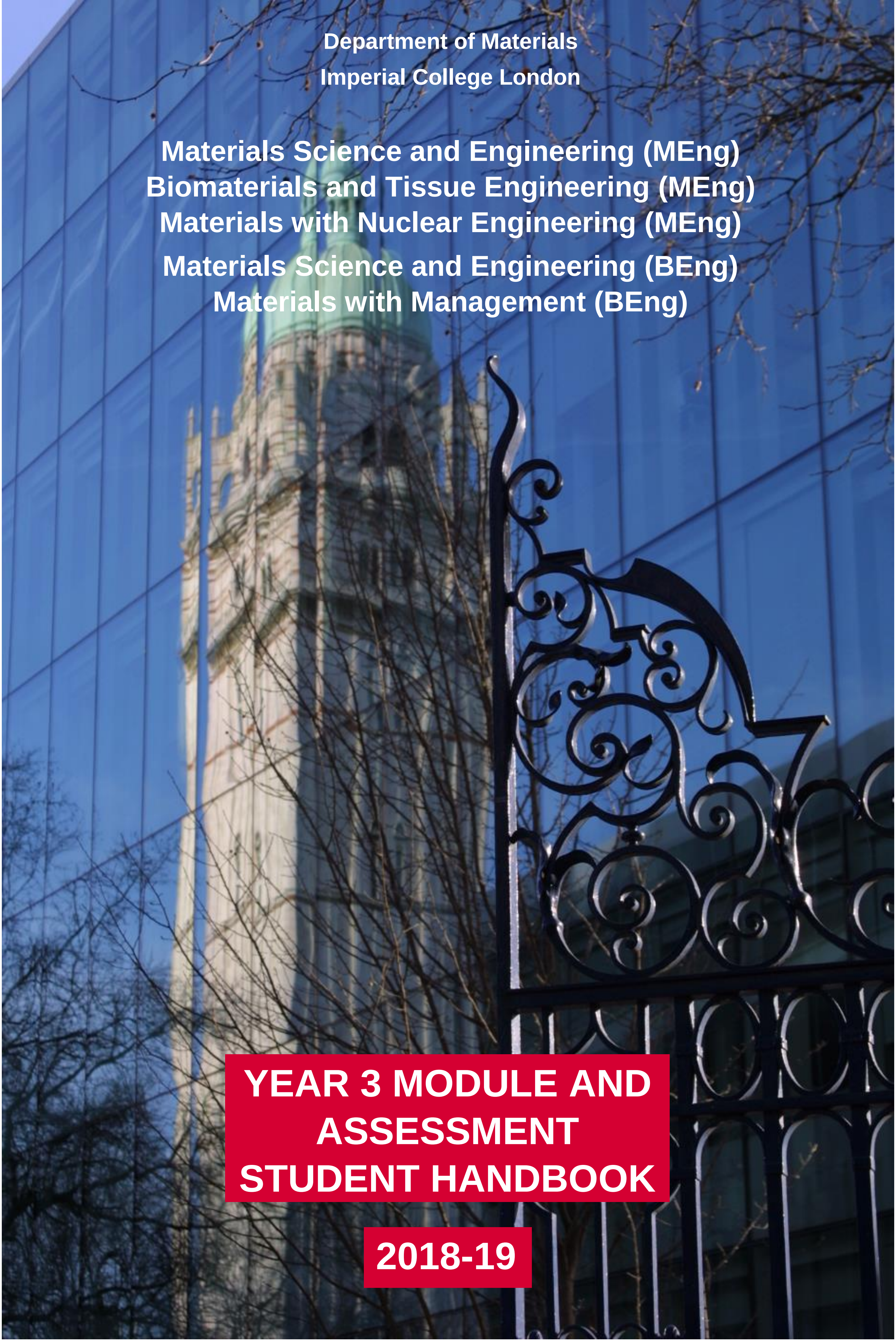

Department of Materials
Imperial College London

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 3 MODULE AND ASSESSMENT STUDENT HANDBOOK

2018-19

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.

Contents

1. Programme Information

Key dates 2018–19

Term dates

Autumn term:	29 September - 14 December 2018
Spring term:	5 January - 22 March 2019
Summer term:	27 April - 28 June 2019

Closure dates

Christmas/New year:	24 December 2018 – 1 January 2019 (College reopens on 2 January 2019)
Easter holiday:	18 April – 23 April 2019 (College reopens on 24 April 2019)
Early May bank holiday:	6 May 2019
Spring bank holiday:	27 May 2019
Summer bank holiday:	26 August 2019

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 inter-departmental exchange (IDX) and Horizons/Business modules that can also be taken.

**MSE 301 Integrated Materials Engineering Portfolio	40%
**MSE 302 Materials Characterisation	10%
MSE 308 Ceramics and glasses	10%
MSE 309 Polymers and composites	10%
MSE 310 Electronic structure and Optoelectronics	10%
MSE 312 Nanomaterials 1	10%
MSE 314 Introduction to nuclear engineering	10%
MSE 315 Biomaterials	10%
MSE 317 Modelling of Materials Processing and Performance	10%
MSE 313 Nuclear Chemical Engineering	10%
MSE318 Surfaces and Interfaces	10%
BS0806 Entrepreneurship (BEng Man)	10%
BS0802 Innovation management (BEng Man)	10%

Progression

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

Placement

1. Option of NOT taking a placement – awarded MEng in Materials Science and Engineering (240 ECTS)
2. Option of taking minimum 10-week placement – awarded MEng in Materials Sciences and Engineering with Placement (270 ECTS).

The Department MUST be notified of your intention no later than 21st June 2019.

No changes will be possible after this date.

2. Module Information

MSE 302
Materials Characterisation

Course Co-ordinator: Prof Stephen Skinner
Status: Third Year UG Materials Science and Engineering Core
Prerequisites: Completion of 2nd year

Aims

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

Learning outcomes

Diffraction (Prof S Skinner)

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

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

Focussed Ion Beam instruments and Secondary Ion Mass Spectrometry (Dr S Fearn)

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

- 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 (LEIS)
- 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 (LMIS), and electron ionisation (EI) sources, and plasma sources.
- Discuss characteristics of primary ion sources such as their brightness and limiting effects such as spherical and chromatic aberrations in the formation and resolution of scanned ion beams for SIMS
- 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 (Dr A Parry)

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

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

Scanning Probe Microscopies (Dr V Bemmer)

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

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

Thermal analysis (Mr R Sweeney)

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

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

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

A “Microstructural characterisation of materials”, 2nd Edition, David Brandon & Wayne D Kaplan (Wiley)

B “Fundamentals of Powder Diffraction and Structural Characterisation of Materials”, V.K. Pecharsky and P.Y. Zavalij, Kluwer, 2003

B “Surface Analysis: the principle techniques”, J.C. Vickerman and I. Gilmore, J. Wiley & Sons, 2009

B “Structure from Diffraction Methods”, Eds. D.W. Bruce, D. O’Hare and R.I. Walton, John Wiley & Sons Ltd, Chichester, UK, 2014

C Characterization of Materials Elton N. Kaufmann, Wiley InterScience (Online service), Hoboken, NJ : John Wiley and Sons 2012 2nd ed.

A ‘An Introduction to Time-of-Flight Secondary Ion Mass Spectrometry (ToF-SIMS) and its Application to Materials Science’ by Sarah Fearn 2015 (Online ISBN: 978-1-6817-4088-1 • Print ISBN: 978-1-6817-4024-9)

Structure, teaching and learning methods

28 lectures: Autumn term
1 classwork exercise: Autumn term
4 practical lab sessions: Autumn term

Assessment

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 (40%) covering the four practical labs associated with the course and complete a classwork session (10%).

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.

MSE 307
Engineering Alloys 1: From Theory to Application

Course Co-ordinator: Dr Ben Britton

Status: MEng and BEng Third Year option and MSc option

Prerequisites: MSE 203, 204, 104, 101, 201 or equivalents – including knowledge of metallurgical thermodynamics and deformation mechanisms; introductory fatigue, fracture and creep; principles of materials selection; introductory understanding of metals processing; basic economics and accounting; undergraduate level mathematics

Aims

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

Overall objectives (cross threading themes):

- 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.

Unit 1 – Materials selection & engineering design (5 hrs - Dr T B Britton)

- You will consolidate core concepts in metallurgy and microstructure, and apply these to deliver contextual approach to engineering design
- As a case study, you will explore materials selection in an aeroengine and consider the engineering needs and drivers for components, and how these influence materials selection
- You will consider how microstructure can be engineered during manufacturing to provide varied properties: two phase microstructures; precipitate development; alloy portioning; and the use of equilibrium and non-equilibrium microstructures

Unit 2 – Development of ferrite microstructures by thermomechanical treatment of austenite (5 hrs – Prof T Paxton)

- You will comprehend the growth of ferrite in local interfacial equilibrium
- You will explore the role of chemical potential
- You will apply theories of diffusion in the Fe-C system
- You will explain the precipitation of carbonitrides in steels

Unit 3 – Additive manufacturing, welding and repair (4 hrs – Dr Minh-Son Pham)

- You will justify the need to additive manufacture components, including the drivers, opportunity windows, cost benefits and design opportunities
- You will explore the role of repair, including cold spray technologies (e.g. for blisk applications)
- You will understand the effect of heating and cooling rates, residual stress and microstructure control in additive manufacturing
- You will be able to outline the effect of additive manufacturing processes on the generation of microstructures, linked to performance limits, process windows and the introduction of structural defects (inclusions, porosity, and residual stress)

Unit 4 – Materials as a driver for automotive mass production (4hrs – Dr Chris Gourlay)

- You will evaluate material selection within a car, focussing on steel vs aluminium vs magnesium alloys and the role of a mixed materials strategy where the "right material is in the right place"
- You will consider drivers in the automotive industry, including safety, crash worthiness, mass production and economies of scale
- You will relate microstructure-property relationships in automotive alloys and the engineering goals (cost, performance, weight, processability) and lifetime management
- You will consider alloy recycling and the challenges with recycled alloys

Unit 5 – Materials as an enabler for flight (4hrs – Dr Ben Britton)

- You will consider the engineering design involved in a jet engine, fuselage, and landing gear
- You will explore alloy selection for these demanding aerospace applications (including safety and performance)
- You will relate processing of titanium alloys to microstructure, including the role of phase transformations, phases and local crystal orientations
- You will explore the use of Ni-alloys in the engine, and the role of elemental portioning, microstructure, creep, formability and life
- You will be able to relate microstructure, processing and performance to component failure analysis and revisions to safety cases

Unit 6 – Precipitate control of microalloyed steel (5 hrs, including coursework exercise – Prof T Paxton)

- You will relate thermodynamic stability and solubility to the generation of transition metal cabonitrides
- You will calculate the solubility product
- You will explain thermomechanical processing routes for microalloy steels
- You will apply and develop a software programme to create target microalloy steel microstructures

Recommended textbooks A = required, B = recommended but not essential, C = background reading.	
A	H. K. D. H. Bhadeshia and R. Honeycombe, Steels: Microstructure and Properties, Butterworth-Heinemann; 4th edition (24 Jan. 2017), ISBN-13: 978-0081002704
A	George Krauss, Steels: Processing, Structure and Performance, ASM International; 2nd edition (30 May 2015), ISBN-13: 978-1627080835
A	The Superalloys, RC Reed, CUP, 2007
A	Titanium, Lutjering and Williams, Springer, 2003.
B	Light Alloys: Metallurgy of the Light Metals. IJ Polmear, 3rd Ed., Arnold, 1995.
C	The Jet Engine, Rolls Royce
C	Metals Speciality Handbooks in Nickel and Titanium, ASM Int'l (Donachie)
C	Welding Metallurgy, Second Edition, Sindo Kou http://onlinelibrary.wiley.com/book/10.1002/0471434027
	Journal Articles • Lu, K. "The Future of Metals" (2010) Science v 328 pp 319-320 • Banerjee, D. and Williams, J.C. "Perspectives on titanium science and technology" (2013) Acta Materialia https://doi.org/10.1016/j.actamat.2012.10.043 • Hirsch, J., and Al-Samman, T. "Superior light metals by texture engineering: Optimized aluminum and magnesium alloys for automotive applications" (2013) Acta Materialia https://doi.org/10.1016/j.actamat.2012.10.044 • Rombach, G. "Raw material supply by aluminium recycling – Efficiency evaluation and long-term availability" " (2013) Acta Materialia https://doi.org/10.1016/j.actamat.2012.08.064 • T. N. Baker, "Microalloyed steels", Ironmaking & Steelmaking, 43, 264 (2016) DOI: 10.1179/1743281215Y.0000000063 • T. N. Baker, "Processes, microstructure and properties of vanadium microalloyed steels," Materials Science and Technology, 25, 1083-1107 (2009) DOI: 10.1179/174328409X453253 • P. Gong, E.J. Palmiere , W.M. Rainforth, "Dissolution and precipitation behaviour in steels microalloyed with niobium during thermomechanical processing," Acta Mater., 97, 392 (2015) DOI: 10.1016/j.actamat.2015.06.057 • P. Gong, E.J. Palmiere , W.M. Rainforth ,"Thermomechanical processing route to achieve ultrafine grains in low carbon microalloyed steels, "Acta Mater., 119, 43, (2016) DOI: 10.1016/j.actamat.2016.08.010 • P. Gong, E.J. Palmiere , W.M. Rainforth, "Characterisation of strain-induced precipitation behaviour in microalloyed steels during thermomechanical controlled processing", Acta Mater., 124, 83 (2017) DOI: 10.1016/j.matchar.2016.12.009 • Gu, D.D., Meiners, W., Wissenbach, K. and Poprawe, R., "Laser additive manufacturing of metallic components: materials, processes and mechanisms" International Materials Reviews (2012) http://dx.doi.org/10.1179/1743280411Y.0000000014 • Sames WJ, List FA, Pannala S, Dehoff RR, Babu SS. The metallurgy and processing science of metal additive manufacturing. International Materials Reviews 2016:1, http://www.tandfonline.com/doi/abs/10.1080/09506608.2015.1116649

	• Ashby, M.F. “Multi-objective optimization in material design and selection” Acta Materilia (2000) https://doi.org/10.1016/S1359-6454(99)00304-3

Structure, teaching and learning methods

27 contact hours (lectures + workshops + computational exercise): Autumn term

Assessment

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 a numerical model and exploration in the theme of the solubility product in microalloyed steels.

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%.

MSE 308
Ceramics and Glasses

Course Co-ordinator: Prof Eduardo Saiz
Status: MEng and BEng Third Year option
Pre-requisites: None

Aims

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

Learning outcomes

Part A: Ceramics Processing (Prof E Saiz)

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

- Describe powder characterization methods. Interpret results from powder analysis (particle size, particle size distributions, specific surface areas).
- Describe the different types of particles (particles, agglomerates, granules, flocs, colloids, aggregates).
- Understand the parameters that control powder packing and the dry pressing of ceramic powders.
- Describe the origins and characteristics of different forces between particles including their typical orders of magnitude.
- Explain the types of colloids and explain the different methods to stabilize colloidal suspensions (electrostatic stabilization, steric stabilization, electrosteric stabilization).
- Define the terms zeta potential, isoelectric point, flocculation, coagulation and gelation and explain qualitatively how they are related to interparticle forces.
- Understand the importance of rheology in ceramic and glass processing including rheology of liquids (e.g. melt glass) and suspensions of solid particles in liquid (e.g.

ceramic slips). Newtonian liquids. Non-Newtonian flow. Understand the parameters that determine the rheology of a powder suspension
- 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.
- Understand general concepts in solid-liquid-vapour systems: surface/interface energies; wetting and contact angles; capillary forces and the relevance of these concepts to ceramic and glass processing.
- Describe the different stages of solid state sintering, the mass transport processes occurring and their consequences for the developing microstructure.
- Explain the interaction between grain growth, pore stability and microstructure in solid state sintering and how this can be controlled to give dense fine-grained final microstructures.
- Describe qualitatively the processes taking place during liquid phase and viscous glass sintering, explain the dominant factors in selection of a suitable liquid and critically compare its advantages/disadvantages with respect to solid state sintering.

Part B. Mechanical properties of ceramics and glasses (Dr F Giuliani)

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

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

Part C. Electrodynamic properties and high-frequency applications of ceramics (Prof N Klein)

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

- Explain and calculate the relation between the electrical polarizability and dielectric constant by the Clausius-Mossotti equation.
- Explain the temperature dependence of the dielectric constant by the Clausius-Mosotti equation
- Be able to explain and apply the concept of the complex dielectric permittivity and its relation to the reflection and absorption of electromagnetic waves.
- Explain the concept of a dielectric resonator and its applications in microwave communication technology
- Explain the definition of the Q factor, its relation to the loss tangent and how it is being measured.

- Explain and calculate the dielectric function of an ionic crystal in terms of the harmonic oscillator model and explain its relation to infrared absorption by phonons
- Explain intrinsic and extrinsic microwave losses of ceramics

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

Structure, teaching and learning methods

The course is delivered by lectures (with some class exercises) and parts A and B and C are given concurrently.

Assessment

Examination

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%.

MSE 309
Polymers and Composites

Course Co-ordinator: Prof E Saiz

Status: MEng and BEng Third Year option, MSc Advanced option

Prerequisites: None

Aims

The overall aim of this course is to introduce students to the main methods and fundamental principles used for the processing of polymers and composite materials and to develop an understanding of the factors that influence their mechanical properties

Learning outcomes

Polymers (Prof M Shaffer)

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

- 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

- Derive simple equations relating to polymer rheology and use them to address processing problems
- Introduce the major types of fibre reinforcement used in structural composites, and how they compare
- Describe strategies to maximise alignment of polymer chains to access their intrinsically high strength and stiffness
- Consider the nature of polymer composite matrices and the interface with the reinforcing fibres
- Provide pointers to current research directions in polymer matrix composites, including hierarchical, nanocomposite, and multifunctional systems

Elastic behaviour of composites (Dr F Bouville(tbc))
At the end of this part of the course the student will be able to:

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

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

- appreciate the key engineering and scientific reasons for the development of metal-matrix composites
- describe and classify processing technologies for metal-matrix composites
- understand the role of wetting and adhesion at dissimilar interfaces in the fabrication and mechanical response of composites
- use simple micromechanical models to describe the reinforcement mechanisms in metal-matrix composites

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

- discuss the importance of chemical and thermal compatibility in choosing reinforcement and matrix material
- compare and contrast different processing technologies for the fabrication of ceramic matrix composites
- develop a simple model to estimate the strength of a fibre in a composite
- describe and analyse fibre push-out and pull-out test to measure adhesion at the fibre-matrix interface
- explain the role of interfaces in toughening and crack propagation in CMCs.

Polymer Matrix Composites (tbc)
At the end of this part of the course the student will be able to:

- describe a number of processing technologies for polymer matrix composites
- be aware of a range of new architectures based on fabrics to address the problem of interlaminar cohesion in laminates

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

A
1) RJ Young and PA Lovell "Introduction to polymers" Chapman and Hall 1983
2) D. Hull and T.W. Clyne, An introduction to Composite Materials, 2nd Edition, Cambridge Solid State Series, 1996
3) F. L Matthews, R. D. Rawlings, Composite Materials: Engineering and Science, Chapman and Hall 1994
4) T. W. Clyne,P. J Whiters, An Introduction to Metal Matrix Composites University of Cambridge University of Cambridge. Cambridge Solid State Science Series, 1995
5) K K Chawla, Composite Materials, Springer, 2nd Edition, 1998

B
6) RJ Crawford "Plastics Engineering" Pergammon 1987.
7) AJ Kinloch and RJ Young "Fracture behaviour of polymers" Applied Science 1983
8) JG Williams "Fracture Mechanics of polymers" Ellis Horwood 1984.
9) CB Bucknall "Toughened Plastics" Applied Science 1977 (Dated Introductory parts only)
10) Concise Encyclopaedia of Composite Materials, ed. by A. Kelly, Elsevier, 1999
11) K. K. Chawla, Fibrous Materials, Cambridge University Press, 1998

C
12) M. Taya, R. J. Arsenault, Metal Matrix Composites – Thermomechanical Behaviour, Pergamon Press, 1989
13) K. K. Chawla, Ceramic Matrix Composites, Chapman and Hall, 1993
14) Handbook of Ceramic Composites, ed. by N. P. Bansal, 2005

Structure, teaching and learning methods

The course is delivered by lectures and course material is available through Blackboard.

Assessment

Examination
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%.

MSE 310
Electronic Structures and Opto-Electronic Properties

Course Co-ordinator: Professor Jason Riley
Status: MEng and BEng Third Year option and MSc Advanced MSE option
Prerequisites: A-level Physics and Mathematics

Aims
This course describes the electronic devices used to emit light, transmit light and detect light and to show how these elements can be combined to create integrated systems for fibre optic communications, solar energy conversion and displays.

Learning outcomes
The students will be able to:

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

- Sketch and clearly label the key components of a liquid crystal display.

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

B 1. Optoelectronics, An Introduction. J.H. Wilson and J.F.B. Hawkes, Prentice Hall International Series in Optoelectronics, ISBN 0-13-638495-1.
2. Optoelectronics, An Introduction. J.C.A. Chaimowicz, Butterworth Heinemann, ISBN 0-7506-0803-X.
3. Colour and the Optical Properties of Materials, R.J.D. Tilley, Wiley, ISBN 978-0-470-74695-0

C
4. Physics Of Semiconductor Devices. S.M.Sze, John Wiley and Sons, ISBN 0-471-09837-X.
5. Lectures On The Electrical Properties Of Materials. L. Solymar and D. Walsh, Oxford Science Publications, ISBN 0-19-856280-2.
6. The Physics of Solar Cells, J. Nelson, Imperial College Press, ISBN 1-86094-340-3
7. Introduction to Liquid Crystals: Chemistry and Physics. P.J. Collings, ISBN-10: 074840483X

Structure, teaching and learning methods

The course is delivered by lectures and course material is available through Blackboard.

Assessment

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

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

Examination

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

MSE 312
Nanomaterials I

Course Co-ordinator: Prof Mary Ryan
Status: MEng and BEng 3rd Year option and MSc Advanced Materials option
Prerequisites: None

Aims

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

Learning outcomes

Properties and Processing of Nanostructured Materials (Prof M Ryan)
At the end of the course students should be able to:

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

Electronic Properties of Nanostructured materials (Prof J Riley)
At the end of the course students should be able to:

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

Vapour Phase Deposition of Thin Film Nanostructures (Dr P Petrov)
At the end of this part of the course the student will be able to:

- 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

Ethics and social impact of Nanomaterials (Ryan/Petrov/Dr A Goode)
At the end of this part of the course the student will be able to:

- Understand and discuss the concept of responsible development; and discuss in general terms the potential impact of nanomaterials on human health and the environment

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

B Nanostructures and Nanomaterials - Synthesis, Properties and Applications
Guozhong Cao, Imperial College Press.

C Metal Nanoparticles – Synthesis, Characterization and Applications
D. Feldheim and C. Foss, Marcel Decker

Structure, teaching and learning methods

24 lectures: Autumn term

Assessment

Examination
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 be required to sit an additional examination question. The pass mark for the MSc Advanced Materials is 50%.

MSE 315
Biomaterials

Course Co-ordinator: Prof J R Jones
Status: MEng and BEng 3rd Year Option and MSc Advanced Materials option
Prerequisites: Core modules in years 1 and 2

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

Learning outcomes

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

- Identify various components of the human body, describe their function and explain the effects of ageing on the structure and mechanical properties of various groups of tissues and organs.
- Describe the major classes of biomedical implant materials, their means of fixation, stability and advantages and disadvantages when used as implants devices and in artificial organs.
- Explain the types of failure of implants and devices in various clinical applications and reasons for failure.

- Describe the physiological principles involved in the replacement of various parts of the body with artificial organs, transplants or tissue engineered constructs and the clinical compromises involved.
- Defend the relative merits of replacing a body part with a tissue engineering construct, discuss the principles involved in growing body parts in vitro and describe the physiological and clinical limitations involved.
- Be capable of rapidly researching the literature for new developments in replacement of tissues and organs.
- Be able to communicate alternative means to repair or replace parts of the body to both healthcare professionals and patients.

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

A *Biomaterials, Artificial Organs and Tissue Engineering ,*LL Hench, JR Jones Eds, Woodhead Publishing, 2005

B *Biomaterials Science: An Introduction to Materials in Medicine,* BD. Ratner, AS Hoffman, FJ Schoen, JE Lemons Eds*,* Academic Press, 2004

C An introduction to bioceramics, LL Hench and J Wilson Eds, World Scientific, 2nd edition 2013

Structure, teaching and learning methods

24 lectures: Autumn Term

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

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

Following an introductory lecture, students are split into two groups for two further introductory lectures to bring students from different backgrounds up to speed for the course. The lecture schedule and course layout is attached Materials and Mechanical Engineering students are given two lectures on basic biology concepts in Biology for engineers, Bioengineering students are given an introduction to the properties and structure of metals, ceramics, polymers and composites.

Handouts given at lectures are the slides presented by the lecturer, with space for extra notes. Full notes are not given as this may discourage students from attending.

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

Assessment

Examination

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

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

MSE 317
Materials Modelling

Course Co-ordinator: Prof A Horsfield

Status: Option course for year 3 MEng and BEng, and core course for MSc in Advanced MSE

Prerequisites: N/A

Aims

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

Learning outcomes

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

Introduction (Prof A Horsfield)

- Overview of computer simulation
- Length and time scales
- Introduction to MATLAB

Finite Elements and Crystal Plasticity (Dr Yilun Xu)

- Hamilton's principle
- Use of 1D truss and 2D continuum finite elements for elastic problems
- Crystal slip and the slip rule
- 1D crystal plasticity in fcc single crystals
- 2D FE fcc polycrystal plasticity

Monte Carlo Methods (Prof A Horsfield)

- Understand the algorithm for Metroplolis Monte Carlo
- Apply Metropolis Monte Carlo to finding the equilibrium distribution of one or more particles

Diffusion (Prof A Horsfield)

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

Phase Field Methods (Prof A Horsfield)

- Understand the concept of a phase field
- Understand the relation of the free energy to the equation of motion of the phase field
- Understand the Cahn-Hilliard equation for spinodal decomposition
- Solve the Cahn-Hilliard equation for the spinodal decomposition of a binary alloy.

Energy landscapes (Dr P Tangney)

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

Molecular Dynamics (Dr P Tangney)

- Understand the molecular dynamics method for calculating finite temperature properties.

- Understand how to perform a Molecular Dynamics simulation (velocity Verlet) and a simple way to introduce the effect of a surrounding medium (Langevin dynamics).
- Use Langevin dynamics to compute equilibrium properties of a model polymer in solution

Research Lecture (Dr Joseph Prentice)

- Understand a current research topic that employs computer simulation

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

A *Review: Phase field method* R. S. Qin and H. K. D. H. Bhadeshia, Mater. Sci. Tech., Vol. 26, pp. 803- 811, (2010)

B *Numerical Recipes,* W.H. Press *et al*, Cambridge University Press 1989; *Understanding Molecular Simulation, Second Edition: From Algorithms to Applications,* D. Frenkel and B. Smit, Academic Press (2002).

Structure, teaching and learning methods

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

Assessment

Coursework

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

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

MSE 318
Surfaces and Interfaces

Course Co-ordinator: Prof Sandrine Heutz
Status: MEng/BEng Year Three option and MSc Advanced MSE Option
Prerequisites: Year 1 and 2 Materials course, foundations of solid state Physics and Chemistry.

Aims

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

Outline (to be modified into Learning outcomes)

1. *Structure of surfaces (4 hours)*
    - Nomenclature
    - Defects
    - Techniques: LEED, RHEED, STM/SPM, GIXD
2. *Energy of surfaces (2 hours)*
    - Surface free energy, surface tension
    - Wulff shape
    - Curved interfaces
3. *Electronics and chemical bonding at interfaces (6 hours)*
    - Recap on bonding
    - Charge distribution at surfaces and interfaces
    - Electronic states at surfaces
    - Techniques: XPS, HAXPES, UPS
4. *Reactions at surfaces (3 hours)*
    - Adsorption: chemisorption vs physisorption
    - Diffusion
    - Introduction to film growth (link with MSE412)
5. *Characterising buried interfaces (3 hours)*
    - TEM, SIMS, EXAFS, neutron reflectivity
6. *Case studies (3 hours)*
    - Magnetism
    - Organic electronics
    - Energy

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

A Surface Analysis - The Principal Techniques, John C. Vickerman, Ian S. Gilmore

B Surfaces and Interfaces of Solids, Hans Lüth

C Physics of Surfaces and Interfaces, Harald Ibach

Structure, teaching and learning methods

21 lectures

3 hours student-led article discussion

Assessment

Examination

The course is examined in the summer term. The examination paper, duration 2.5 hours is in 2 sections. Section A is contains short questions and is compulsory (40 marks); section B contains 5 long questions worth 20 marks each, and the students should answer three of those.

Coursework

20 marks are associated with the article presentation exercise (preparation and presentation).

The pass mark for the BEng/MEng cohort is 40% and for the MSc Advanced Materials Science and Engineering programme is 50%. The module contributes 100 marks of the BEng and MEng year 3 programmes.

3. Assessments

Coursework, tests and laboratory exercises make up the coursework mark that is used in the calculation of the year mark. The tables in this section will help you to be able to plan your study and revision timetable based on the due dates for the various elements. Each of the items here have a corresponding assessment description sheet that is included at the end of the handbook. This also includes a rough rubric for each assessment that can be used to guide the preparation of the item.

Coursework elements (excluding laboratory exercises)

Module	Due Date	% Contribution to Module
MSE 307 Coursework	Thurs 13 Dec 18	23%
MSE 302 Lab report	Tues, 8 Jan 18	40%
MSE 302 XRD Classwork	In class	10%
MSE 317 Modelling Problem set 1	Thurs 31 Jan 19	23.3%
MSE 317 Modelling Problem set 2	Thurs 21 Feb 19	23.3%
MSE 301 Literature Review	Thurs 7 Mar 19	5%
MSE 317 Modelling Problem set 3	Thurs 14 Mar 19	23.3%
MSE 301 Materials Engineering Portfolio	Thurs 21 Mar 19	0% (prerequisite for graduation/progression)
MSE 318 Surfaces and Interfaces Essay	Tues 19 Feb 19	10%
MSE 318 Surfaces and Interfaces Slides	Mon 11 Mar 19	-
MSE 318 Surfaces and Interfaces Presentation	Tues 12 Mar 19	10%

Coursework tests

Module	Due Date	% Contribution to Module
MSE 317 Modelling Test	8/05/2019	30%
MSE 301: Managerial Economics	TBC	25%

Exercises for modules outside of the Department of Materials are not captured in this list.

Design study deadlines

Design study contributes 45% of the MSE301 mark.

Assessment title	Group/Individual Deadline	Company Deadline
Initial GANTT chart	Mon 15 Oct 2018 4pm	N/A
Concept design report	Mon 12 Nov 2018 4pm	Mon 19 Nov 2018 4pm
Presentation and defence of concept	Mon 10 Dec 2018 4pm	N/A
Integrated proto-type test day	Mon 11 Feb 2019 4pm	N/A
Technical drawing	Mon 18 Feb 2019 4pm	N/A
Letter to customer	N/A	Mon 18 Feb 2019 4pm
Parts List + Signed off Drawings	N/A	Mon 18 Mar 2019 4pm
Fabrication record	N/A	Mon 18 Mar 2019 4pm
Final design report	Mon 11 Mar 2019 4pm	Mon 18 Mar 2019 4pm
Integrated design test day	13-14/6/2019	
Defence of final design	13-14/6/2019	N/A
Peer marking of contribution	Mon 10 June 2019	N/A
Final Presentation	17-18/6/2019	N/A

4. Assessment forms and rubrics

Individual Coursework Information form

Module code	MSE 301
Year of Study	3rd year
Assignment Name	Literature Review
Academic in Charge	Dr Martyn McLachlan
Marker	Academic assigned as your supervisor
When the assignment is presented to the students	First week of Spring term
Method of submission	Blackboard Learn
Student's self-study hours	10-15 hours of self-study required

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 the main body text should not exceed 2500 words.

Individual Coursework Information Form

Module code	MSE 301
Year of Study	3rd year
Assignment Name	Materials Engineering Portfolio
Academic in Charge	Dr Paul Franklyn
Marker	(Not assessed, but prerequisite to progression/graduation)
When the assignment is presented to the students	In the assessment section of the handbook
Method of submission	Blackboard Learn
Student's self-study hours	1-2 hours (It should be prepared through other components and simply require compilation)

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.

Individual Coursework Information Form

Module code	MSE 302
Year of Study	3rd year
Assignment Name	XRD Class work assignment
Academic in Charge	Richard Sweeney
Marker	GTAs
When the assignment is presented to the students	Middle of autumn term
Method of submission	Hard copy (during in the lesson)
Student's self-study hours	1-hour of revision should be sufficient – a recap will be given during the session.

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.

Guideline mark scheme

Category	**Mark**
Data Table (p6)	/1.5
Structure	/1
Indexing	/2
Structure Factor	/3
Data Table (p12)	/1.5
Graph	/2
Lattice Parameter value	/1
Composition	/2
Doublet explanation	/2
Separation increase explanation	/2
Presentation and clarity	/2
Total	**/20**

Individual Coursework Information Form

Module code	MSE 302
Year of study	3rd year
Assignment name	Lab Report
Academic in charge	Dr Ahu Parry
Marker	Dr Ahu Parry
When the assignment is presented to the students	1st week of the Lectures (Autumn term)
Method of submission	Blackboard Learn
Student's self-study hours	1-2 hours of self-study before each lab session and 10-20 hours before lab report submission

Assignment details

MSE 302 Labs aim to provide students with hands-on experience of advanced characterisation equipment, namely; basic X-ray diffraction (XRD), scanning electron microscopy (SEM), secondary ion mass spectrometry (SIMS), atomic force microscopy (AFM) and transmission electron microscopy (TEM). Students will learn about the aspects of sample preparation for each technique and carry out experiments using each of the analytical tools (where required supported by a skilled demonstrator). The objective is to obtain specific information pertaining the samples provided at the beginning of each laboratory. The characterisation data that is generated is expected to be of a standard that would be suitable for publication in a materials research or education journal. In order to carry out a full analysis of the data students will learn the basic aspects of a number of software tools, including; ImageJ, MatLab, Origin, GSAS and Gwyddion.

Other requirements

The output from the various laboratories are a full write up, detailing the experiments that were conducted and the major findings. The format should resemble the appropriate scientific literature and follow the style of a communication/letter style article.

MSE 302-Materials Characterization-Rubric for 2018-2019 Lab reports

	Criteria	Marks (100 total)
Scientific writing skills, group based work and report quality	✓ Demonstration of the understanding of the characterisation content ✓ Demonstration of group-based work and discussions ✓ Appropriate scientific writing skills ✓ Citation of the appropriate literature	/20
Characterisation Methods	✓ Reporting of the experimental conditions ✓ Analysis of the results (use of different image processing and plot analysis techniques correctly) ✓ Discussion of the results (analytical discussion of the results from both characterization method point of view as well of understanding of the material properties) ✓ Conclusions that has driven from characterisation method and material quality point of view	/70
Questions	✓ Answers to the questions provided in relation to the report content	/10

Individual Coursework Information Form

Module code	MSE 307
Year of Study	3rd Year and MSc Adv
Assignment Name	Enhanced Understanding of Element Partitioning in Alloys
Academic in Charge	Dr Ben Britton
Marker	Alex Foden and Dr Vivian Tong
When the assignment is presented to the students	At the beginning of the lecture course
Method of submission	Blackboard Learn
Student's self-study hours	3-hours Timetabled in Lecture & 6 hours self-study.

Assignment details

Completion of a Matlab based computational exercise where we utilise theories from the lectured course to explore the partitioning of elements in alloys.

Other requirements

Submitted via blackboard, as write up of the assignment. Please include code & a descriptive narrative to answer the questions posed.

Individual Coursework Information Form

Module code	MSE 317
Year of Study	3rd year and MSc Adv
Assignment Name	Modelling Problem set 1
Academic in Charge	Andrew Horsfield
Marker	Yilun Xu
When the assignment is presented to the students	21 January 2018
Method of submission	Blackboard Learn
Student's self-study hours	20 hours of self-study required

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.

Individual Coursework Information Form

Module code	MSE 317
Year of Study	3rd year and MSc Adv
Assignment Name	Modelling Problem set 2
Academic in Charge	Andrew Horsfield
Marker	Andrew Horsfield
When the assignment is presented to the students	4 February 2019
Method of submission	Blackboard Learn
Student's self-study hours	20 hours of self-study required

Assignment details

Carry out 5 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.

Individual Coursework Information Form

Module code	MSE 317
Year of Study	3rd year and MSc Adv
Assignment Name	Modelling Problem set 3
Academic in Charge	Dr Paul Tangney
Marker	Dr Paul Tangney + TBC
When the assignment is presented to the students	25 February 2019
Method of submission	Blackboard Learn
Student's self-study hours	20-hours of self-study required

Assignment details

Students will be provided with a MATLAB code, 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.

The assignment is in two parts:

Part 1: Structural relaxation

Perform structural relaxations of a polymer. Provide images of the final relaxed structure. Provide the potential energy of the relaxed polymer and one sentence to explain why the polymer adopts the shape that it does. A substantial proportion of the marks awarded will be for how low in potential energy the relaxed structure is.
[12 marks]

Part 2: Dynamics

A. Find a suitable time step for molecular dynamics simulations by plotting the standard deviation of the energy fluctuations as a function of time step at two different temperatures. Provide one or two sentences of comment on the plots, and report the value of the time step chosen for use in Part 2B. **[10 marks]**
B. Perform a series of molecular dynamics simulations to explore a property of the system (e.g. average end-to-end distance of the polymer) as a function of temperature or of the properties of the solvent. Report the results in the form of one captioned plot accompanied by one or two sentences of explanation. Marks will be awarded for the quality of the simulations and the quality of the plots and error analysis. The marks for the sentences will be awarded, not for what is discovered, but for their scientific quality, i.e., what is important is that the plot supports the statements made, that the student has thought carefully about the simulations and what they mean, and that the results are presented clearly and logically. **[18 marks]**

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.

Individual Coursework Information Form

Module code	MSE 318
Year of Study	3rd year and MSc Adv
Assignment Name	Essay and Presentation
Academic in Charge	Professor Sandrine Heutz
Marker	Sandrine Heutz and David Payne
When the assignment is presented to the students	First week of lectures in Spring Term
Method of submission	Blackboard learn
Student's self-study hours	10 hours of self-study
Deadline date	Deadline for essay 19th February 2019 4pm (week 6 of lectures). Deadline for providing the presentation file is Monday 11th March 2019 4pm. Presentations 12th March 2019 (week 9 of lectures)

Assignment details

Students will research a paper that includes at least one topic related to surface science and that relates to at least one theme of the department of Materials. They will then write an essay on the paper, developing a critical discussion of the surface science aspects presented in the paper, and giving suggestions for alternative surface science-based approaches to provide further insights into the research problem.

They will then present the paper in a 3-minute "Pecha-Kucha" oral presentation to the rest of the class.

Other requirements

Essay- 1 page minimum font size 11.
Presentation: template provided, includes 9 slides scrolling every 20 seconds.