Materials 2 (SCEE08016) Course Guide

January 2023

This guide sets out the structure and content for the Materials 2 course. It will also guide you on what we expect you to do each week, and the size of each activity. This is to help you pace your studies, keep on track, and adjust where necessary.

The guide has the following sections:

1. Overview of the Course
2. Developing your own **materials toolbox:**
   WHAT, **HOW**, and **Resources**
3. Course Outline
4. Assessments
5. Course delivery
6. How the current course was created, shared values*, asking questions and a philosophy of pedagogy

1. Overview of the Course

The **aim** of the course is to provide a broad introduction to the materials used in engineering, their properties, and structures.

Materials are at the core of all disciplines of engineering. Engineers are better engineers when they have an awareness and understanding of the properties of materials. Science gives us a framework for understanding materials, within which we can include all classes of materials, hence to some extent unifying the treatment of metals, ceramics, polymers and composites. This is materials science. At the heart of materials science is microstructure, which characterises the internal architecture of substances. A description of the composition and internal architecture of materials gives us a basis for understanding engineering properties.

Developing a broad knowledge of the underpinning science of materials, and how this links with properties, enables you to apply these concepts in engineering. This involves thinking carefully, discerning key concepts in a particular situation, and beginning to appreciate the complexities, subtleties and ambiguities that arise when dealing with materials. This skillset is part of your development as a problem-solving engineer.

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*Materials differs from many other engineering subjects: it is a huge subject in itself and, compared with many subjects, you know more already from everyday knowledge and intuition. A team of us developed the course in its current style in Autumn 2020. Our intention was to anchor the course around shared values: love of subject, integrity, care, rigorous science and engineering practice, acceptance and appreciation of people's strengths and differences, play and curiosity.

The **learning outcomes** for the course are:

1. Understand basic concepts of material properties and material structures.

2. Have knowledge of specific material classes: metals, polymers and ceramics; and how to extend this to 'hybrid' material classes e.g. composites and foams.

3. Be familiar with concepts in materials of: selection, processing, and applications in engineering.

4. Think about and link concepts in materials: everyday knowledge, the underpinning science, and engineering applications; and appreciate the importance of materials understanding in all engineering disciplines.

5. Have a foundation of learning to spark curiosity and fascination about materials that extends beyond the course.

Information on the course can also be found in PATH at
https://path.is.ed.ac.uk/courses/SCEE08016_SV1_SEM2/information

2. Developing your own Materials Toolbox

The materials toolbox is a methodology* for dealing with materials in engineering and beyond engineering. In the course we use the methodology as a way of teaching, studying, and learning about materials. Outside the course the methodology can be used to tackle anything that involves materials where you want to take a systematic approach. For example: in other courses, individual and group projects, in industry, and in research.

An intention in the course is that you develop your own **materials toolbox**. As an engineer, you will be able to choose to apply this to any material, even if you have not used the material before. During your career, new materials will be introduced into engineering applications, and developing your materials toolbox will allow you to understand and then use these new materials.

In the course you can develop a foundational set of tools and skills for using with materials in engineering. This materials toolbox is simple but when used with curiosity and care, over time, it can be developed to be extremely powerful for going deep into important and interesting questions in engineering and research.

materials toolbox = WHAT + HOW + Resources

WHAT, **HOW**, and **Resources** are described below.

*A methodology is a high-level system for doing, teaching or studying something

WHAT

The **WHAT** Framework is at the heart of Materials 2. It covers the course content, but it is useful beyond this. Everything in materials science and engineering can be fitted into this framework. It provides the context for the understanding of materials that you will develop during this course, and in the future.

The WHAT Framework

- **Materials**
- **Properties**
- **Small scale structure** (microstructure)
- Processing / manufacturing
- **Applications**

- **Materials** [classes]**,** for example: metals (gold), ceramics (brick), polymers (string), along with other groupings and classifications, such as composites and foams.

- **Properties** describe in precise ways how materials behave.

- **Small scale structure** (we will often use the term **microstructure**) characterises the internal architecture of substances. A description of the composition and internal architecture of materials gives us a basis for understanding engineering properties.

- We will cover **processing / manufacturing** briefly in the course. How you process a material is strongly linked to its properties and microstructure. We will not, however, cover processing and manufacture in depth in Materials 2, as this will come later in your degree programme.

- **Applications** examine how materials are applied to do something useful in engineering. We need to be able to make a part that is useful and to be sure that it performs as we expect. Examples of previous applications are part of any engineer's materials toolbox

HOW

How we learn and use the **WHAT** framework is covered in **HOW**, which gives core concepts for learning, e.g. asking **questions** (asking questions, learning to ask better questions), **interest** (what interests you? what doesn't? how can exploring this help you engage with your learning?) . Being curious and asking questions is a key part of learning well. Further information about **HOW** (core concepts for learning and learning to learn) is in the final section of this guide.

How we want you to engage with your learning: for seminars, laboratories, engaging with us and each other online, and indeed for doing any activity on the course is summarised by:

HOW, IN ACTION
for all involved in the course
1. Show up
2. Bring curiosity and care
3. Focus on what matters

Resources

In the context of the materials toolbox, we define "Resources" broadly, it is not only the resources section on the Materials 2 Learn site.

Resources cover: textbooks, handbooks, manufacturers' data sheets, databases, Ansys GRANTA – materials and processes database and software tools, academic papers – original research publications and review articles. In short, any materials-related resources available in the library and on the internet. You do not need to engage with/learn all of these in this course; you will gradually build your abilities for using resources over time.

The internet and mobile devices have changed how most of us access data significantly – we can now get near-instant access to huge amounts of data. Being able to decide what information we need, where to find it, and what quality it is are key skills that you will develop with practice and over time.

3. Course Outline

Materials 2 is divided into three sections, as shown below. The course outline is intended to help you pace your studies.

<table>
<tr><th>Week</th><th>Topics</th><th colspan="2">Other activities</th></tr>
<tr><td colspan="4">Section 1: Introduction and Materials Foundations</td></tr>
<tr><td>1</td><td>Why are materials important for engineers?
Classification of materials.
What are you going to study in this course?
Introduction to your building own materials toolbox.
How to learn and engage with the course</td><td colspan="2"></td></tr>
<tr><td colspan="4">Section 2: Properties and Microstructure
How do things behave and why? The building blocks for using and understanding materials</td></tr>
<tr><td>2</td><td>Properties:
What are material properties?
How do we find material property data (tests, resources, Ashby materials section chart)?
Testing for mechanical properties; what happens inside the material as it is deformed?</td><td colspan="2" rowspan="3"></td></tr>
<tr><td>3</td><td>Small scale structure (microstructure):
Structures on different length scales
Links between everyday observations, properties, material classes, and small scale structures.
As an engineer, which structures are essentially fixed, and which can you change?</td></tr>
<tr><td>4 – 5</td><td>Small scale structures of metals, ceramics and polymers
Classifications of metals, ceramics and polymers.
The small scale structure of metals, ceramics and polymers and links to their behaviour.
What makes alloys stronger than pure metals?</td><td rowspan="2">Lab
*</td><td rowspan="3">Granta
*</td></tr>
<tr><td>5 – 6</td><td>Phase Diagrams
What are phases in materials?
Use phase diagrams to understand metallic alloy microstructure and properties.</td></tr>
<tr><td colspan="4">Section 3: Materials Stories</td></tr>
<tr><td>7-10</td><td>Examples of applications of materials. Deepening your understanding of materials and making connections through case studies.
Concrete and timber.
Composite materials.
The Challenger disaster and Liberty ships.
Additive manufacturing.</td><td colspan="2"></td></tr>
<tr><td>11</td><td>Revision</td><td colspan="2"></td></tr>
</table>

* Other activities during the course:

- You will have a **Materials 2 lab** scheduled at some point during Weeks 4 to 6. This will appear in your personal timetable.
- You will be introduced to **Ansys Granta materials software** during Materials 2.

4. Assessments

Laboratory
You will do a materials testing laboratory and examine materials. This is assessed by a report (20% of your final grade). The report is submitted online and is due to be 2 weeks after the lab. Flexible Learning Week counts, e.g. if you do the lab in week 4 the report is due to be submitted in Flexible Learning Week, or if you do the lab in week 5 the report is due to be submitted in week 6.

Exam
There will be an exam in the summer examinations (April/May; 80% of your final grade). It will be 90 minutes and be held in an exam hall. It will comprise 4 questions, each marked out of 25. Further details will be given later in the course. Past papers from: 2011-2013, 2015-2020 are relevant; the format is not identical, but the question style and content are relevant to the course. The past papers from 2021 and 2022 are relevant are in the same format as the exam in 2023.

You will be able to take in a single sheet of A4 paper printed or written on both sides with additional notes and reminders which you find useful. We suggest you start building up an idea of what you want to have on this sheet as you engage with the course and the weekly question sets.

5. Course delivery

The course delivery has three parts:

- Staff to students
- Things for you to do
- Feedback – for students and for the course teaching staff

Staff to students: We will give information, videos, resources, questions etc. and guidance on what to do, typically on the Learn site.

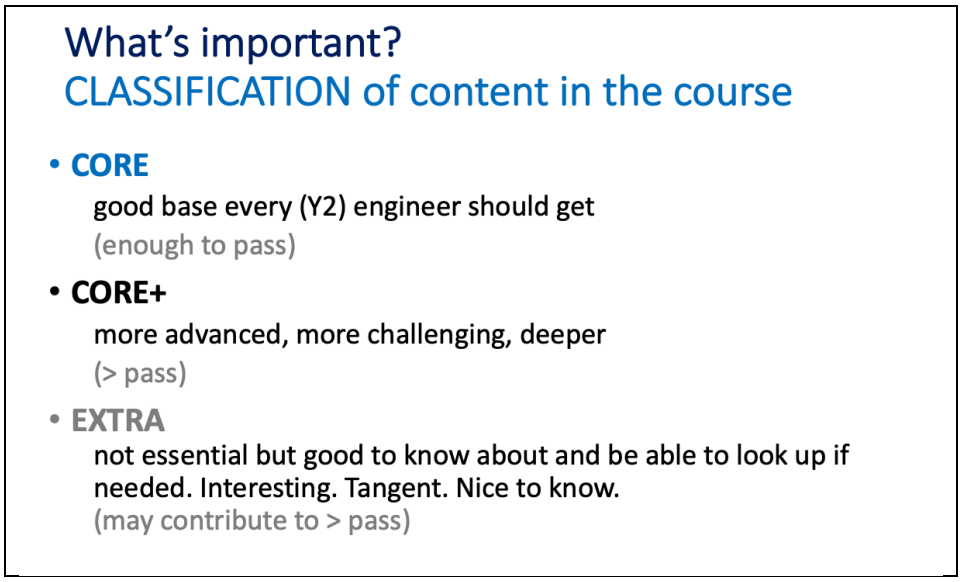
Things for you to do: Your responsibility is to engage with these.

Feedback to students: Following this we will provide feedback in various ways e.g. our responses to questions (written, video format) so you can compare these with your own responses, and begin to learn how to give yourself feedback; **discussions in seminars**; Discussion Board on Learn; using the office hour slots.

Feedback from students to staff: We encourage you to give us feedback on the course to help us develop the course and for you and for future students. Please give us feedback whenever appropriate, you can do this in **seminars**, our office hours, by email (jane.blackford@ed.ac.uk or Tom T.Reynolds@ed.ac.uk), via your course reps, and in course questionnaires.

Weekly overview: Materials 2 Guide to activities for the week
We will provide a weekly overview at the start of each week. Typically, it will be a sheet with a list of activities. The aim of these lists is so you know what is expected of you each week, and the approximate size of each activity. This is to help you pace your studies, keep on track, and make adjustments as necessary.

Classification of content
In the course we'll use the terms **core**, core+ and extra to guide you about the importance and context of course content. It is important to recognise and appreciate these classifications are not absolute – the boundaries between them are blurred.



Seminars
The primary purpose of the seminars is to create in-person connection to allow us all to engage with the course. The key thing with seminars is that you *show up*, and to get the most from them you need to engage with the course materials and questions *before* the seminar.

Surgery hour
We will provide at least one surgery hour each week. In many weeks there will be two surgery hours – one with Jane Blackford and one with Tom Reynolds.

Discussion Board
We will have a Discussion Board on Learn where you can ask questions and we will respond.

6. How the current course was created, shared values, asking questions, and a philosophy of pedagogy

The course in its current style was first delivered in January 2021 and was curated during Autumn 2020 in covid lockdown. It stems from *Materials Science and Engineering 2* that was taught in previous years, however, the style of delivery changed considerably. Development of the course was a collaboration: led by Dr Jane Blackford with Dr Tom Reynolds, Dr James Maguire, Catherine Megregian and Helena Perez-Martin. What follows gives some insight into our process.

From the outset it was our intention that our shared **values** were brought into the course:

- love of subject
- integrity
- care
- rigorous science and engineering practice
- collaboration
- support
- sharing good practice
- acceptance and appreciation of people's strengths and differences
- curiosity
- play – *play is how we learn*
- trust cool stuff to emerge

Key **questions** we had in mind in devising the course were:

- With regard to **materials**, what do **engineers** need to **know**, **understand,** and **do**?
- What's in the best interests of the students, to enhance their learning?
- And learning for the whole course delivery team? So, everyone can perform at their best.

From our conversations, **questions** and reflections while preparing the course a set of **core concepts for learning** emerged. These are at the heart of how we want you to engage with learning: the **HOW** in the **materials toolbox** (while they underpin the course, they may not always be directly apparent to you). They are based on: **experience, neuroscience, psychology, and common sense.** These are central to the course and learning about materials, science and engineering – learning how to learn … anything.

Being curious and asking **questions** is at the heart of learning. Engaging with questions is a route to discovering **knowledge**, **understanding**, and how to **do** things. We discover what **interests** us, and what doesn't. Questions can help us to really **connect** – to connect to learning, to connect materials themselves, and to connect ourselves and each other as we develop our own understanding and abilities to do things.

So, start with what you know, and what you don't. Begin engaging with questions – in your own time and in your own way – that's a great step. It's when we're engaged with questions that other core concepts for learning will naturally come in.

HOW Core concepts for learning
Based on **experience, neuroscience, psychology, and common sense**

#interest
#real stuff
#awareness
#questions
#thinking&linking
#rigour
#clear communication
#resources
#balance
#messy stuff
#into-the-record
#time-to-process
#getting-stuck #making-mistakes
#feedback
#connection
#safe environment
#everyone is different
#curiosity

A **philosophy of pedagogy*** was central to curating the course. This remains **core** for the teaching delivery team to keep in mind. And collectively let's keep the third point in mind, *everyone* involved in the course has opportunities for learning *(#multiscale-learning)*.

A philosophy of pedagogy: there are 3 important pillars in good pedagogy:

- The first is to communicate knowledge and information.
- The second is to create a safe environment that allows the students to be curious.
- And the third is to walk along that path of learning together - student, teacher, and group.

***pedagogy**, *noun,* **definition**: the method and practice of teaching, especially as an academic subject or theoretical concept [from Oxford Languages]