Department of Materials

Imperial College London

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 1 COURSE INFORMATION

1. Year Structure

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

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

Module	Name		Credits
MATE40001	**Mathematics and Computing I**	% Contribution	**10**
	Autumn Test – December	30%	
	Spring Test - March	20%	
	Summer Test – June	20%	
	Computing – in-class Test	15%	
	Computing – coding challenge	15%	
MATE40002	**Performance of Structural Materials**	% Contribution	**10**
	Materials Selection Exercise	30%	
	Mechanics Test 1	15%	
	Mechanics Test 2	15%	
	Steels Test 1	15%	
	Steels Test 2	15%	
	Steels Lab	10%	
MATE40003	**Engineering Practice I**	% Contribution	**10**
	Initial Gantt Chart	Pass/Fail	
	Concept Design Report	15%	
	Presentation of Concept Design	5%	
	Integrated proto-type test day	Pass/Fail	
	Technical Drawing and Letter	10%	
	Parts List and signed off drawings	5%	
	Fabrication Record	5%	
	Final Design Report	25%	
	Integrated test day	Pass/Fail	
	Peer Marking Contribution	10%	
	Design Defence	15%	
	Presentation of Final Design	10%	
MATE40004	**Structure I**	% Contribution	**10**
	Metallography Lab	7%	
	Cooling Curves Lab	7%	
	Crystal Structure Lab	7%	
	Crystallography Test 1	12.5%	
	Crystallography Test 2	12.5%	
	End of Module Exam	54%	
MATE40005	**Fundamentals of Processing**	% Contribution	**10**
	Titration Lab	7%	
	Polymer Synthesis Lab	7%	
	Rheology Lab	7%	
	End of Module Exam	80%	
MATE40006	**Properties 1**	% Contribution	**10**
	Electrical Properties Lab	6%	
	Dielectrics and Magnetism Lab	6%	
	Fracture Mechanics Lab	8%	
	End of Module Exam	80%	

Progression

Progression criteria for Year 1 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

MATE40001 Mathematics and Computing I

Why study this module?

The missions of Mathematics and Computer Programming are to equip students with sufficient knowledge to use them effectively, for the purpose of understanding and applying the quantitative methods of Materials Science and Engineering. The module content takes into account the broad spectrum of pre-university syllabi. At the end of this module students will be able to:

- use vector algebra to solve simple geometric and materials science and engineering (MSE) problems.
- apply matrix algebra to the solution of systems of linear algebraic equations and eigenvalue problems.
- employ calculus to solve problems in MSE.
- select and apply a method to analyse a data set.
- classify and solve ordinary differential equations.
- express and manipulate complex functions.
- create python code to implement numerical methods and solve problems from MSE.

How will I be Taught?

Mathematics

48 lectures: Throughout the year

12 tutorials: Throughout the year

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 & 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%
Spring Test - March	20%
Summer Test - June	20%
Computing – in-class Test	15%
Computing – coding challenge	15%

MATE40002 Performance of Structural Materials

Why study this module?

In this module you will learn how to select a material for a specified structural function. This will involve you calculating the forces on an object and using selection tools to identify the optimal material for deployment. A case study involving steel will be used to illustrate to you the use of this approach in industry.

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

- Determine the optimal structural material for a specified application.
- Analyse the forces involved in maintaining bodies in equilibrium.
- Use the concepts of elastic stresses and strains and their relationships.
- Calculate the shear stresses and displacements developed in simple objects.
- Describe how metals properties can be altered by the engineer to give the desired response by manipulation of the microstructure.
- Apply the knowledge gained in this module to select a material for a specified structural function

How will I be Taught?

Materials Selection: 6 lectures, 4 laboratories and 2 workshops along with the group poster exercise afternoon

Mechanics: 5 lectures and 5 workshops

Steels: 6 Lectures, 1 laboratory and 2 feedback sessions

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 materials selection exercise will allow you to put into practice the principles introduced. You will have the opportunity to review the steel life-cycle with respect to the processing, structure, property principles taught across year 1.

Reading List:

- Materials Selection in Mechanical Design, M.F. Ashby, Butterworth-Heinemann
- Mechanics of Engineering Materials, P.P. Benham, R.J. Crawford & C.G. Armstrong, Pearson, Prentice Hall
- Mechanics of Materials, Riley, Sturges and Morris, Wiley and Sons
- Mechanical Metallurgy, GE Dieter, McGraw-Hill.

How will I be assessed?

The module will be assessed by: two in-class tests for Mechanics, a Materials Selection exercise culminating in a poster presentation and two in-class tests on steel as an engineering material. You will also complete a laboratory involving steels as part of this module and will be assessed by a short submission at the end of the lab.

How will I receive feedback?

You will receive written feedback and indicative marks on the tests and practical work within two weeks of submission. Both in-class tests for steel will be peer marked and feedback will be given within a week.

Module Breakdown:

	% Contribution
Materials Selection Exercise	30%
Mechanics Test 1	15%
Mechanics Test 2	15%
Steels Test 1	15%
Steels Test 2	15%
Steels Lab	10%

MATE40003 Engineering Practice I

Why study this module?

You will develop your engineering skills by working as a member of a team to design and fabricate an actuator. You will employ three phases of design: concept, proto-type and final design. To deliver the complex system each company (approximately 12 students) will be split into small groups (3-4 students), each working on a specific component. Project management and team working skills are essential for successful delivery of the final design. To support the exercise you will learn about sketching, technical drawing, Arduino programming, 3D printing, laser cutting and CNC machining.

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

- produce components of a system using laser cutting, CNC machining and 3D-printing from technical drawings.
- employ the Arduino platform to control hardware.
- design a working actuator.
- perform as a member of a team to deliver a project to specification and on-time.

How will I be Taught?

10 lectures: Autumn term

10 group teaching: Spring term

70 hrs of practical sessions: Spring & Summer term

The cohort is split into eight competing companies charged with designing an actuator. Each company is split into a number of sub-teams responsible for a different component of the machine. Through a series of lectures and workshops you will receive training in sketching, CAD drawing, CNC machining, laser cutting, 3D printing and Arduino programming. Then companies work to design an actuator fit for purpose.

Reading List:

- Manual of Engineering Drawing: Technical Product Specification and Documentation to British and International Standards, Colin H. Simmons; Butterworth-Heinemann 2012
- Technical Drawing with Engineering Graphics, Frederick E. Giesecke et al; Peachpit Press 2016
- Exploring Arduino, Jeremy Blum, Wiley 2013
- Arduino: The Ultimate Beginner's Guide to Learn and Understand Arduino Programming Effectively, Zach Webber; CreateSpace Independent Publishing Platform 2018

How will I be assessed?

There are six reports to be submitted through the project; a Gantt chart and a concept design report at the early stage; technical drawings, parts list, fabrication record and final design report at the mid-stage. Feedback is provided on all reports to help groups improve their designs. There are three presentation exercises in the project; the first at the concept stage and two on completion of the project, the final presentation includes demonstration of the final machine. Marks provided by your peers contribute 10% of the marks for this module.

How will I receive feedback?

Feedback is provided at all stages in this module to help groups and companies improve their designs. Two non-assessed test-days, where companies run prototypes of their machines and receive feedback, are built into the timetable.

Module Breakdown:

	% Contribution
Initial Gantt Chart	Pass/Fail
Concept Design Report	15%
Presentation of Concept Design	5%
Technical Drawing and Letter	10%
Parts List and signed off drawings	5%
Production Record	5%
Final Design Report	25%
Peer Marking Contribution	10%
Design Defence	15%
Presentation of Final Design	10%

MATE40004 Structure I

Why study this module?

The module will provide you with an understanding of how materials are structured from the atomic to the micron scale. You will consider how atoms are bound together to form molecules and bulk materials, the positioning of atoms on a lattice, the different types of defect that may arise and the structure of macromolecules.

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

- Describe the structure of materials from the atomic to the micron scale.
- Explain the different types of interatomic and intermolecular bonding.
- Define how atoms are arranged in a crystal structure in terms of a basis and a lattice.
- Compare the different types of defect in a material.
- Extract from binary phase diagrams qualitative and quantitative information on phase composition.
- Classify disordered materials.

How will I be Taught?

48 lectures: Autumn term

7 workshops: Autumn term

12 hrs of laboratory sessions: 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, small group tutorials and at workshops. Practical classes will be give you the chance to study the structure of some common materials.

Reading List:

- D Hull and DJ Bacon. Introduction to Dislocations, Butterworth-Heinemann, 2011.
- RJ Young. Introduction to Polymers, Chapman and Hall, 1981.
- GE Dieter. Mechanical Metallurgy, McGraw-Hill, 1989.
- JMG Cowie. Polymers: Chemistry and physics of modern materials, Blackie, 1991.
- JE Gordon. The New Science of Strong Materials, Pelican, 1968.
- AM Glazer. Crystallography: A Very Short Introduction, Oxford University Press, 2016

How will I be assessed?

The module will be assessed by in class tests, written reports on the practical exercises and an end of module examination. The 'in-class' tests are formative 'progress' assessments throughout the duration of the module to determine your level of understanding and are not for credit.

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
Metallography Lab	7%
Cooling Curves Lab	7%
Crystal Structure Lab	7%
Crystallography Test 1	12.5%
Crystallography Test 2	12.5%
End of Module Exam	54%

MATE40005 Fundamentals of Processing

Why study this module?

This module will introduce the principles that underpin materials processing. You will learn how thermodynamics can be used to predict whether a synthesis or extraction process is spontaneous at a particular temperature and how the speed of a process can be altered.

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

- State and explain the laws of thermodynamics.
- Predict the spontaneity of a reaction.
- Apply thermodynamic principles to materials extraction.
- Determine the rate law for a process.
- Discuss how the rate of a reaction can be altered.
- Employ thermodynamic and kinetic principles in relation to redox reactions.

How will I be Taught?

48 lectures: Spring term

10 group teaching: Spring term

12 hrs of laboratory 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, small group tutorials and at workshops. Practical classes will give you the chance to study the structure of some common materials.

Reading List:

- Basic Chemical Thermodynamics, EB Smith, ICP 2004
- Physical Chemistry 10th edition, PW Atkins and J De Paula, OUP 2009
- Electrode Dynamics, AC Fisher, OUP 1996
- Electrode Potentials, RG Compton and GHW Sanders, OUP 1996

How will I be assessed?

The modules will be assessed by: in class tests, written reports on the practical exercises and an end of module examination.

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
Titration Lab	6%
Rolling Lab	6%
Rheology Lab	8%
End of Module Exam	80%

MATE40006 Properties I

Why study this module?
The module will develop your understanding of the structural and functional properties of materials. You will explore the origins of magnetism, conductivity, elasticity and plasticity, finding how behaviour is related to processing and microstructure.
At the end of this course students will be able to:

- Classify conductors, insulators and semiconductors.
- Describe a dielectric material and its parameters such as polarizability, dielectric constant, and dielectric susceptibility.
- Explain and illustrate the different types of magnetism.
- Understand the role of defects in both brittle linear elastic materials and also plastic materials.
- Understand the origins of elasticity in rubber-like materials and how these fundamental principles determine material properties.

How will I be Taught?
48 lectures: Spring term
10 group teaching: Spring term
12 hrs of laboratory sessions: Spring & 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, small group tutorials and at workshops. Practical classes will be give you the chance to study the structure of some common materials

Reading List:

- RJ Young. Introduction to Polymers, Chapman and Hall, 1981.
- GE Dieter. Mechanical Metallurgy, McGraw-Hill, 1989.
- JMG Cowie. Polymers: Chemistry and physics of modern materials, Blackie, 1991.
- JE Gordon. The New Science of Strong Materials, Pelican, 1968.
- AM Glazer. Crystallography: A Very Short Introduction, Oxford University Press, 2016.
- Molecular Driving Forces: Statistical Thermodynamics in Biology, Chemistry, Physics, and Nanoscience. K. Dill and S. Bromberg. Garland Science 2010.

How will I be assessed?
The modules will be assessed by: in class exercises, written reports on the practical exercises and an end of module examination. The 'in-class' exercises are formative 'progress' exercises are not for credit.

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
Polymer Synthesis Lab	6%
Electrical Properties Lab	6%
Fracture Mechanics Lab	8%
End of Module Exam	80%

3. Laboratory Overview

This section explains how the 1st year undergraduate laboratories are organised in the Department of Materials. All laboratories are compulsory – if you are unable to attend a laboratory, you must submit a mitigating circumstance form. You will be issued a lab coat and safety glasses once you have had the safety training.

In the **Autumn term**, you will complete the introductory Materials Selection laboratories – consisting of 2 afternoons – where you explore some of the more fundamental mechanical properties such as hardness, tensile strength, flexural strength as well as physical properties such as density and electrical and thermal conductivities of different classes of materials. These laboratories are more like workshops, i.e. not assessed, but are designed to help you understand the lecture material with thought provoking discussions and aid you with the Case Study that will be assessed as part of Materials Selection (see module description for MATE40002 Performance of Structural Materials). They remain compulsory.

In the **Spring and Summer** terms you will complete 5 laboratories in each term that are associated with the modules MATE40004 Structure 1, MATE40005 Fundamentals of Processing and MATE40006 Properties 1. These are assessed – please see either the Year Structure or the Module Information section of this handbook for details. You will work in groups of 4 (composed of your tutorial group: A1, B1, C1, D1 etc.). Each laboratory consists of 2 lab sessions (described as afternoon 1 and afternoon 2).

Each laboratory session will require a different form of submission. The purpose of this is to allow you to learn in a focussed way the skills associated with creating the various portions of the full laboratory report as well as practising assembling a complete report. Each laboratory contains questions that will not be submitted for assessment, however it is anticipated that you will engage with your GTA or academics in the laboratory and your group to contemplate and discuss these questions. Each are designed to promote greater insight into the laboratory purpose and process.

No	Name of laboratory and associated module	Assessment	Due date Timeline
	Spring Term		
1	Metallography and Optical microscopy MATE40004 Structure 1	Descriptions	At the end of 2nd afternoon – 5 pm
2	Cooling Curves and Construction of Phase Diagrams MATE40004 Structure 1	Whole Report	At the end of 1st afternoon – 5 pm Whole Report – 9th March 2020
3	Polymer Synthesis MATE40005 Fundamentals of Processing	Introduction	The day after the 2nd afternoon – 5 pm
4	Crystal Structure and Bubble Raft MATE40004 Structure 1	Graphical Abstract	At the end of 2nd afternoon – 5 pm
5	Titration MATE40005 Fundamentals of Processing	Experimental Procedure	The day after the 2nd afternoon – 5 pm
	Summer Term		
1	Fracture Mechanics MATE40006 Properties 1	Log-Log Graph and Table	At the end of 2nd afternoon – 5 pm
2	Electrical Properties of Materials MATE40006 Properties 1	Results	The day after the 2nd afternoon – 5 pm
3	Dielectric and Magnetic Properties of Materials MATE40006 Properties 1	Conclusion	The day after the 2nd afternoon – 5 pm
4	Rheology MATE40005 Fundamentals of Processing	Whole Report	1 week
5	Structure and Properties of Steel MATE40002 Performance of Structural Materials	Discussion	The day after the 2nd afternoon – 5 pm

4. Coursework Deadlines for the academic year

This is a **SAMPLE** planner from 2019-20 academic year.

Term	Module	Assignment/Event	Due Date	Format	Feedback/Marks
Autumn	MATE40002	Materials Selection Exercise	09:00 28/11/2019	Group Submission electronically via Blackboard Learn	2.5 weeks*
Spring	MATE40001	Programming Challenge	09:00 13/01/2020	Group Submission electronically via Blackboard Learn	3 weeks*
	MATE40004, MATE40005	Labs	This depends on your lab group and lab assignment (see separate lab deadline planner)	Electronically via Blackboard Learn	2 weeks from submission
	MATE40003	Design Study – Initial GANTT Chart	16:00 16/01/2020	Group submission electronically via Blackboard Learn	Next day
	MATE40003	Design Study – Concept Design Report	Design Office Deadline: 16:00 06/02/2020 Company Deadline: 16:00 13/02/2020	Group submission electronically via Blackboard Learn	1 week
	MATE40003	Design Study – Presentation of Concepts	Company Deadline: 13:00 14/02/2020	Oral	Same day
	MATE40003	Design Study – Integrated proto-type test day	Company Deadline: 13:00 13/03/2020	Oral	Same day
	MATE40003	Design Study – Technical drawing and letter	Company Deadline: 16:00 07/05/2020	Individual and Group submission electronically via Blackboard Learn	1 week
Summer					
	MATE40002, MATE40005, MATE40006	Labs	This depends on your lab group and lab assignment (see separate lab deadline planner)	Electronically via Blackboard Learn	2 weeks from submission

Term	Module	Assignment/Event	Due Date	Format	Feedback/Marks
	MATE40003	Design Study – Final Design Report Submission	Design Office deadline: 16:00 28/05/2020 Company Deadline: 16:00 28/05/2020	Group submission electronically via Blackboard Learn	3 weeks
	MATE40003	Design Study – Peer Assessment	16:00 02/06/2020	Individual and Group submission electronically via Blackboard Learn	3 weeks

* 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 and Tests Timetable

This is a **SAMPLE** timetable from 2019-20 academic year.

05/11/2019 AM MATE40004 Crystallography Test 1
20/11/2019 AM MATE40001 Computing Test
10/12/2019 AM MATE40004 Crystallography Test 2
11/12/2019 AM MATE40001 Autumn Maths Test
12/12/2019 AM MATE40004 Structure 1 **EXAM**

18/03/2020 AM MATE40006 Properties 1 **EXAM**
19/03/2020 AM MATE40005 Fundamentals of Processing **EXAM**
20/03/2020 AM MATE40001 Spring Maths Test

15/05/2020 AM MATE40002 Mechanics Test 1
20/05/2020 AM MATE40002 Steels Test 1
05/06/2020 AM MATE40001 Summer Maths Test
08/06/2020 AM MATE40002 Mechanics Test 2
10/06/2020 AM MATE40002 Steels Test 2