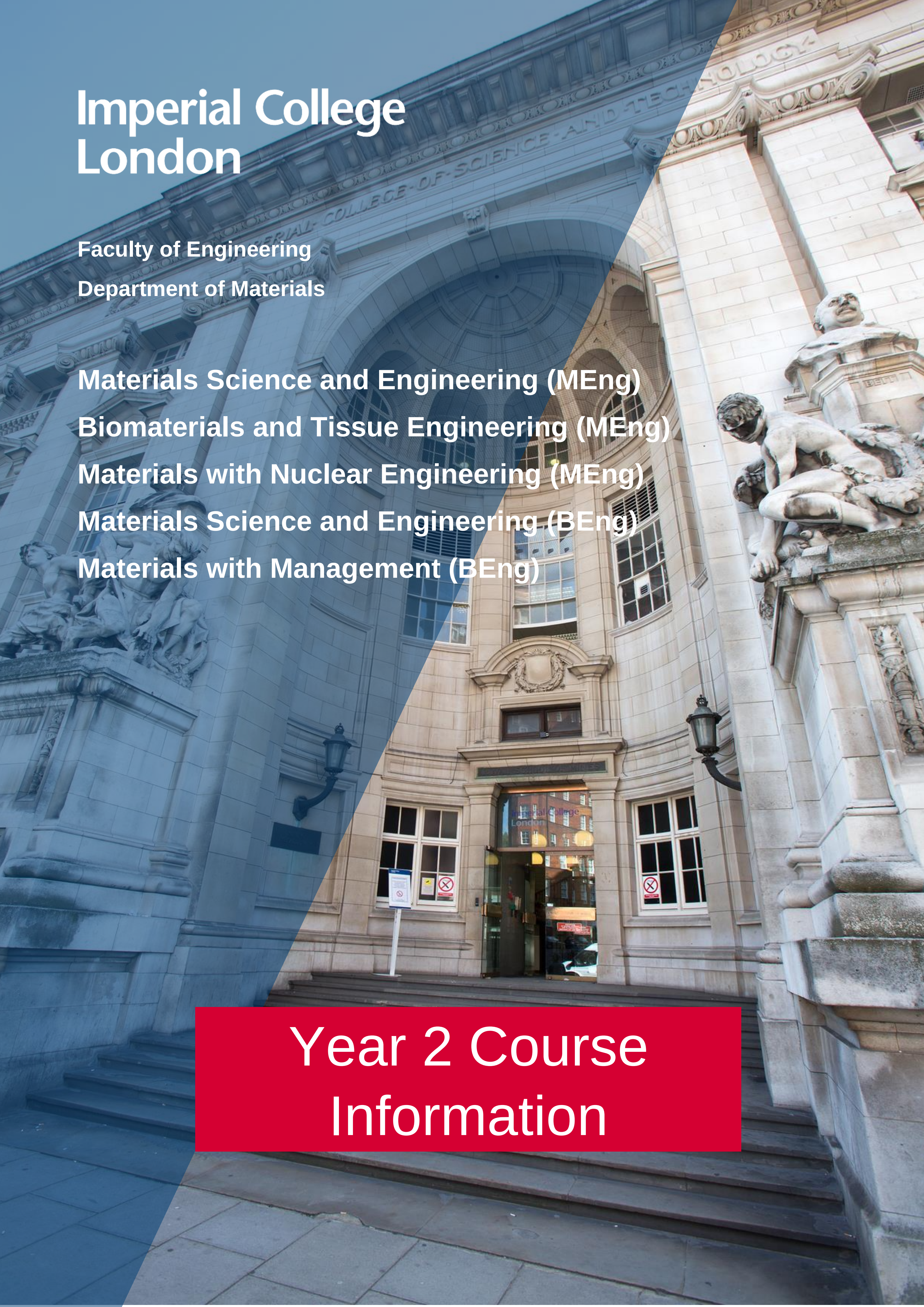

Imperial College London

Faculty of Engineering

Department of Materials

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

Year 2 Course Information

1. Year Structure

For BEng awards, year 2 is weighted at 35% (Yr 1 – 7.5% & Yr 3 - 57.5%)

For MEng awards, year 2 is weighted at 20% (Yr 1 – 7.5% & Yr 3+4 – 36.25%)

Second year comprises 6 modules: 5 which are primarily lectures courses, 1 of which has a significant lab component and which is around engineering essential skills. These modules are listed below along with the relative module weighting in the year structure and the contribution of each component to the module.

Module	Name	% Contribution
MATE50001	Autumn Test - December	30%
	Summer Test - June	40%
	Computing – in-class Test - June	15%
	Computing – coding challenge	15%
MATE50002	Degradation and Corrosion Test - December	30%
	Devices Test - March	25%
	Batteries Test - June	25%
	Group Poster Ex - June	20%
MATE50003	Technical drawing	5 %
	Characterisation plan	5 %
	Characterisation data and analysis	30 %
	Manufacturing methods	5 %
	Suggestion for improvement	5 %
	Group presentation	40 %
	Peer assessment	10 %
MATE50004	Examination - April	100%
MATE50005	Examination – December	40%
	Characterisation Exercise – Spring	35%
	Technique Laboratory submissions – Autumn	25%
MATE50006	Examination – April	100%

Progression

Progression criteria for Year 2 are:

- Achieving an aggregate mark of at least 40% in each module
- Achieving a mark for the year of at least 40%

2. Module Information

MATE50001 Mathematics and Computing II

Why study this module?

This course is a continuation of the first-year course MATE40001 and aims to give students a firm foundation in the aspects of Mathematics and Computing of most relevance to Materials Science and Engineering, especially the topics required in subsequent years of study.

At the end of this module students will be able to:
- employ vectors calculus to solve problems in MSE.
- relate Fourier series and Fourier transforms and apply to diffraction and systems described by partial differential equations.
- operate tensor algebra in problems related to elasticity, anisotropic dielectrics and conductivity.
- construct partial differential equations to solve a problem in MSE.
- apply vector algebra and partial differential equations to address problems in electromagnetism.
- discuss experiments in which the outcome is uncertain.
- create python code to implement numerical methods and solve problems in MSE.

How will I be Taught?

Mathematics

48 lectures: Autumn and Summer terms

8 workshops: Autumn and Summer terms

Computer Programming

24 hrs of programming sessions: Autumn term

New mathematical concepts will be introduced to you in lectures. You will have an opportunity to test your understanding of the material through problem solving, non-assessed problems will be reviewed in small group tutorials. Computing will be taught to you through a series of interactive teaching sessions in which a coding concept will be introduced and then used by you in a program that solves a set problem.

Reading List:

- *Mathematical Methods for Physicists and Engineers, K. F. Riley, M. P. Hobson and S. J. Bence, CUP 2006*
- *Engineering Mathematics Through Applications, K. Singh, Palgrave Macmillan 2003*
- *Mathematical Methods in the Physical Sciences, M. Boas, Wiley 2006*
- *Mathematical Methods for Physicists, G. Arfken and H. Weber, Academic Press 1995*
- *Practical Physics, G. Squires, CUP 2001*
- *Think Python 1st Edition, by Allen B. Downey*

How will I be assessed?

The mathematical aspects of the module will be assessed in termly tests. Your computing skills will be tested through a group programming challenge as well as an in-class assessment.

How will I receive feedback?

You will receive indicative marks on the tests and practical work within two weeks of submission. Formative feedback on the tests will be provided as a written commentary on where the cohort performed well and poorly.

Module Breakdown:

	% Contribution
Autumn Test - December	30%
Summer Test - June	40%
Computing – in-class Test - June	15%
Computing – coding challenge	15%

MATE50002 Performance of Functional Materials

Why study this module?

In this module you will first consider the performance of materials in the environment and how this may influence their use, looking at the degradation of glasses and polymers and the corrosion of metals. Functional materials underpin the electronics industry and the design criteria for semiconductors in devices will be described. Finally, the performance of battery materials will be discussed, combining concepts in materials processing, structure and properties from across the first two years.

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

- Appraise materials for use in different environments.
- Calculate the rate of loss of a material under a given set of conditions.
- Illustrate the key components in simple electronic devices.
- Describe the strengths and weaknesses of different battery designs.
- Compute the theoretical performance of a battery given thermodynamic and kinetic parameters.

How will I be Taught?

34 lectures: Throughout the year

7 workshops: Throughout the year

4 hrs of Lab sessions: Summer term

New concepts will be introduced to you in lectures. You will have an opportunity to test your understanding of the material through problem solving, non-assessed problems will be reviewed in lectures and at workshops. A group poster project will give you the opportunity to review battery materials with respect to the processing, structure and property principles taught across years 1 and 2.

Reading List:

- *S. Sze and M.-K. Lee, Semiconductor Devices. Physics and Technology, John Wiley and Sons*
- *C. Kittel, Introduction to Solid State Physics, 8th ed. Wiley, 2005.*
- *D.A. Jones, Principles and Prevention of Corrosion, Macmillan 1991*
- *RJ Young and PA Lovell, Introduction to Polymer Science, Chapman And Hall 1991*
- *Robert A. Huggins, Advanced batteries- Material Science Aspects https://link.springer.com/book/10.1007/978-0-387-76424-5*

How will I be assessed?

The modules will be assessed by three in-class tests on Materials Degradation, Semiconductor Devices and Battery Materials plus a group poster presentation exercise on batteries.

How will I receive feedback?

You will receive written feedback and indicative marks on the tests and practical work within two weeks of submission. Feedback on tests is provided as a written commentary on where the cohort performed well and poorly.

Module Breakdown:

	% Contribution
Degradation and Corrosion Test - December	30%
Devices Test - March	25%
Batteries Test - June	25%
Group Poster Ex - June	20%

MATE50003 Engineering Practice II

Why study this module?

You will gain the experience of working in a team- reflecting on how Engineers in industry often operate. The project work will allow you to develop the characterisation knowledge learned in the year 2 Characterisation Module (MATE50005), develop confidence in using departmental characterisation facilities, generate and analyse your own data and consider the importance of materials design and selection.

In your groups you will identify the key components of an object that you are provided with, determine the function of each component and how this contributes to the overall operation and, using your characterisation skills and knowledge as a Materials Scientist, determine exactly what materials each of the components are made from and rationalise choices made by the manufacturer. Using this knowledge, your group will be able to elucidate the processing routes used for the manufacture of each component and of the completed object and then consider how, using your knowledge, you would improve the object. What is improved is up to your team to decide, it may be as simple as how to use lower cost materials or how to use better materials that may result in greater efficiency or an increased lifetime – how about improving the primary functionality or adding more functionality. The choices are up to you to consider and investigate.

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

- Produce engineering drawings of the object you are given and the new object you define.
- Determine the materials used in the key components of your object.
- Understand more about materials selection to critique the materials you have identified.
- Describe the manufacturing methods employed in the production of your object.
- Plan, within budget, a series of analytical experiments.
- Propose alternative materials for your object that you consider would improve it.
- Operate effectively as a team.

Skills you will develop during this module:

- Characterisation skills and data interpretation.
- Project management.
- Communication skills (technical briefings, meetings, presentations).
- Technical drawing.

How will I be Taught?

1hr introduction lecture: End of Spring term/beginning of Summer term

6-8 hrs guest lectures: Summer term

40 hrs of practical/labs: Summer term

The cohort will be divided into groups such that each group will have no more than 8 members. Each group will be provided with a household object that will have to be drawn, disassembled and the key components identified. Using the facilities within teaching labs and the suite of characterisation equipment you have been introduced to previously you will determine which materials have been used in the key components and identify how the overall object functions. Each group will have a virtual budget that will be used to access the resources and facilities required. Each group will have an assigned academic mentor with whom you will meet regularly during the course of the project.

Reading List:

- Introduction to Engineering Design (Samuel and Weir)
- Materials selection in mechanical design (Ashby)

How will I be assessed?

There will be near continual assessment for the duration of the practical work. A total of 5 pieces of work will be submitted during the project in addition to an oral presentation. In addition, there will be an element of peer-assessment within each of the groups that contribute to the overall mark. The 5 pieces will cover:

1. **Technical drawing and primary component identification. (5%)**
2. **Plan for characterisation (rationale, timing, costs)(5%)**
3. **Summary of characterisation data and data analysis. (30%)**
4. **Identification of manufacturing methods used. (5%)**
5. **Suggestions for improvement. (5%)**

Each group **<u>must</u>** submit **<u>all</u>** of these pieces on time or a **<u>mark of zero</u>** will be awarded for all of the 5 components.

Each group will also give a presentation of their findings, all members of the cohort should be present for all of the presentations. The presentation is worth 40% of the total.

Finally, an individual mark (10%) will be decided anonymously by each group for each group member, marks awarded should be accompanied by a brief justification.

How will I receive feedback?

Formative feedback will be provided on all 5 pieces of work by your academic mentor. The feedback will allow you to refine your knowledge and ensure that by the time pf your presentation that you are confident with your data and your understanding of the design and manufacture of your object. Evaluation of the presentation will be provided by means of a group grade and by written comments made by the academic panel observing the presentations

Please note that marks are likely to be common amongst group members, but this requires engagement and participation by all members. Those who do not engage with their teams can expect their marks to be adjusted accordingly. Any team member with concerns over the contribution of another member should, in the first instance raise this politely with the team member, if this is unsuccessful it should be brought to the attention of the academic mentor immediately.

Module Breakdown:

	% Contribution
Technical drawing	5
Characterisation plan	5
Characterisation data and analysis	30
Manufacturing methods	5
Suggestion for improvement	5
Group presentation	40
Peer assessment	10

MATE50004 Structure II

Why study this module?

In this module you will evaluate how a material's structure determines its properties/performance and learn how the structure of a material can be controlled at the microscale through appropriate processing.

At the end of this course students will be able to:
- Construct and analyse ternary phase diagrams.
- Describe the formation and role of precipitates in materials science and engineering.
- Illustrate the role of surfaces and interfaces in material processing and properties.
- Describe and predict the properties of polymers
- Describe and predict the properties of composite materials.

How will I be Taught?

56 lectures: Spring term
10 workshops: Spring term

New concepts will be introduced to you in lectures. You will have an opportunity to test your understanding of the material through problem solving, non-assessed problems will be reviewed in lectures and at workshops.

Reading List:

- *Solid Surfaces, Interfaces and Thin Films, Hans Lüth*
- *D.A. Porter and K.E. Easterling, Phase Transformations in Metals and Alloys, Second Edition, Chapman and Hall, 1992*
- *An introduction to composite materials, Hull & Clyne, Cambridge University Press, Cambridge, 1996*
- *Introduction to Polymer Science, RJ Young and PA Lovell, Chapman And Hall 1991*

How will I be assessed?

The module will be assessed by a written examination.

How will I receive feedback?

Feedback on examinations is provided through written commentaries on each question that state where the cohort did well and highlight common mistakes.

Module Breakdown:

	% Contribution
Examination - April	100%

MATE50005 Materials Characterisation

Why study this module?

The ability to characterise materials and to assess the structure, morphology, composition, and functional/mechanical properties of materials is underpinning all fields of Materials Science and Engineering. By studying this module, you will enhance your skills in the application of advanced characterisation techniques for the study of structure-property relationships in materials. This module is designed to give you the firm foundation in the fundamentals of the Materials Characterisation techniques that you may employ in the Engineering Practice II, Processing Laboratory and Individual Research Project modules.

How will I be Taught?

38 lectures: Autumn term

5 Lab sessions/Workshops: Autumn term

An open-ended characterisation exercise will take place in the Spring term, leading to a report due at the end of the Spring term.

The fundamental principle of Materials Characterisation will be discussed in lectures and you will have an opportunity to test your understanding in workshops. Your skills in using characterisation instruments will be developed through a series of laboratory sessions, part of the practical course will involve you using a series of different techniques to determine the composition, morphology, structure and properties of an unknown material.

Reading List:

- Characterization of Materials, E.N. Kaufmann, 2nd edition, Wiley (2012).
- Materials characterization : introduction to microscopic and spectroscopic methods, Y. Leng, 2nd edition, Wiley (2013).
- Microstructural Characterisation of Materials, D. Brandon & W. D. Kaplan, 2nd edition, Wiley (2008).
- A Journey into Reciprocal Space, A.M. Glazer, Morgan & Claypool (2017).
- Introduction to magnetic materials, B.D. Cullity, C.D. Graham, 2nd edition, IEEE/Wiley (2015). (Supplementary)
- An Introduction to Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) and its Application to Materials Science, S. Fearn, Morgan & Claypool (2015). (Supplementary, available online)
- Surface Analysis: the principal techniques, J.C. Vickerman and I. Gilmore, Wiley (2009).
- Electron Paramagnetic Resonance Spectroscopy Fundamentals. P. Bertrand, 1st edition (2020). (Supplementary)
- Fundamentals of Crystallography, C. Giacovazzo, 3.rd edition, Oxford University Press (2011) (Supplementary)

- Principles of Instrumental Analysis, D.A. Skoog, 6th edition, Brooks/Cole (2007). (Supplementary)
- Organic Spectroscopy, W. Kemp 3rd edition, Red Globe Press (1991).
- Characterisation Methods in inorganic Chemistry, M.T. Weller and N. A Young, Oxford University Press (2017).

How will I be assessed?

The module will be assessed by a written examination that will test both your understanding of the fundamental principles underpinning the different techniques and your ability to interpret experimental data. You will also submit written reports on the laboratory exercises.

How will I receive feedback?

You will receive indicative marks on the tests and practical work within two weeks of submission. Formative feedback on the tests will be provided as a written commentary on where the cohort performed well and poorly.

Module Breakdown:

	% Contribution
Examination – December	40%
Characterisation Exercise – Spring	35%
Technique Laboratory submissions – Autumn	25%

MATE50006 Properties II

Why study this module?

In this module you will learn how to understand the mechanical and physical properties of materials with emphasise on mechanisms by which a structural material may fail, and states of stress from the crystal scale to components. You will also revisit the electronic and magnetic properties of materials, introducing quantum mechanical concepts, to form a deeper understanding of magnetism and charge transport.

At the end of this course students will be able to:
- Calculate, Understand and manipulate stress and strain tensors in materials and components.
- Analyse the micro mechanisms of fatigue and fracture in ductile and brittle materials.
- Employ the free and the nearly free Electron model to describe the electronic properties of a material.
- Appraise material magnetism using classical and quantum models.
- Explain the response of different materials to an AC electric field.

How will I be Taught?

60 lectures: Spring term
12 workshops: Spring term

New concepts will be introduced to you in lectures. You will have an opportunity to test your understanding of the material through problem solving, non-assessed problems will be reviewed in lectures and at workshops.

Reading List:

- *JF Nye, Physical Properties of Crystals, OUP, 1957*
- *GE Dieter, Mechanical Metallurgy, McGraw-Hill, 1988*

- *TL Anderson, Fracture Mechanics, Fundamentals and Applications. Taylor and Francis, 2005.*
- *C. Kittel, Introduction to Solid State Physics, 8th ed. Wiley, 2005.*
- *J. Singleton, Band Theory and Electronic Properties of Solids, 1st ed. OUP Oxford, 2001.*

How will I be assessed?

The module will be assessed by a written examination.

How will I receive feedback?

Feedback on examinations is provided through written commentaries on each question that state where the cohort did well and highlight common mistakes.

Module Breakdown:

	% Contribution
Examination – April	100%

3. Coursework Deadlines

This is a SAMPLE planner from 2020-21 academic year.

Term	Module	Assignment/Event	Due Date	Format	Feedback/Marks
Autumn	MATE50005	Technique Laboratory Sessions	9:00 1 week after lab session	Electronically via Blackboard Learn	2 weeks *
Spring					
	MATE50005	Characterisation Exercise Report Draft	9:00 Group A: 08/03/2021 Group B: 15/03/2021	Electronically via Blackboard Learn	2 weeks*
	MATE50003	Case Study Assignment 1- Technical drawing and primary component identification	9:00 29/04/2021	Electronically via Blackboard Learn	2 weeks *
Summer					
	MATE50005	Characterisation Exercise Report Final	9:00 Group A: 04/05/2021 Group B: 04/05/2021	Electronically via Blackboard Learn	4 weeks*

	MATE50003	Case Study Assignment 2- Plan for characterisation (rationale, timing, costs)	9:00 06/05/2021	Electronically via Blackboard Learn	2 weeks *
	MATE50003	Case Study Assignment 3- Summary of characterisation data and data analysis	9:00 20/05/2021	Electronically via Blackboard Learn	2 weeks *
	MATE50003	Case Study Assignment 4- Identification of manufacturing methods used	9:00 27/05/2021	Electronically via Blackboard Learn	2 weeks *
	MATE50003	Case Study Assignment 5- Suggestions for improvement	9:00 03/06/2021	Electronically via Blackboard Learn	2 weeks *
	MATE50001	Programming Challenge	9:00 08/06/2021	Electronically via Blackboard Learn	2 weeks *
	MATE50002	Batteries Poster file submission	9:00 10/06/2021	Electronically via Blackboard Learn	2 weeks *
	MATE50003	Case Study Assignment 6- Case Study Presentation	9:00 TBC	Presentation and submission of slides electronically	2 weeks *
	MATE50003	Case Study Assignment 7- Peer Assessment	N/A	N/A	N/A Marks for the Case Study will be scaled after the peer assessment session.

* 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.

Provisional Examination Timetable

This is a SAMPLE timetable from 2020-21 academic year.

14/12/2020 AM	MATE50005.T: Characterisation - Test
15/12/2020 AM	MATE50002.T1: Performance - Corrosion and Degradation Test
17/12/2020 AM	MATE50001.T1: Maths - Autumn Test
25/03/2021 AM	MATE50002.T2: Performance - Devices Test
27/04/2021 AM	MATE50004.T: Structure Exam
28/04/2021 AM	MATE50006.T: Properties - Exam
18/05/2021 PM	MATE50001.Computing – in-class Test
07/06/2021 AM	MATE50002.T3: Performance - Batteries Test
09/06/2021 AM	MATE50001.T2:Summer Test – June