

Engineering Tripos Part IB, 2P3: Materials, 2018-19

Lecturers

[Dr G McShane and Prof M Sutcliffe](#) [1]

Timing and Structure

Weeks 1-8 Michaelmas term. 16 lectures, 2 lectures/week

Aims

The aims of the course are to:

- Build on the Part IA Materials course to extend understanding of:
- (i) the fundamental thermodynamic and kinetic principles that govern the microstructure and properties of materials;
- (ii) the practical materials processing techniques that employ these principles to manipulate microstructure and properties for engineering applications;
- (iii) strategies for modelling the deformation and failure of materials.

Objectives

As specific objectives, by the end of the course students should be able to:

- Understand the importance of temperature, composition and deformation in controlling the evolution of material microstructure and properties.
- Understand the general principles in interpreting phase diagrams and the theory of phase transformations.
- Understand and describe the concept of the thermodynamic driving force for microstructural change.
- Understand how diffusion occurs, and derive and apply mathematical models of one-dimensional diffusion.
- Understand the analogy between mass diffusion and thermal diffusion.
- Apply thermodynamic and kinetic principles to predict a range of material behaviour, including rubber elasticity, oxidation and corrosion.
- Apply these thermodynamic and kinetic principles to practical materials processing (e.g. solidification and casting; precipitation in metals; crystallisation in polymers; doping of semiconductors).
- Understand and model the deformation response of a range of engineering materials, including temperature-dependent creep and metal forming processes.
- Understand and model the stress-state dependence of failure for a range of engineering materials.

Content

Materials thermodynamics and diffusion (6L, Prof M.P.F. Sutcliffe)

(1) Chap. 17, GLU2; (2) Chap. 21,24-27; (3) Chap. 3-7; (4) Chap. 5,9,17 (5) Chap. 6, (6) Chap. 7, sections 7.4 and 7.5

- Role of entropy: entropic interpretation of the ideal gas law; polymer elasticity.
- Phases and phase diagrams (teach yourself).
- Free energy: thermodynamic basis of phase equilibrium; osmosis.
- Theory of diffusion in solids

- Oxidation and corrosion

Materials processing (6L, Dr G.J. McShane)

(1) Chap. 18, 19, GLU2; (3) Chap. 8-13,15,16,24-26; (4) Chap. 7,10,11,15.

- Phase transformations: thermodynamic and kinetic principles; theory of nucleation and growth; TTT and CCT diagrams.
- Casting of metals.
- Heat treatment of aluminium alloys and steels.
- Diffusion analysis in materials processing.
- Polymer processing.

Deformation and failure of materials (4L, Dr G.J. McShane)

(1) Chap. 6, 13; (2) Chap. 20,22,23; (3) Chap. 15,21,28; (4) Chap. 8.

- Modelling of deformation processing of metals.
- Annealing, recovery and grain size control in metals.
- High temperature deformation and creep in metals; deformation mechanism maps.
- Plasticity and failure: failure envelopes for metals, concrete and fibre composites.

REFERENCES

- (1) ASHBY, M., SHERCLIFF, H. & CEBON, D. *MATERIALS: ENGINEERING, SCIENCE, PROCESSING AND DESIGN*
- (2) ASHBY, M.F. & JONES, D.R.H. *ENGINEERING MATERIALS 1*
- (3) ASHBY, M.F. & JONES, D.R.H. *ENGINEERING MATERIALS 2*
- (4) CALLISTER, W.D. *MATERIALS SCIENCE AND ENGINEERING: AN INTRODUCTION*
- (5) JONES, R.A.L. *SOFT CONDENSED MATTER*
- (6) TABOR, D. *GASES, LIQUIDS AND SOLIDS*

Examples papers

1. Teach Yourself Phase Diagrams (issued before the start of term)
2. Materials Thermodynamics and Diffusion
3. Materials Processing
4. Deformation and Failure of Materials

Booklists

Please see the [Booklist for Part IB Courses](#) [2] for full references for this course.

Examination Guidelines

Please refer to [Form & conduct of the examinations](#) [3].

UK-SPEC

The [UK Standard for Professional Engineering Competence \(UK-SPEC\)](#) [4] describes the requirements that have to be met in order to become a Chartered Engineer, and gives examples of ways of doing this.

UK-SPEC is published by the Engineering Council on behalf of the UK engineering profession. The standard has been developed, and is regularly updated, by panels representing professional engineering institutions, employers and engineering educators. Of particular relevance here is the '[Accreditation of Higher Education Programmes](#)' (AHEP) document [5] which sets out the standard for degree accreditation.

The [Output Standards Matrices](#) [6] indicate where each of the Output Criteria as specified in the AHEP 3rd edition document is addressed within the Engineering and Manufacturing Engineering Triposes.

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Links

[1] <mailto:gjm31@cam.ac.uk>, mpfs1@cam.ac.uk

[2] <https://www.vle.cam.ac.uk/mod/book/view.php?id=364081&chapterid=43421>

[3] <http://teaching.eng.cam.ac.uk/content/form-conduct-examinations>

[4] <http://www.engc.org.uk/ukspec.aspx>

[5] <http://www.engc.org.uk/standards-guidance/standards/accreditation-of-higher-education-programmes-ahep/>

[6] <http://teaching.eng.cam.ac.uk/content/output-standards-matrices>