Materials Science and Engineering (MEng)
Biomaterials and Tissue Engineering (MEng)
Materials with Nuclear Engineering (MEng)
Materials Science and Engineering (BEng)
Materials with Management (BEng)
Introduction

This handbook contains specific information for the Year 3 students in the 2018-2019 cohort, including the module details and assessment deadlines and year composition for this academic year. It is to be used in conjunction with the General Handbook for all students for full regulations and guidance on the undergraduate programmes in the Department of Materials.

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1. Welcome from Year Co-ordinators

Dr Jonathan Rackham
Room: G04 RSM
Tel: +44 (0) 20 7594 1782
Email: j.rackham14@imperial.ac.uk

Welcome back everyone! This is the year where you can start following your own interests within Material Science and Engineering, so take a deep breath and dive on in. For some of you, this year is also the culmination of your studies here in the Department of Materials, so grasp every opportunity you have to shine! The expectations of independence also increase this year, especially in the Design Study. This expectation will only increase next year, so take this year as a chance to enjoy how it feels. Some of you will also be looking further ahead towards careers, so keep your eyes open for opportunities at the Careers Fairs!

As your Year Co-ordinator I am your first point of contact for any issues you have relating to your studies. I will be meeting regularly with your student representatives and will work with them to make your Year 3 experience a smooth one. I am also responsible for ensuring you receive consistent and accurate information about your coursework, exams and expectations throughout the year, so do not hesitate to contact me with any queries you may have!

Good luck!

2. Programme Information

Key dates 2019–20

Please note that academic activities will take place from the beginning of each term and can run to the last day of term. Therefore, do not plan travel inside the term dates.

<table>
<thead>
<tr>
<th>Term Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autumn term: 28 September 2019 - 13 December 2019</td>
</tr>
<tr>
<td>Spring term: 4 January 2020 - 20 March 2020</td>
</tr>
<tr>
<td>Summer term: 25 April 2020 - 26 June 2020</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Closure Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Christmas/New year: 23 December 2020 – 1 January 2020 (College reopens on 2 January 2020)</td>
</tr>
<tr>
<td>Easter Holiday: 9 April 2020 – 14 April 2020 (College reopens on 15 April 2020)</td>
</tr>
<tr>
<td>Early May Bank Holiday: 8 May 2020</td>
</tr>
<tr>
<td>Spring Bank Holiday: 25 May 2020</td>
</tr>
<tr>
<td>Summer Bank Holiday: 31 August 2020</td>
</tr>
</tbody>
</table>
Year structure

3rd year comprises 2 core modules (marked with a ** below) and 5 elective modules. All potential modules are listed below along with the relative module weighting in the year structure. Not all modules are always available and some modules are linked to specific degree structures and are not generally available. There are additional fixed programme (nuclear and management) courses that will each count 10% to the year structure and Horizons/Business modules that can also be taken.

** MATE96001 (MSE 301) Integrated Materials Engineering Portfolio 40%
** MATE96002 (MSE 302) Materials Characterisation 10%
MATE96003 (MSE 307) Engineering Alloys 10%
MATE96004 (MSE 308) Ceramics and glasses 10%
MATE96005 (MSE 309) Polymers and composites 10%
MATE96006 (MSE 310) Electronic structure and Optoelectronics 10%
MATE96007 (MSE 312) Nanomaterials 1 10%
MATE96008 (MSE 315) Biomaterials 10%
MATE96009 (MSE 317) Modelling of Materials Processing and Performance 10%
MATE96010 (MSE318) Surfaces and Interfaces* 10%
BS0806 Entrepreneurship (BEng Man) 10%
BS0802 Innovation management (BEng Man) 10%

*Not on offer in 2019-2020

Progression

Progression from year 3 requires passing every module with a minimum of 40%
Placement

If you are on the MEng degree awards, your 12-week work placements will take place at the end of year 3 during the summer break. There will be a series of talks/ careers fairs/ tutorials to help you with finding a suitable placement.

Placement Co-ordinator
Dr Minh-Son Pham
Room: B301F, 3rd Floor, Bessemer Building, South Kensington Campus
Tel: +44 20 7594 9529
Email: son.pham@imperial.ac.uk

There are 2 pathways:

1. Option of NOT taking a placement – awarded MEng in Materials Science and Engineering (240 ECTS). Your degree will not be Bologna Compliant. However, the degree is still an accredited IOM3 engineering qualification.

2. Option of taking minimum 12-week placement – awarded MEng in Materials Sciences and Engineering with Placement (270 ECTS). This will mean their degree is Bologna compliant and is also an accredited IOM3 engineering qualification.

The Department MUST be notified of your intention no later than 19th June 2020. No changes will be possible after this date.

When you have completed your placement, at the beginning of your 4th year, you will need to submit a report as well as do a presentation.

<table>
<thead>
<tr>
<th>Assignment Name</th>
<th>Work placement Report and Presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic in Charge</td>
<td>Dr. Minh-Son Pham</td>
</tr>
</tbody>
</table>
| Deadline date                 | Report: 08/10/2020
|                               | Presentation: 13th, 15th, 16th Oct 2020 |
| Percentage of the module total| 10% including 5% - Report and 5% - Oral presentation |

**Assignment details**

**Report:**
The nature of work carried out on work placements varies considerably and it is expected that this will be reflected in the placement reports. There are, therefore, no rigid requirements for the contents of the report. The report, however, is expected to be about 2,000 words in length. The aim of the report is to convey what you did during your placement, why it was interesting and/or important, and what was learned from the experience.

**Presentation:**
You need to give an oral presentation about your work placement. The presentation consists of 10 minutes for slides and 5 minutes for questions and answers. Your presentation will be evaluated on the basis of overall structure, timekeeping, quality of presentation slides/figure, technical content, and quality of explanations and answers.
**MIT Placements**

The Department has an exchange agreement with MIT. The agreement allows up to five students to study at MIT; four students on summer placements, and one student completing the Autumn semester in the Department of Materials or the Department of Nuclear Science and Engineering. It is not possible for a student to take both a summer placement and spend a semester at MIT.

Students must apply in Autumn term and are selected on the following basis:
+ Fit to the host Departments at MIT.
+ Their year 1 and 2 performance.
+ Their marks achieved in year 3 up until the time of selection.
+ References from Personal and Senior Tutor, note the department will approach the individuals for references.

Students on the MEng Bio are not eligible for term time studies at MIT due to their core course requirements.

The term time exchanges run from the beginning of the MIT autumn term and for the duration of that term. The department will assist with funding for flights, visa or health insurance costs. Students doing a project at MIT in the summer are awarded a bursary for the period of the placement, presently £630 per week. The student at MIT in term time is supported such that they will not be financially disadvantaged by studying at MIT.

The student spending the Autumn term at MIT will need to do 2 modules at MIT for credit and these will need to be approved by the DUGS. The remaining 2 modules must be done at Imperial and would normally come from the Spring term offering. The selected student is expected to start a research project at MIT and where possible transfer the work to Imperial having identified a suitable supervisor. The department placement coordinator can help in matching up students to projects at MIT but students would be expected to be the link between MIT and Imperial supervisors after that time. The student spending the Autumn at MIT who is following the MEng with Placement programme will be expected to submit a work placement report at the normal time but will do their Placement Presentation on return to Imperial. Students who complete a summer placement will be assessed at the same time as the rest of the cohort.

The mark conversion between MIT and the Department of Materials is agreed as follows:

<table>
<thead>
<tr>
<th>Grade</th>
<th>MIT Mark Range</th>
<th>Imperial Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>A+</td>
<td>85-100</td>
<td>92.5</td>
</tr>
<tr>
<td>A</td>
<td>70-84</td>
<td>77</td>
</tr>
<tr>
<td>A-</td>
<td>67-69</td>
<td>68</td>
</tr>
<tr>
<td>B+</td>
<td>63-66</td>
<td>64.5</td>
</tr>
<tr>
<td>B</td>
<td>60-62</td>
<td>61</td>
</tr>
<tr>
<td>B-</td>
<td>57-59</td>
<td>58</td>
</tr>
<tr>
<td>C+</td>
<td>53-56</td>
<td>54.5</td>
</tr>
<tr>
<td>C</td>
<td>50-52</td>
<td>51</td>
</tr>
<tr>
<td>C-</td>
<td>47-49</td>
<td>48</td>
</tr>
<tr>
<td>D</td>
<td>40-46</td>
<td>43</td>
</tr>
<tr>
<td>F</td>
<td>&lt;40</td>
<td>30</td>
</tr>
</tbody>
</table>
3. Course work Deadlines

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.

<table>
<thead>
<tr>
<th>Term</th>
<th>Module</th>
<th>Assignment/Event</th>
<th>Due Date</th>
<th>Format</th>
<th>Feedback/Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autumn</td>
<td>MATE96002 (MSE 302)</td>
<td>XRD Classwork</td>
<td>End of your classwork session</td>
<td>Hardcopy</td>
<td>2 weeks (after all sessions have be held)*</td>
</tr>
<tr>
<td></td>
<td>MATE96002 (MSE 302)</td>
<td>Introductory Lab Sessions</td>
<td>Day after your lab session, 15:00 (depends on your lab group)</td>
<td>Electronically via Blackboard Learn</td>
<td>2 weeks*</td>
</tr>
<tr>
<td></td>
<td>MATE96001 (MSE 301)</td>
<td>Design Study – Initial GANTT Chart</td>
<td>16:00 10/10/2019</td>
<td>Group submission via Blackboard Learn</td>
<td>Next day</td>
</tr>
<tr>
<td></td>
<td>MATE96001 (MSE 301)</td>
<td>Design Study – Concept Design Report</td>
<td>Design Office Deadline: 16:00 14/11/2019 Company Deadline: 16:00 21/11/2019</td>
<td>Group submission electronically via Blackboard Learn</td>
<td>1 week</td>
</tr>
<tr>
<td></td>
<td>MATE96001 (MSE 301)</td>
<td>Design Study – Presentation of Concepts</td>
<td>13:00 13/12/2019</td>
<td>Oral</td>
<td>Same day</td>
</tr>
<tr>
<td></td>
<td>MATE96003 (MSE 307)</td>
<td>Coursework: Class based Assignment</td>
<td>15:00 12/12/2019</td>
<td>Electronically via Blackboard Learn</td>
<td>3 weeks*</td>
</tr>
<tr>
<td>Spring</td>
<td>MATE96002 (MSE 302)</td>
<td>Lab Report</td>
<td>15:00 14/01/2020</td>
<td>Electronically via Blackboard Learn</td>
<td>4 weeks*</td>
</tr>
<tr>
<td></td>
<td>MATE96009 (MSE 317)</td>
<td>Problem set 1</td>
<td>15:00 30/01/2020</td>
<td>Electronically via Blackboard Learn</td>
<td>2 weeks*</td>
</tr>
<tr>
<td></td>
<td>MATE96001 (MSE 301)</td>
<td>Design Study – Integrated proto-type test day</td>
<td>5/02/2020</td>
<td>Oral</td>
<td>Same day</td>
</tr>
<tr>
<td></td>
<td>MATE96001 (MSE 301)</td>
<td>Design Study – Technical drawing and letter</td>
<td>Group deadline: 16:00</td>
<td>Individual and Group</td>
<td>1 week</td>
</tr>
<tr>
<td>Course Code</td>
<td>Title</td>
<td>Submission Date(s)</td>
<td>Method of Submission</td>
<td>Feedback Mark Timeframe</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>-------</td>
<td>--------------------</td>
<td>----------------------</td>
<td>------------------------</td>
<td></td>
</tr>
<tr>
<td>MATE96009 (MSE 317)</td>
<td>Problem set 2</td>
<td>15:00 20/02/2020</td>
<td>Electronically via Blackboard Learn</td>
<td>2 weeks*</td>
<td></td>
</tr>
<tr>
<td>MATE96001 (MSE 301)</td>
<td>Literature Review</td>
<td>15:00 03/03/2020</td>
<td>Electronically via Blackboard Learn</td>
<td>2 weeks*</td>
<td></td>
</tr>
<tr>
<td>MATE96009 (MSE 317)</td>
<td>Problem set 3</td>
<td>15:00 05/03/2020</td>
<td>Electronically via Blackboard Learn</td>
<td>2 weeks*</td>
<td></td>
</tr>
<tr>
<td>MATE96001 (MSE 301)</td>
<td>Materials Engineering Portfolio</td>
<td>15:00 19/03/2020</td>
<td>Electronically via Blackboard Learn</td>
<td>1 Week*</td>
<td></td>
</tr>
<tr>
<td>MATE96001 (MSE 301)</td>
<td>Design Study – Final Design Report</td>
<td>Design Office deadline: 16:00 12/03/2020 Company Deadline: 16:00 19/03/2020</td>
<td>Individual and Group submission electronically via Blackboard Learn</td>
<td>3 weeks</td>
<td></td>
</tr>
<tr>
<td>MATE96001 (MSE 301)</td>
<td>Design Study – Parts List, Final Technical Drawings, Fabrication Record and Peer Marking Contribution</td>
<td>Company Deadline: 16:00 19/03/2020</td>
<td>Group submission electronically via Blackboard Learn</td>
<td>3 weeks</td>
<td></td>
</tr>
<tr>
<td>MATE96001 (MSE 301)</td>
<td>Design Study – Group Defence</td>
<td>Company Deadline: 11&amp;12/06/2020</td>
<td>Oral</td>
<td>Same day</td>
<td></td>
</tr>
<tr>
<td>MATE96001 (MSE 301)</td>
<td>Design Study – Integrated test day and Final presentation</td>
<td>Company Deadline: 15&amp;16/06/2020</td>
<td>Group submission electronically via Blackboard Learn</td>
<td>3 weeks</td>
<td></td>
</tr>
</tbody>
</table>

* The above dates do not include the Student Office processing time which can be up to additional 5 working days on top of the estimated feedback/mark timeframe.
## Exam Timetable

<table>
<thead>
<tr>
<th>Day</th>
<th>AM</th>
<th>Lunch</th>
<th>PM</th>
<th>Lunch</th>
<th>PM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monday</strong></td>
<td></td>
<td></td>
<td></td>
<td>302</td>
<td></td>
</tr>
<tr>
<td><strong>Tuesday</strong></td>
<td></td>
<td></td>
<td>308</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Wednesday</strong></td>
<td></td>
<td></td>
<td>315</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Thursday</strong></td>
<td></td>
<td></td>
<td>312</td>
<td>Mitigation Board</td>
<td></td>
</tr>
<tr>
<td><strong>Friday</strong></td>
<td>Bank Holiday</td>
<td></td>
<td></td>
<td>309</td>
<td>310</td>
</tr>
</tbody>
</table>

### Exams 2020

<table>
<thead>
<tr>
<th>Wk 31</th>
<th>Wk 32</th>
<th>Wk 33</th>
<th>Wk 34</th>
<th>Wk 35</th>
<th>Wk 36</th>
<th>Wk 37</th>
<th>Wk 38</th>
</tr>
</thead>
<tbody>
<tr>
<td>27th Apr</td>
<td>4th May</td>
<td>11th May</td>
<td>18th May</td>
<td>25th May</td>
<td>1st June</td>
<td>8th June</td>
<td>15th June</td>
</tr>
</tbody>
</table>

- **Bank Holiday**
- **Teaching Committee**
- **Mitigation Board**

**27th Apr**: Bank Holiday
**8th June**: Teaching Committee
4. Module Information

MATE96001 (MSE 301) Integrated Materials Engineering Portfolio

**Core: For all BEng/MEng programmes**

**Module Leaders:** Luc Vandeperre and Jason Riley

**Module Breakdown:**

MATE96001 module includes the Design Study, the Literature Review, BPES BS0850 Managerial Economics, Materials Engineering Portfolio and the Comprehensive Exam at the end of the year.

<table>
<thead>
<tr>
<th>% Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literature Review</td>
</tr>
<tr>
<td>BPES BS0850 Managerial Economics</td>
</tr>
<tr>
<td>Design Study</td>
</tr>
<tr>
<td>Materials Engineering Portfolio</td>
</tr>
<tr>
<td>Comprehensive Exam</td>
</tr>
</tbody>
</table>

Further details of the design study and associated due dates are on a separate handbook which will be issued to you during the introductory lecture by Prof Luc Vandeperre during the Freshers Week.

**Literature review information form**

<table>
<thead>
<tr>
<th>Module code</th>
<th>MATE96001 (MSE 301)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of Study</td>
<td>3rd year</td>
</tr>
<tr>
<td>Assignment Name</td>
<td>Literature Review</td>
</tr>
<tr>
<td>Academic in Charge</td>
<td>Prof Jason Riley</td>
</tr>
<tr>
<td>When the assignment is presented to the students</td>
<td>First week of Spring term</td>
</tr>
<tr>
<td>Method of submission</td>
<td>Blackboard Learn</td>
</tr>
<tr>
<td>Student’s self-study hours</td>
<td>e.g. 10-15 hours of self-study required</td>
</tr>
<tr>
<td>Deadline date</td>
<td>Tuesday 3rd March 2020 3pm</td>
</tr>
<tr>
<td>Percentage of the module total</td>
<td>5%</td>
</tr>
<tr>
<td>Estimated marking/feedback time</td>
<td>2 weeks marking time (administrative process time will be added on additionally)</td>
</tr>
<tr>
<td>Turn-it-in requirement</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Assignment details**

Students are required to research the scientific literature on a topic assigned by their supervisor and to write a literature review as would be suitable for a review article for a journal or as the literature introduction to a thesis/project. Students should gain the skills for finding literature sources, distilling that information and presenting in a well referenced form. The submission needs to reflect the students work and the referencing and any plagiarism is taken very seriously in this exercise: it should not be about “beating” turn-it-in, but about following good literature review guidelines.

**Other requirements**

These will be as dictated by the supervisor but should not exceed 2500 words.
Rubric:
Year 3 Literature Review

Macro Structure /10
- Clear and informative title
- Divided into appropriate sections (Abstract, Intro, etc.)
- Headings and sub-headings informative
- References complete and correctly cited in text and list of references

Micro Structure/90

Abstract /5
- Concise
- Outlines aim of review, findings and conclusions

Introduction /10
- Introduces topic
- Clear, logical progression from title to aims of review
- Aims/hypotheses well-formulated

Results & Discussion /30
- Clear description of any sub-division of the task
- Summary of main findings
- Appropriate use of tables/figures
- Clarity and content of tables/figures
- Appropriate analysis/exploration of data from literature
- Clear statement of main findings,
- Findings related to aims/hypotheses
- Sensible/logical conclusions drawn based on literature
- Any limitations/challenges identified and discussed
- Implications of review in relation to the question set
- Suggestions for improvement/future research

Content /20
- Appropriate literature used
- Quality of literature e.g. peer-review vs websites
- Information taken from a variety of sources- not other reviews
- Use of any additional resources e.g. government reports

Originality /10
- Evidence of independent and original thought throughout review

Style/15
- Ideas clearly and concisely expressed
- Good punctuation and spelling
- Paragraphs used in a clear way to support reading comprehension
- Clear presentation of dissertation (fonts, margins, etc.)
- Good use of English and grammar
- Figures and tables well-formatted
- Within 2500 word limit ± 10%

TOTAL /100
Materials engineering portfolio information form

<table>
<thead>
<tr>
<th>Module code</th>
<th>MATE96001 (MSE 301)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of Study</td>
<td>3rd year</td>
</tr>
<tr>
<td>Assignment Name</td>
<td>Materials Engineering Portfolio</td>
</tr>
<tr>
<td>Academic in Charge</td>
<td>Dr Paul Franklyn</td>
</tr>
<tr>
<td>When the assignment is presented to the students</td>
<td>First week of Autumn term</td>
</tr>
<tr>
<td>Method of submission</td>
<td>Blackboard Learn</td>
</tr>
<tr>
<td>Student’s self-study hours</td>
<td>1-2 hours (it should be prepared through other components and simply require compilation)</td>
</tr>
<tr>
<td>Deadline date</td>
<td>Thursday 19th March 2023 3pm</td>
</tr>
<tr>
<td>Percentage of the module total</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Assignment details

Each student should prepare an Engineering Portfolio of their individual work in a manner consistent with how work would be recorded and presented for achievement of professional qualification using the CEng model as a reference. To this end, they should include a reflective commentary of about one-page summarising how these activities have developed their engineering skills and analysing where further skill development would be beneficial. The portfolio should contain at a minimum:

1. The reflective summary
2. Updated curriculum vitae
3. An updated personal development plan
4. The literature review
5. The individual design section from the technical design study
6. Examples showing the individual contributions to the team efforts

Where students have carried out activities outside the required curriculum to develop their engineering skills, they are advised to include these for future reference. Students can take the majority of these exercises from previous submissions and should cover each item with their personal tutor between years 1 and 3.

Other requirements

No specific format is dictated and no limit is placed on length. Students should note that the item is recorded, checked and noted, but that the mark is 0 or 100% and the submission is compulsory. This is a document you may require later in your professional career, please consider how best you can present the information such that it will be logical to you in the future.
MATE96002 (MSE 302) Materials Characterisation

<table>
<thead>
<tr>
<th>Core: For all BEng/MEng/MSc programmes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module Leader:</td>
</tr>
<tr>
<td>Stephen Skinner</td>
</tr>
<tr>
<td>Teaching Staff:</td>
</tr>
<tr>
<td>Sarah Ferne</td>
</tr>
<tr>
<td>Victoria Bemmer</td>
</tr>
<tr>
<td>Richard Sweeney</td>
</tr>
<tr>
<td>Alex Porter</td>
</tr>
<tr>
<td>Jon Rackham</td>
</tr>
</tbody>
</table>

Why study this module?
This course is designed to give students a firm foundation in the fundamentals of Materials Characterisation that will be required in subsequent years of study, in particular in their long research project and internships. The mission of Materials Characterisation is to explain the use of advanced techniques for the study of structure-property relationships in materials. The course content takes into account the exposure of the students to characterisation methods in years 1 and 2.

How will I be Taught?
25 lectures: Autumn term (during week 2 and 3 of the Autumn term)
4 workshops
3 introductory laboratory sessions
An open-ended characterisation exercise will take place in the Autumn term, leading to a report due at the start of the Spring term.

How will I be Assessed?
Examination
The course is examined in the summer term. The examination paper, duration 2 hours, has 7 questions and is comprised of a mixture of short questions plus a long question that is based on analysing a series of experimental results and writing a reasoned interpretation of these data (50%).

Coursework
Students are expected to submit one report (35%) related to the open-ended characterisation exercise, complete a workshop (7.5%) and attend a number of practical sessions (7.5%).

The module contributes 100 marks towards the third year in both the BEng and MEng assessment schemes (50% each for the exam and coursework). The pass mark for the module is 40% for both BEng and MEng students.

Reading List:
Required Reading

Recommended Reading
- Structure from Diffraction Methods, D.W. Bruce, D. O’Hare and R.I. Walton, Wiley (2014)

Background Reading
Learning Outcomes of this Module:

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

**Ion Beam Characterisation**
On successfully completing this course, students will be able to:
- Understand and discuss fundamental ion-solid interactions for a range incident ion energies, and ion beam types i.e. mono-atomic and cluster ion beams. This topic includes the modelling program, SRIM.
- Understand ion beam interactions on materials, and how the sputtered material is used in different techniques e.g. secondary ion mass spectrometry (SIMS) and low energy ion scattering.
- Understand and discuss the difference between these two techniques and origin of the measured species.
- Understand the concept of, and calculate ion beam dose, and discuss how this influences ion beam analyses: static and dynamic SIMS.
- Understand the important effects such as oxygen and caesium surface coverage on the efficiency of positive and negative secondary ion formation, respectively.
- Understand the basic SIMS equation and the importance of sputter yield and ionisation efficiency.
- Understand the concept of mass and depth resolution, and how they are influenced by experimental conditions.
- Discuss the application of SIMS to surface analysis and its modes of operation including mass spectra, surface imaging and concentration depth profiling.
- Understand the difference between time-of-flight, magnetic sector and quadrupole mass filters.
- Understand the importance of vacuum levels in the instrumentation for high level detection analyses.
- Understand the characteristics of primary ion sources such as liquid metal ion sources, and electron ionisation sources, and plasma sources.
- Discuss characteristics of primary ion sources such as their brightness.
- Understand the origin of channelling contrast obtained with highly collimated ion beams.
- Understand and discuss the application and use of Ion beam instruments in surface analyses and materials characterisations.

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

Scanning Probe Microscopies
On successfully completing this course, students will be able to:
• Explain what scanning probe microscopy is.
• Discuss the lateral imaging range and sensitivity to structure and properties.
• Specifically describe the theory, use and operation of the scanning tunnelling microscope and atomic force microscope including strengths and weaknesses of each technique.
• Discuss applications of scanning probe microscopies to materials characterisation.

Thermal analysis
On successfully completing this course, students will be able to:
• Describe the different types of thermal analysis techniques.
• Describe the limitations and challenges of the various techniques.
• Be able to select the most appropriate thermal analysis technique for a variety of characterisation investigations.
• Interpret thermal analysis data for simple materials.
Characterisation exercise report information form

<table>
<thead>
<tr>
<th>Module code</th>
<th>MATE96002 (MSE302)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of Study</td>
<td>Year 3</td>
</tr>
<tr>
<td>Assignment Name</td>
<td>Characterisation Exercise Report</td>
</tr>
<tr>
<td>Academic in Charge</td>
<td>Dr Jonathan Rackham</td>
</tr>
<tr>
<td>When the assignment is presented to the students</td>
<td>Introduced at the beginning of year/first lecture (Autumn week 1)</td>
</tr>
<tr>
<td>Method of submission</td>
<td>Blackboard submission</td>
</tr>
<tr>
<td>Student’s self-study hours</td>
<td>20 hours</td>
</tr>
<tr>
<td>Deadline date</td>
<td>Spring term, week 2. Tuesday 14th Jan.</td>
</tr>
<tr>
<td>Percentage of the module total</td>
<td>70% of the coursework component (35% of the module)</td>
</tr>
<tr>
<td>Estimated marking/feedback time</td>
<td>4 weeks from submission.</td>
</tr>
<tr>
<td>Turn-it-in requirement</td>
<td>No</td>
</tr>
</tbody>
</table>

Assignment details
Students will work in groups of four to characterise a pair of related samples whose identities are unknown. The identities and the relationship between the samples must 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:
- Scanning electron microscopy (with energy dispersive X-ray spectroscopy)
- X-ray diffraction
- Atomic force microscopy

In addition to these techniques, transmission electron micrographs will be available where relevant.

Other requirements
The report should be written in the style of a short paper with a focus on presentation of results and discussion. A document template is provided (MS Word and LaTeX) and must be used. Report to be submitted as a PDF, maximum 4 pages in length.

Rubric:
It is anticipated that reports will comprise the following content (indicative weightings in parentheses)
- Abstract (10%)
- Experimental Details (15%)
- Results & Discussion (50%)
- Conclusions (15%)

As the samples are unknown an introduction is not required.
There will also be component of the assessment for quality of written communication, presentation and accurate referencing, contributing 10% of the overall mark.
Characterisation introductory lab sessions information form

<table>
<thead>
<tr>
<th>Module code</th>
<th>MATE96002 (MSE302)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of Study</td>
<td>Year 3</td>
</tr>
<tr>
<td>Assignment Name</td>
<td>Characterisation Introductory Lab Sessions</td>
</tr>
<tr>
<td>Academic in Charge</td>
<td>Dr Jonathan Rackham</td>
</tr>
<tr>
<td>When the assignment is presented to the students</td>
<td>Introduced at the beginning of year/first lecture (Autumn week 1), briefing at end of characterisation lab course</td>
</tr>
<tr>
<td>Method of submission</td>
<td>Blackboard</td>
</tr>
<tr>
<td>Student’s self-study hours</td>
<td>1h</td>
</tr>
<tr>
<td>Deadline date</td>
<td>Each to be submitted the day after the lab session</td>
</tr>
<tr>
<td>Percentage of the module total</td>
<td>15% of the coursework component (7.5% of the module)</td>
</tr>
<tr>
<td>Estimated marking/feedback time</td>
<td>2 weeks from submission</td>
</tr>
<tr>
<td>Turn-it-in requirement</td>
<td>No</td>
</tr>
</tbody>
</table>

Assignment details

Students will attend three lab sessions in groups of four. Each session will introduce them to a different instrument(s):

the scanning electron microscope (1h)
transmission electron microscope (1h)
atomic force microscope and thermal analysis equipment (1h joint)

The students will be guided through each session by a worksheet with practical assistance provided by a GTA. The worksheet will pose various questions about the instrument and sometimes require relevant results/images to demonstrate various phenomena.

Other requirements

Any images submitted must show a scale bar and be annotated to highlight the relevant phenomenon.

Rubric:

Three submissions will be made on Blackboard, one to accompany each laboratory session, with credit divided as shown below.

Scanning Electron Microscope – 5%
Transmission Electron Microscope – 5%
Atomic Force Microscope/Thermal Analysis – 5%

Answers to the worksheets will be submitted mostly as short answer or multiple choice questions, with some elements requiring the submission of accompanying images.
**XRD class work assignment information form**

<table>
<thead>
<tr>
<th>Module code</th>
<th>MATE96002 (MSE 302)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of Study</td>
<td>Year 3</td>
</tr>
<tr>
<td>Assignment Name</td>
<td>XRD Class work assignment</td>
</tr>
<tr>
<td>Academic in Charge</td>
<td>Richard Sweeney</td>
</tr>
<tr>
<td>When the assignment is presented to the students</td>
<td>Middle of autumn term – exact dates TBC</td>
</tr>
<tr>
<td>Method of submission</td>
<td>Hard copy (during the session)</td>
</tr>
<tr>
<td>Student’s self-study hours</td>
<td>1 hour of revision should be sufficient – a recap will be given during the lesson.</td>
</tr>
<tr>
<td>Deadline date</td>
<td>By the end of the session</td>
</tr>
<tr>
<td>Percentage of the module total</td>
<td>15% of the coursework component (7.5% of the module)</td>
</tr>
<tr>
<td>Estimated marking/feedback time</td>
<td>2 weeks marking time. However the scripts will not be returned until all timetabled sessions have been held.</td>
</tr>
<tr>
<td>Turn-it-in requirement</td>
<td>No</td>
</tr>
</tbody>
</table>

**Assignment details**

This is a highly interactive session designed to re-inforce and enhance understanding of some of the concepts covered in the XRD lectures.

During this exercise the students will process some example data to determine the structure type, lattice parameter and composition of a brass specimen.

This will be achieved by following a step by step process explained in the booklet provided.

Staff and GTAs will be on hand to help and to answer any questions.

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. It will be returned after marking.

**Other requirements**

Students should bring with them a calculator, pen, pencil, eraser and ruler.

**Rubric:**

**XRD Class work marking rubric**

All questions must be entered into the assignment booklet where indicated using the spaces provided.

All tables must be completed with the correct values as instructed. Particular attention must be given to the use of the appropriate number of decimal places and significant figures.

Graphs must include labelled axes with a suitable choice of range. All data points must be plotted clearly. The line of best fit biased towards low NRF values must be shown and the intercept should be indicated.

Throughout, you should check that the values obtained seem sensible.

Where an example procedure has been given, you must follow the same procedure.

When calculating the composition, full working must be shown. The answer given must be within +/- 1% (absolute) of the correct answer. The sum of Cu and Zn must =100%

For free text questions, you must give a logical, coherent account that fully addresses the question. (For the doublet question, it is insufficient to simply state that there are two wavelengths).

The work should be presentable and legible throughout with clear and succinct answers.
### Mark allocation

<table>
<thead>
<tr>
<th>Category</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Table (p6)</td>
<td>1.5</td>
</tr>
<tr>
<td>Structure</td>
<td>1</td>
</tr>
<tr>
<td>Indexing</td>
<td>2</td>
</tr>
<tr>
<td>Structure Factor</td>
<td>3</td>
</tr>
<tr>
<td>Data Table (p12)</td>
<td>1.5</td>
</tr>
<tr>
<td>Graph</td>
<td>2</td>
</tr>
<tr>
<td>Lattice Parameter value</td>
<td>1</td>
</tr>
<tr>
<td>Composition</td>
<td>2</td>
</tr>
<tr>
<td>Doublet explanation</td>
<td>2</td>
</tr>
<tr>
<td>Separation increase explanation</td>
<td>2</td>
</tr>
<tr>
<td>Presentation and clarity</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20</strong></td>
</tr>
</tbody>
</table>
Why study this module?
This course is titled Engineering Alloys 1: From Theory to Applications
In this course students 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.
This course is well placed to lead into the 4th year module “Engineering Alloys 2: A Crystal Approach”

Learning outcomes:
- You will consider engineering with alloys, and multi-objective engineering design problems (cost, temperature, performance – e.g. creep, fatigue, strength, processability, light weighting, material costs & lifecycle).
- You will discuss approaches to engineering design and lifing, where failure and optimisation of alloys dominate function (drawing in ideas of process-microstructure-properties) in solid stage metal components.
- You will realise a deeper understanding of the science of alloys as a microstructure system with an engineering goal. This includes exploring microstructure mapping and crystallographic texture evolution in engineering alloys.

How will I be Taught?
27 contact hours (includes lectures, workshops and a computational exercise): Autumn Term (2 x two hour sessions per week)

How will I be Assessed?
Examination (80%)
The course is examined in the summer term in a single 2½ hour examination paper composed of five questions. Students answer 3 questions from the 5 available, each worth 20 marks giving a total of 60 for the paper. The balance of questions will broadly reflect the balance of lectures.

Coursework (20%)
Unit 6 includes a coursework based exercise, led during the lecture period. This includes development of understanding of crystallographic texture in engineering alloys.
The module contributes 100 marks towards the third year in both the BEng and MEng assessment schemes.
The pass mark for the individual module on the BEng and the MEng courses is 40%.

Reading List:
- The Superalloys, RC Reed, CUP, 2007
- Titanium, Lutjering and Williams, Springer, 2003
- The Jet Engine, Rolls Royce
- Metals Speciality Handbooks in Nickel and Titanium, ASM Int’l (Donachie)
Workshop report coursework information form

<table>
<thead>
<tr>
<th>Module code</th>
<th>MATE96003 (MSE 307)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of Study</td>
<td>3rd year and MSc Adv</td>
</tr>
<tr>
<td>Assignment Name</td>
<td>Workshop Report</td>
</tr>
<tr>
<td>Academic in Charge</td>
<td>Dr Ben Britton</td>
</tr>
<tr>
<td>When the assignment is presented to the students</td>
<td>Wk 9 25/11/2019 Workshop</td>
</tr>
<tr>
<td></td>
<td>Wk 10 02/12/2019 Workshop</td>
</tr>
<tr>
<td>Method of submission</td>
<td>Blackboard Learn</td>
</tr>
<tr>
<td>Student’s self-study hours</td>
<td>3 hours lecture, 3 hours in lecture hall practical, 12 hours self study</td>
</tr>
<tr>
<td>Deadline date</td>
<td>Thursday 12th December 2019, 3pm</td>
</tr>
<tr>
<td>Percentage of the module total</td>
<td>20%</td>
</tr>
<tr>
<td>Estimated marking/feedback time</td>
<td>50 students – 5-page reports – 2-3 weeks marking</td>
</tr>
<tr>
<td>Turn-it-in requirement</td>
<td>No</td>
</tr>
</tbody>
</table>

Assignment details

We will explore the measurements of microstructure and crystallographic texture (i.e. preferred crystal orientations) using MTEX and analysis of electron backscatter diffraction (EBSD) data. Students will be required to:

Answer a series of (short) questions on measurement, analysis, and importance of texture in engineering alloys.

Analysis example EBSD maps in MTEX (a matlab toolbox for texture, which is not available in Python)

Simulate texture evolution during processing

Other requirements

Report will include:
Answers to a pro-forma question sheet
Published matlab/mtex code, made suitably readable (e.g. with comments and appropriate variable names)
Results that demonstrate measurement of microstructure and texture evolution

Rubric: Development of the lab script & marking will be performed before the start of term in cooperation with the GTAs.
Why study this module?
The overall aim of this course is to introduce students of the main methods and fundamental principles used for the processing of engineering ceramics (and, to a lesser degree, glass and glass ceramics) and develop an understanding of the factors that influence their mechanical properties. Furthermore, the course will give an introduction to microwave application of ceramics and discuss the electrodynamic response from dc to infrared frequencies and its correlation to the microstructure.

Learning outcomes:
- Describe the different types of particles (particles, agglomerates, granules, flocs, colloids, aggregates).
- Describe powder characterization methods. Interpret results from powder analysis (particle size, particle size distributions, specific surface areas).
- Understand the parameters that control powder packing and the dry pressing of ceramic powders.
- Explain the types of colloids and explain the different methods to stabilize colloidal suspensions (electrostatic stabilization, steric stabilization, electrosteric stabilization).
- Describe standard ceramic wet processing techniques and understand the key parameters in the formulation of ceramic slurries for processing.
- Describe the structure of glasses and their formation. Explain the models of glass structure: crystallite model and random network model. Describe the structure of oxide glasses: silica, silicate glasses, borate glasses.

How will I be Taught?
27 contact hours (includes lectures and class exercises): Spring Term (2 x two hour sessions per week)

How will I be Assessed?
The course is examined in the summer term. The examination paper, duration 2.5 hours, has 5 questions and students must answer 3. The module contributes 100 marks of the third year. The pass mark for the individual module on the BEng and the MEng scheme is 40%.

Reading List:
- Ceramic processing and sintering, M.N. Rahaman, Marcel Dekker (1995)
- 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.
Why study this module?
The overall aim of this course is to introduce students to the main methods and fundamental principles used for the processing of polymers and composite materials and to develop an understanding of the factors that influence their mechanical properties.

Learning outcomes:
- Identify and describe suitable methods to process polymers into useful products, including both blending and forming, for thermoplastics and thermosets.
- Describe the characteristic rheology of polymers melts, and how the phenomenology controls the nature and quality of thermoplastic products, including the formation of defects.
- Introduce the major types of fibre reinforcement used in structural composites, and how they compare.
- Consider the nature of polymer composite matrices and the interface with the reinforcing fibres.
- To define a composite material, and give examples of common matrices and fibrous reinforcements, their properties and how they are made.
- Explain the relevance of fibre flexibility and can quantify it.
- Argue the advantages and disadvantages of classifying composites on the basis of matrix or architecture.
- Make a quick assessment of realistic property ranges that can be obtained when making a composite of 2 materials.
- Discuss a range of failure modes for fibre reinforced composites (axial and transverse tensile failure, axial compression failure).
- Appreciate the key engineering and scientific reasons for the development of metal-matrix composites.
- Describe and classify processing technologies for metal-matrix composites.

How will I be Taught?
27 contact hours (includes lectures and class exercises): Spring Term (2 x two hour sessions per week)

How will I be Assessed?
The course is examined in the summer term. The examination paper, duration 2.5 hours, has 5 questions. Students are required to answer 3 questions. The module contributes 100 marks of the third year. The pass mark for the individual module is 40% for BEng and MEng students. The pass mark for the MSc Advanced Materials course is 50%.

Reading List:
- RJ Young and PA Lovell “Introduction to polymers” Chapman and Hall 1983
• CB Bucknall “Toughened Plastics” Applied Science 1977 (Dated Introductory parts only)
• Concise Encyclopaedia of Composite Materials, ed. by A. Kelly, Elsevier, 1999
• M. Taya, R. J. Arsenault, Metal Matrix Composites – Thermomechanical Behaviour, Pergamon Press, 1989
• K. K. Chawla, Ceramic Matrix Composites, Chapman and Hall, 1993
• Handbook of Ceramic Composites, ed. by N. P. Bansal, 2005
Why study this module?
This course describes the electronic devices used to emit light, transmit light and detect light and to show how these elements can be combined to create integrated systems for fibre optic communications, solar energy conversion and displays.

Learning outcomes:
- Explain the background physics necessary for an understanding of the optoelectronic properties of materials;
- Discuss how reflection and refraction give rise to colour from transparent materials;
- Describe the influence of microstructure on colour (scattering and diffraction);
- Illustrate the absorption and luminescence of light from a material;
- Design a material with a specified absorption edge;
- Rationalise the broad emission obtained from a phosphor;
- Describe a fibre optic communication link;
- Compare and contrast a fibre optic links and a copper wire for data communication;
- Describe the materials used and principles of operation of light emitting diodes (LEDs) working in the visible and infra-red parts of the electromagnetic spectrum;
- Describe semiconductor lasers with reference to band gap and refractive index engineering as well as optical feedback;
- To discuss the economic and environmental viability of photovoltaic cells and define energy pay-back time;
- Justify why silicon is a material used in solar cells despite the fact that it is an indirect band gap semiconductor;
- Describe recent developments in silicon solar cell technology aimed at increasing efficiency and reducing unit cost;
- Sketch the different phases a liquid crystal may exhibit and explain how the different phases can be characterised;
- Explain why a chiral liquid crystal acts as a waveguide;
- Sketch and clearly label the key components of a liquid crystal display.

How will I be Taught?
27 contact hours (includes lectures and class exercises): Spring Term (2 x two hour sessions per week)

How will I be Assessed?
The course is examined in the summer term. The examination paper, duration 2.5 hours, has 5 questions and students must answer 3.
The module contributes 100 marks of the third year. The pass mark for the individual module on the BEng and the MEng scheme is 40%.
For MSc students the pass mark for the component is 50%. The component is an optional module within the lecture element of the MSc programme.

Reading List:
• The Physics of Solar Cells, J. Nelson, Imperial College Press.
• Introduction to Liquid Crystals: Chemistry and Physics. P.J. Collings.
MATE96007 (MSE 312) Nanomaterials

Optional: For all BEng/MEng/MSc programmes

Module Leader: Mary Ryan
Teaching Staff: Jason Riley, Peter Petrov

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

Learning outcomes:
• Explain the effect of nanoscale structure on the mechanical properties of materials
• Describe the formation, properties and applications of nanoporous materials
• Understand the effects of surface energy on the thermodynamics of nanoscale systems
• Describe bottom-up versus top-down routes for nanomaterials processing
• Discuss nucleation versus growth of nanostructures and describe surface versus diffusion limited growth regimes
• Explain surface plasmon resonance in metals.
• Discuss why the colour of metal nanoparticles differs from that of the bulk material.
• Calculate the Bohr radius of an exciton.
• Describe quantum confinement in semiconductor Q-dots.
• Illustrate how nanowires can be employed in sensor applications.
• Describe chemical and physical methods for thin film deposition
• Understand the architecture of the CMOS transistors currently use for fabrication of integrated circuits.
• Describe the manufacturing and device performing challenges related to transistors size scaling down to 22nm, 14nm and below.
• Give examples and discuss the manufacturing process of 2D and 3D CMOS devices.
• Give examples of “post-CMOS” nanomaterials and devices
• Compare the methods for electrical testing of nanomaterials and thin film devices
• Understand and discuss the concept of responsible development; and discuss in general terms the potential impact of nanomaterials on human health and the environment

How will I be Taught?
24 lectures: Autumn Term (2 x two hour sessions per week)

How will I be Assessed?
The course is examined in the summer term. The examination paper, duration 2.5 hours. The students must answer 3 questions from a total of 5.
The module contributes 100 marks of the third year. The pass mark for the individual module is 40% for BEng and MEng students. MSc Advanced Materials students will be required to sit an additional examination question. The pass mark for the MSc Advanced Materials is 50%.

Reading List:
• 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
MATE96008 (MSE 315) Biomaterials

Core: MEng Biomaterials and Tissue Engineering
Optional: For all other programmes

Module Leader: Julian Jones
Teaching Staff: Stefano Angioletti-Uberti
Alexander Porter

Why study this module?
This course is designed to give students the firm foundation in the fundamentals of Biomaterials required in subsequent years of study for those taking Advanced Biomaterials in year 4 and for those taking the MEng in Biomaterials and Tissue Engineering and to serve as a self-standing unit.
The mission of the Biomaterials module is to explain the types and properties of materials needed for various medical applications and how to synthesise and characterise these materials.

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

How will I be Taught?
24 lectures: Autumn Term (2 x two hour sessions per week)
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.
The module is delivered to students from different departments. To bring all the students from different backgrounds up to speed the cohort will be, after an introductory lecture, split into two groups for the following two lectures; Materials and Mechanical Engineering students are given two lectures on basic concepts in biology for engineers, whilst Bioengineering students are given an introduction to the properties and structure of metals, ceramics, polymers and composites.
The cohort is taught as a single group for the remainder of the module. A published book has been created as a companion to the course. This also contains a CDROM that has supplementary lectures and study questions. Copies are available in the library.

How will I be Assessed?
The course is examined in the summer term. The examination paper, duration 2.5 hours, has 5 questions of which students must answer 3 (20 marks per question).
The module contributes 100 marks of the third year. The pass mark for the individual module in the BEng scheme and MEng scheme is 40%. The pass mark for the MSc programmes is 50%
**Reading List:**

MATE96009 (MSE 317) Materials Modelling

Core: MSc in Advanced MSE
Optional: For all BEng/MEng programmes

Module Leader: Andrew Horsfield
Teaching Staff: Yilun Xu
              Paul Tangney
              Joseph Prentice

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

Learning outcomes:
• Introduction to computer simulation - Length and time scales
• Introduction to MATLAB
• Understanding Finite Elements and Crystal Plasticity
• Understand the algorithm for Metropolis Monte Carlo
• Apply Metropolis Monte Carlo to finding the equilibrium distribution of one or more particles
• Understand the diffusion equation and how to solve it using finite differences and Fourier Transforms
• Understand the merits of explicit and implicit solvers
• Apply kinetic Monte Carlo to solve the diffusion equation
• Understand the concept of a phase field
• Understand the relation of the free energy to the equation of motion of the phase field
• Understand the Cahn-Hilliard equation for spinodal decomposition
• Solve the Cahn-Hilliard equation for the spinodal decomposition of a binary alloy.
• Understand the concept of a potential energy surface in the context of aggregates of atoms
• Understand how the atoms’ real potential energy surface may be approximated to make atomistic calculations tractable.
• Understand the basics of how different types of bonding (ionic, covalent, metallic, van der Waals) are modelled.
• Understand what it means to find the minimum-energy structure of a molecule or crystal.
• Understand the molecular dynamics method for calculating finite temperature properties.
• Understand how to perform a Molecular Dynamics simulation (velocity Verlet) and a simple way to introduce the effect of a surrounding medium (Langevin dynamics).
• Understand a current research topic that employs computer simulation

How will I be Taught?
8 hrs lectures with 16 hrs of exercise classes (MEng and BEng), or 9 hours lectures with 18 hrs exercise classes (MSc): Spring term (a three hour session per week)

How will I be Assessed?
Assessment is through 3 problem sets, a 2 hour online multiple-choice test, and a research essay (MSc only).
For MEng and BEng students, the problem sets have equal weight and together are worth 70 marks; the test is worth 30 marks.
For MSc students, the problem sets have equal weight and together are worth 60 marks; the test is worth 30 marks, and the essay is worth 10 marks.
The module contributes 100 marks of the third year. The pass mark for the individual module is 40% for BEng and MEng students. The pass mark for the MSc Advanced Materials programme is 50%.
**Reading List:**


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**Modelling problem set 1 information form**

<table>
<thead>
<tr>
<th>Module code</th>
<th>MATE96009 (MSE 317) / MSE 467</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of Study</td>
<td>3rd year and MSc Adv</td>
</tr>
<tr>
<td>Assignment Name</td>
<td>Modelling Problem set 1</td>
</tr>
<tr>
<td>Academic in Charge</td>
<td>Andrew Horsfield</td>
</tr>
<tr>
<td>When the assignment is presented to the students</td>
<td>Monday 20th January 2020</td>
</tr>
<tr>
<td>Method of submission</td>
<td>Blackboard Learn</td>
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<tr>
<td>Student’s self-study hours</td>
<td>20 hours of self-study required</td>
</tr>
<tr>
<td>Deadline date</td>
<td>Thursday 30th January 2020, 3pm</td>
</tr>
</tbody>
</table>
| Percentage of the module total | MSc: 20% 
UG: 70% / 3 = 23.333% |
| Estimated marking/feedback time | 2 weeks |
| Turn-it-in requirement | No |

**Assignment details**

There are two sets of problems to be done: one on finite elements and one on crystal elasticity.

**Other requirements**

The answers are to be written onto the question sheets, and then scanned and uploaded to Blackboard.

**Rubric:**

Two question sheets, each worth 20 marks.
### Modelling problem set 2 information form

<table>
<thead>
<tr>
<th>Module code</th>
<th>MATE96009 (MSE 317)</th>
</tr>
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<tr>
<td>Year of Study</td>
<td>3rd year and MSc Adv</td>
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<tr>
<td>Assignment Name</td>
<td>Modelling Problem set 2</td>
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<td>Academic in Charge</td>
<td>Andrew Horsfield</td>
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<tr>
<td>When the assignment is presented to the students</td>
<td>Monday 3rd February 2020</td>
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<td>Deadline date</td>
<td>Thursday 20th February 2020 3pm</td>
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<tr>
<td>Percentage of the module total</td>
<td>MSc: 20%</td>
</tr>
<tr>
<td></td>
<td>UG: 70% / 3 = 23.333%</td>
</tr>
<tr>
<td>Estimated marking/feedback time</td>
<td>2 weeks</td>
</tr>
<tr>
<td>Turn-it-in requirement</td>
<td>No</td>
</tr>
</tbody>
</table>

#### Assignment details

Answer questions and solve problems based on the theory and class exercises for Metropolis Monte Carlo, Diffusion and Phasefield.

#### Other requirements

Must fit in the space provided on the homework template. If handwritten, then must be scanned and saved as a PDF before submitting to Blackboard.

#### Rubric:

Problem sheet worth 45 marks. One question per topic (3 questions), each worth 15 marks.
Modelling problem set 3 information form

<table>
<thead>
<tr>
<th>Module code</th>
<th>MATE96009 (MSE 317)</th>
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<td>3rd year and MSc Adv</td>
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<tr>
<td>Assignment Name</td>
<td>Modelling Problem set 3</td>
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<tr>
<td>Academic in Charge</td>
<td>Dr Paul Tangney</td>
</tr>
<tr>
<td>When the assignment is presented to the students</td>
<td>Monday 24th February 2020</td>
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<td>Student’s self-study hours</td>
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<td>Percentage of the module total</td>
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</tr>
<tr>
<td>Estimated marking/feedback time</td>
<td>2 weeks</td>
</tr>
<tr>
<td>Turn-it-in requirement</td>
<td>No</td>
</tr>
</tbody>
</table>

**Assignment details**

Students will be provided with a MATLAB code and notes and instructions on how to use it. The code performs atomistic simulations (molecular dynamics and structural relaxation) of a simple polymer with or without an implicit solvent. Calculations will be performed and reported on.

**Other requirements**

The number of sentences accompanying each plot is restricted to one or two. Length restrictions on those sentences will be clarified in the assignment notes.

**Rubric:**

The assignment is in two parts, each involving performing some simulations and reporting on the results found.

Part 1: Structural relaxation: 15 marks

Part 2: Dynamics: 25 marks
5. Laboratory Information

The laboratories and workshop timetables for MATE96002 (MSE 302) will be available at the beginning of the term and will be viewable on CelCat.