, covering the pros, cons, and opportunity for development.

## MATE70022 Fusion and Advanced Reactors – Advanced Reactors 1 Coursework Information

Assessment Name:	Advanced Reactors 1
Academic:	Robin Grimes
Submission:	Blackboard Learn
Self-study hours:	5 hours
Assignment details:	Select one GenIV reactor design and: Create of an Infographic (60% marks available). Assessed on: visual appeal; content (facts/depth/breadth); range of sources Writing (up to 500 words) on the topic with a brief history, progress, and opportunities. Assessed on: content, written style, and referencing (references are not included in the word count)

### Rubric:

Item name/number	Value	Description of marking
Advanced Reactors 1 (R. Grimes) -- Infographic	60	The content of the infographic will be assessed based upon the visual appeal, content, and range of sources used.
Advanced Reactors 1 (R. Grimes) -- Text	40	Candidates are expected to write (up to) 500 words on the topic. This part of the assignment will be assessed based upon content, written style, and references used (references do not count towards the word count).



## MATE70022 Fusion and Advanced Reactors – Advanced Reactors 2 Coursework Information

Assessment Name:	Advanced Reactors 2
Academic:	Dr Mike Bluck
Submission:	Blackboard Learn
Self-study hours:	5 Hours
Assignment details:	Select one small/advanced modular reactor design and: Create of an Infographic (60% marks available). Assessed on: visual appeal; content (facts/depth/breadth); range of sources Writing (up to) 500 words on the topic with a brief history, progress and opportunities (technical and economic). Assessment based on: content, written style, and referencing (references are not included in the word count)

### Rubric:

Item name/number	Value	Description of marking
Advanced Reactors 2 (M. Bluck) -- Infographic	60	The content of the infographic will be assessed based upon the visual appeal, content, and range of sources used.
Advanced Reactors 2 (M. Bluck) -- Text	40	Candidates are expected to write (up to) 500 words on the topic. This part of the assignment will be assessed based upon content, written style and references used (references do not count towards the word count).

## MATE70022 Fusion and Advanced Reactors – Advanced Reactors 3 Coursework Information

Assessment Name:	Advanced Reactors 3
Academic:	Dr Mark Wenman
Submission:	Blackboard Learn
Self-study hours:	5 Hours
Assignment details:	Answer in essay form 2 of the questions/discussion points discussed in class on ATF and future fuel systems. Each is expected to be approx. 800 words in length and contain suitable references, figures and tables if required.

### Rubric:

Item name/number	Value	Description of marking
Advanced Reactors 3 (M.Wenman) -- Style	25	Written style and presentation, including use of English.
Advanced Reactors 3 (M.Wenman) -- References	25	References and use thereof

Advanced Reactors 3 (M.Wenman) -- Content	25	Scientific content
Advanced Reactors 3 (M.Wenman) -- Discussion	25	Discussions and conclusions

## Appendix B - Academic Staff List

Name	Initials	Room	Email
<b>Head of Department</b>			
Prof Peter Haynes	PDH	2.01c	p.haynes@imperial.ac.uk
<b>Academic Staff</b>			
Prof Neil Alford	NMA	2.05	n.alford@imperial.ac.uk
Dr Stefano Angioletti-Uberti	SAU	1.08	s.angioletti-uberti07@imperial.ac.uk
Dr Florian Bouville	FB	LM04a	f.bouville@imperial.ac.uk
Dr Ben Britton	BB	B301	b.britton@imperial.ac.uk
Dr Andrew Cairns	AC	2.03D	a.cairns@imperial.ac.uk
Dr Iain Dunlop	ID	1.02	i.dunlop@imperial.ac.uk
Prof Fionn Dunne	FD	1.04	fionn.dunne@imperial.ac.uk
Prof David Dye	DD	1.09	david.dye@imperial.ac.uk
Prof Mike Finnis	MWF	2.27b	m.finnis@imperial.ac.uk
Dr Paul Franklyn	PF	G.03B	p.franklyn@imperial.ac.uk
Dr Baptiste Gault	BG		b.gault@imperial.ac.uk
Dr Theoni Georgiou	TG	1.05	t.georgiou@imperial.ac.uk
Dr Finn Giuliani	FG	LM04D	f.giuliani@imperial.ac.uk
Prof Christopher Gourlay	CG	B301D	c.gourlay@imperial.ac.uk
Prof Robin Grimes	RWG	B303C	r.grimes@imperial.ac.uk
Prof Sandrine Heutz	SH	B336	s.heutz@imperial.ac.uk
Prof Andrew Horsfield	APH	B331	a.horsfield@imperial.ac.uk
Dr Robert Hoye	RH	2.27	r.hoye@imperial.ac.uk
Prof Julian Jones	JRJ	2.07	julian.r.jones@imperial.ac.uk
Prof John Kilner	JAK	2.14	j.kilner@imperial.ac.uk
Prof Norbert Klein	NK	2.01c	n.klein@imperial.ac.uk
Dr Johannes Lischner	JL	B342	j.lischner@imperial.ac.uk
Dr Katharina Marquardt	KM	301b	k.marquardt@imperial.ac.uk
Dr Cecilia Mattevi	CM	2.11	c.mattevi@imperial.ac.uk
Prof Martyn McLachlan	MAM	401H	martyn.mclachlan@imperial.ac.uk
Prof Arash Mostofi	AAM	B332	a.mostofi@imperial.ac.uk
Dr Mark Oxborrow	MO	2.04	m.oxborrow@imperial.ac.uk
Prof David Payne	DP	2.09	d.payne@imperial.ac.uk
Dr Stella Pedrazzini	SP	1.18	s.pedrazzini@imperial.ac.uk
Dr Minh-Son Pham	M-SP	B301F	son.pham@imperial.ac.uk

Prof Alexandra Porter	AEP	B341	a.porter@imperial.ac.uk
Prof Jason Riley	DJR	B3.37	jason.riley@imperial.ac.uk
Prof Mary Ryan	MPR	B338	m.p.ryan@imperial.ac.uk
Prof Eduardo Saiz Gutierrez	ES	LM04.B	e.saiz@imperial.ac.uk
Prof Milo Shaffer	MS	401B	m.shaffer@imperial.ac.uk
Prof Stephen Skinner	SJS	2.06	s.skinner@imperial.ac.uk
Dr Ifan Stephens	IS		i.stephens@imperial.ac.uk
Prof Molly Stevens	MMS	2.08	m.stevens@imperial.ac.uk
Dr Paul Tangney	PT	B330	p.tangney@imperial.ac.uk
Prof Luc Vandeperre	LV	LM.04C	l.vandeperre@imperial.ac.uk
Prof Aron Walsh	AW	2.10	a.walsh@imperial.ac.uk
Dr Mark Wenman	MW	B301A	m.wenman@imperial.ac.uk
Prof Roger Whatmore	RW		r.whatmore@imperial.ac.uk
Dr Fang Xie	FX	1.03	f.xie@imperial.ac.uk

#### Teaching Fellows

Dr Eleanora D'Elia	ED	G04	eleonora.delia10@imperial.ac.uk
Dr Jonathan Rackham	JCR	G04	j.rackham14@imperial.ac.uk
Dr Priya Saravanapavan	PS	G04	p.pavan@imperial.ac.uk
Dr Manjula Silva	MS	G04	k.silva@imperial.ac.uk

#### Technicians

Mr Ben Chan	BC	G04	b.chan@imperial.ac.uk
Mr Greg Casson	GC	G04	g.casson@imperial.ac.uk

#### Student Support

TBC	KLK	G03C	@imperial.ac.uk
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#### Student Office Team

Mrs Raj Adcock	RA	G03A	raj.adcock@imperial.ac.uk
Miss Francesca Williams	FW	G03A	f.williams@imperial.ac.uk
Miss Harpreet Rajbans	HR	G03A	h.rajbans@imperial.ac.uk
Miss Karolina Pielacha	KP	G03A	k.pielacha@imperial.ac.uk

## Appendix C - Research Integrity

Research integrity is about your research practices, how you present the findings of your research and how your research impacts on society and the wider world. At Imperial College London, you will work with internationally renowned academic staff who will guide you to design rigorous, robust, and reproducible research methods. This will ensure that your research is lawful and that any adverse impact your research may have on society, natural environment, or animals is justified and minimised. Research integrity is also about presenting the findings of your research in a responsible manner.

The College has adopted the Council for Science and Technology's Universal Ethical Code for Scientists and upholds its three principles, which are:

- Rigour, Honesty and Integrity
- Respect for Life, the Law and the Public Good
- Responsible Communications: Listening and Informing

**The primary way to ensure research integrity is to promote and maintain a culture of honesty, openness and responsibility.** To this end, the Graduate School has the following professional development opportunities available to postgraduate students:

- Plagiarism Awareness, **mandatory** for both Master's and Doctoral students

This online course was developed by the Graduate School, in conjunction with the Library. It aims to equip you with a working knowledge of the concept of plagiarism and how to avoid it. It also aims to provide you with information to enable you to use and share information ethically, with academic integrity and in accordance with [Imperial College's Examination & Assessment: Academic Integrity Policy](#).

- Copyright for Researchers (Doctoral)

This course aims to equip you with a working knowledge of copyright and licencing so that in your career you can use and share information in a copyright safe way. The course has activities and discussions to give you the opportunity to practice the knowledge and skills acquired through context-based scenarios and examples. You are recommended to share your reflections on the digital canvases throughout the course. This will give you a chance to elaborate what you have learnt in the readings, share examples and challenge your understanding by interacting with your peers.

- Intellectual Property (Doctoral)

This course aims to equip you with a working knowledge of the concept of Intellectual Property (IP), and an awareness and understanding of the basic principles surrounding IP rights, such as patents, copyright, design rights and other forms of IP. An understanding of IP and its application is important for all students; for those intending to continue in academia as well as those intending to enter the commercial world after graduation.

- Introduction to Making your Thesis Open Access (Doctoral)

This workshop will provide a general introduction to open access, with specific reference to the PhD thesis, and related research outputs that may arise from PhD study. You will be introduced to: open access repositories, open access publishing and online support tools such as the Directory of Open Access Journals and Open access button. You will also be provided with the opportunity to discuss Creative Commons licences, the re-use of third-party copyright materials in your thesis and why your thesis is made open access.

- Data Management (Doctoral)

Data is a key research asset, underpinning almost all published research conclusions. In recent years, new technology has enabled us to:

1. Generate and record far more data than ever before; and
2. Share, reuse and combine that data in new ways to generate new insights.

Research data is increasingly a first-class research output, and a little bit of planning will enable you to take advantage of this shift. This course will highlight key considerations and help you to assess when it is appropriate to share your data and how to write a data management plan.

This workshop is supported by a webinar on Research Data Management Plans which covers some of the more practical elements of research data management and will help students to create their own data management plans.

- Science, Research and Integrity (Doctoral)

This workshop is designed to give you a chance to explore and critically analyse the ethics of scientific research in a constructive way. We will critically discuss the structure and implications of specific cases of scientific fraud and will also look at different moral theories and how they might apply not only to specific moral dilemmas, but also to science in general. The session will aim to forewarn you by providing a safe environment within which to formulate and articulate your own views on how you might deal with the sorts of dilemmas you are likely to face during your career.

### **The San Francisco Declaration on Research Assessment (DORA)**

The College has signed the San Francisco Declaration on Research Assessment (DORA). The ethos behind DORA is to improve the ways in which the output of scientific research is evaluated by funding agencies, academic institutions, and other parties. The outputs from scientific research are many and varied, including: research articles reporting new knowledge, data, reagents, and software; intellectual property; and highly trained young scientists. Funding agencies, institutions that employ scientists, and scientists themselves, all have a desire, and need, to assess the quality and impact of scientific outputs. It is thus imperative that scientific output is measured accurately and evaluated wisely.

As such the College has signalled that it will assess research based on quality rather than where it is published, for example journal impact factor. The Graduate School promotes the ethos behind DORA at the following professional development workshops:

- Writing for publication
- How to be an effective researcher
- Global Research Impact and Influence retreat
- Finish Up Move On
- Impact in academia webinars
- Understanding the reviewer

References:

[The San Francisco Declaration on Research Assessment](#) DORA [accessed 26.06.20]

[The UK Concordat to Support Research Integrity – Universities UK](#) [accessed 26.06.20]

[The Universal Ethical Code for Scientists](#) [accessed 26.06.20]

[The European Code of Conduct for Research Integrity](#) – ALLEA (All European Academies) [accessed 20.06.20]