Physical Properties of Materials

Table of Contents

Course Staff ........................................................................................................................................1
Timetable ...........................................................................................................................................2
Your Course at a Glance ....................................................................................................................2
Course Description ...............................................................................................................................3
Assessment .........................................................................................................................................3
References ..........................................................................................................................................4
Learning and Teaching Philosophy Underpinning the Course ...........................................................5
Academic Honesty and Plagiarism .......................................................................................................6
Continual Course Improvement ........................................................................................................7
Administrative Matters ....................................................................................................................7
Rules for Exams .................................................................................................................................8

Course Staff

<table>
<thead>
<tr>
<th>Professor Michael Ferry</th>
<th>Room 341 Materials Science and Engineering (Bldg E10)</th>
<th>Consultation hours: by appointment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecturer (Weeks 2-8)</td>
<td>Phone: 9385 4453 <a href="mailto:m.ferry@unsw.edu.au">m.ferry@unsw.edu.au</a></td>
<td></td>
</tr>
<tr>
<td>Dr Anh Pham</td>
<td>Room 322 Materials Science and Engineering (Bldg E10)</td>
<td>Consultation hours: by appointment</td>
</tr>
<tr>
<td>Lecturer (Weeks 9-13)</td>
<td>Phone: 9385 4427 <a href="mailto:anh.pham@unsw.edu.au">anh.pham@unsw.edu.au</a></td>
<td></td>
</tr>
<tr>
<td>Course Coordinator</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Timetable

<table>
<thead>
<tr>
<th>Type</th>
<th>Day</th>
<th>Week</th>
<th>Time</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>Tuesday</td>
<td>2-8</td>
<td>16:00-18:00</td>
<td>Red Centre (H13) Theatre G001</td>
</tr>
<tr>
<td>Lecture/Tutorial</td>
<td>Wednesday</td>
<td>2-8</td>
<td>11:00-13:00</td>
<td>Webster (G15) Theatre B</td>
</tr>
<tr>
<td>Lecture</td>
<td>Wednesday</td>
<td>9-12</td>
<td>11:00-13:00</td>
<td>Law Building F8 Room 101</td>
</tr>
<tr>
<td>Lecture</td>
<td>Wednesday</td>
<td>13</td>
<td>11:00-13:00</td>
<td>Law Building F8 Room 275</td>
</tr>
</tbody>
</table>

### Your Course at a Glance

<table>
<thead>
<tr>
<th>WEEK</th>
<th>TOPIC*</th>
<th>ASSESSMENT TASK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No scheduled classes for week 1</td>
<td></td>
</tr>
<tr>
<td>2-4</td>
<td>PART I - FUNDAMENTALS OF ELECTRON THEORY</td>
<td></td>
</tr>
</tbody>
</table>
| 2    | • Introduction to the course  
     • Shortcomings of classical physics and the development of quantum physics  
     • Particle and wave nature of matter – Review of de Broglie’s theory, Heisenberg’s uncertainty principle & Pauli’s exclusion principle.  
     • Introduction to the Schrödinger equation – simple solutions to the Schrödinger equation (i.e. free electrons, electron in a potential well, electron tunneling). The wave function and its meaning. Free electron model of a solid. |               |
| 3    | • The Schrödinger equation – model of the hydrogen atom.  
     • Quantum description of the atom: quantum numbers; shapes and distribution of electron orbitals; review of the quantum description of the elements in the periodic table.  
     • The Schrödinger equation – solution for a single electron in the periodic field of a crystal (Kronig-Penney model of a solid). The concept of energy bands in crystals. | TUTORIAL 1 (Parts A-C throughout first 6 weeks) |
| 4    | • Handling multiple electrons in a crystal: Fermi-Dirac statistics; Fermi energy and Fermi surface; density of states; energy bands in crystals; Effective mass of an electron; Brillouin zones  
     • Methods of describing electron energy levels in crystals. Quantum definition of metals, semiconductors & insulators. |               |
| 5-8  | PART II - ELECTRICAL PROPERTIES OF MATERIALS |               |
| 5    | • Electrical conduction in solids  
     • Breakdown of the classical theory of conduction & introduction to the quantum theory and its predictions.  
     • Quantum model of electrical conduction in metals; alloying effects; effect of temperature on conductivity. |               |
| 6    | • Intrinsic semiconducting elements. Compound semiconductors.  
     • Electrical conduction of intrinsic semiconductors: types of charge carriers; relationship between electron and hole densities; conductivity equations.  
     • The combined role of the band gap and temperature on conductivity.  
     • Simple intrinsic semiconductor devices | QUIZ WEEK 8 |
| 7    | • Extrinsic semiconductors: doping - donor and acceptor atoms; conductivity equations; effect of temperature on conductivity - freeze-out curves. |               |
### Course Description

The course will give an overview of modern research topics in material physics with the purpose of encouraging students to engage in the latest research. The focus will be on introducing simple physical model with just enough mathematical formalism to explain the physics in complex materials. The main topics will be: 2D materials, Magnetism and Superconductivity

* A detailed breakdown of topics is given on Page 3 in the Detailed Timetable.

### Assessment

<table>
<thead>
<tr>
<th>Assessment Task</th>
<th>Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Short reports:</strong> Students are expected to summarize their understanding the topics presented in week 9-11 in 2 short reports</td>
<td>20%</td>
</tr>
<tr>
<td><strong>Literature review:</strong> The aim of this assignment is to encourage students to conduct independent literature reviews in the topic of their choices based on the lectures in week 9-11. Students can also choose their own topic based on materials from MATS2001 with prior consultation. The reports are expected to be in professional format similar to a peer-review journal.</td>
<td>40%</td>
</tr>
<tr>
<td><strong>Final presentation:</strong> Student is expected to present their literature review in a group presentation to demonstrate their critical understanding of their own research topics.</td>
<td>40%</td>
</tr>
</tbody>
</table>
NOTE: All reports must contain a completed student declaration sheet and will be due on the dates specified above. Short Reports submitted after the deadline will receive a 10% of maximum grade penalty for every day late, or part thereof. The literature reviews and short reports will be checked for plagiarism. There are no final exams in the course.

Please refer to the UNSW guide to grades:

Assignments Due

<table>
<thead>
<tr>
<th>Assignments due*</th>
<th>Issue</th>
<th>Submission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short report 1</td>
<td>Wed, week 9</td>
<td>Wed, week 13</td>
</tr>
<tr>
<td>Short report 2</td>
<td>Wed, week 9</td>
<td>Wed, week 13</td>
</tr>
<tr>
<td>Literature review</td>
<td>Wed, week 9</td>
<td>Wed, week 13</td>
</tr>
</tbody>
</table>

References

Reference materials include the following textbook (see below) and other course notes handed out throughout the semester. As indicated overleaf, there are numerous other textbooks concerned with the Physical Properties of Materials that students should consult throughout the course.

Reference materials:
Electronic Properties of Materials
Hummel, Rolf E.

Additional required reading materials will be uploaded on Moodle for week 9-11

Other suitable books at elementary level

Learning and Teaching Philosophy Underpinning the Course
(based on UNSW Learning Guidelines)

- **Students are actively engaged in the learning process.**
  It is expected that, in addition to attending classes, students read, write, discuss, and are engaged in solving problems on the electronic properties of materials, and in analysis and evaluation of materials’ electron-related properties in the context of modern theories of physics.

- **Effective learning is supported by a climate of inquiry where students feel appropriately challenged.**
  Problems involving electron theory are challenging; students will be given assignments that will motivate deep analysis of various physical phenomena in materials science and engineering.

- **Learning is more effective when students’ prior experience and knowledge are recognised and built on.**
  This course is built on prior courses in mathematics, physics and chemistry.

- **Students become more engaged in the learning process if they can see the relevance of their studies to professional and disciplinary contexts**
  Students will be asked to analyse the role of electron theory in understanding various physical phenomena in materials science and how properties such as electrical conduction and magnetism influence the science and engineering of existing and new devices and components.

Course Information

<table>
<thead>
<tr>
<th>Units of credit</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parallel teaching</td>
<td>None</td>
</tr>
<tr>
<td>How the course relates to other course offerings and overall program(s) in the discipline</td>
<td>Elements of modern physics are taught as part of first year physics and chemistry courses with mathematics in both first and second years sufficient to understand the content of this course. This course will provide the intellectual framework for understanding physical properties in higher level courses.</td>
</tr>
<tr>
<td>Course aims</td>
<td>To generate a sound understanding of the fundamentals of <em>Modern Electron Theory</em> in order to understand various important physical phenomena including electrical and magnetic properties of materials and to show how such properties influence the design and operation of engineering components and devices used in motors, computers, DVD players, televisions, mobile telephones etc.</td>
</tr>
</tbody>
</table>
| Graduate attributes which will be gained through the course¹ | • Research, inquiry and analytical thinking abilities  
• Capability and motivation for intellectual development  
• Information literacy  
• Ability to communicate effectively  
• Capacity for creativity and innovation  
• Ability to manage information and documentation  
• Ability to function effectively as an individual  
• Capacity for lifelong learning and professional development |
### Expected learning outcomes

<table>
<thead>
<tr>
<th>Expected learning outcomes</th>
<th>Students should gain:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Enhanced critical thinking, analytical and problem solving skills in materials science and engineering</td>
</tr>
<tr>
<td></td>
<td>• A basic understanding of electron theory and its application to a broad range of materials</td>
</tr>
<tr>
<td></td>
<td>• An understanding of the modern physical principles underlying electrical conduction and magnetism in a range of materials</td>
</tr>
<tr>
<td></td>
<td>• An understanding of the importance of Schrödinger’s equation for calculating electrical resistivity in metals, semiconductors and insulators</td>
</tr>
<tr>
<td></td>
<td>• An appreciation of a &quot;materials&quot; contributions and importance in electronic systems</td>
</tr>
</tbody>
</table>

*Based on the professional attributes given in Engineers Australia National Generic Competency Standards - Stage 1 Competency Standard for Professional Engineers and UNSW Graduate Attributes.*

### Academic Honesty and Plagiarism

#### What is Plagiarism?

All details regarding plagiarism can be found here: [https://student.unsw.edu.au/plagiarism](https://student.unsw.edu.au/plagiarism)

It is important to understand what plagiarism is. The general concept is plagiarism is using the words or ideas of others and passing them off as your own. Examples of plagiarism, including self-plagiarism, are:

- **Copying**
  
  Using the same or very similar words to the original text or idea without acknowledging the source or using quotation marks. This includes copying materials, ideas or concepts from a book, article, report or other written document, presentation, composition, artwork, design, drawing, circuitry, computer program or software, website, internet, other electronic resource, or another person's assignment, without appropriate acknowledgement.

- **Inappropriate paraphrasing**
  
  Changing a few words and phrases while mostly retaining the original structure and/or progression of ideas of the original, and information without acknowledgement.
  
  This also applies in presentations where someone paraphrases another's ideas or words without credit and to piecing together quotes and paraphrases into a new whole, without appropriate referencing.

- **Collusion**
  
  Presenting work as independent work when it has been produced in whole or part in collusion with other people. Collusion includes,
  
  - students providing their work to another student before the due date, or for the purpose of them plagiarising at any time
  - paying another person to perform an academic task and passing it off as your own
  - stealing or acquiring another person’s academic work and copying it
  - offering to complete another person’s work or seeking payment for completing academic work.

  This should not be confused with academic collaboration.
• **Inappropriate citation**
  Citing sources which have not been read, without acknowledging the 'secondary' source from which knowledge of them has been obtained.

• **Self-plagiarism**
  ‘Self-plagiarism’ occurs where an author republishes their own previously written work and presents it as new findings without referencing the earlier work, either in its entirety or partially.

  Self-plagiarism is also referred to as 'recycling', 'duplication', or 'multiple submissions of research findings' without disclosure. In the student context, self-plagiarism includes re-using parts of, or all of, a body of work that has already been submitted for assessment without proper citation.

  The Learning Centre also provides substantial educational written materials, workshops, and tutorials to aid students, for example, in:
  
  o correct referencing practices;
  o paraphrasing, summarising, essay writing, and time management;
  o appropriate use of, and attribution for, a range of materials including text, images, formulae and concepts.

  Individual assistance is available on request from The Learning Centre.

  Students are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting, and the proper referencing of sources in preparing all assessment items.

**Continual Course Improvement**

• At the end of the course, students will be asked to provide evaluative feedback through myExperience, the University's course and teaching evaluation and improvement process

• Students are encouraged to address any problems regarding teaching of this course at the annual staff-student meeting

• Student comments on teaching during the session are welcome and will be appreciated

• At times students may be asked to answer a short questionnaire for feedback on the course

**Administrative Matters**

• Students should attend at least 80% of all classes.

• Students unable to submit assignments on time or attend the mid-session quizzes or final exams on health grounds should make a request for special consideration. Information on this process can be found here: [https://student.unsw.edu.au/special-consideration](https://student.unsw.edu.au/special-consideration). Medical certificates or other appropriate documents must be included. Students should also advise the lecturer of the situation.

• Unless otherwise specified in the task criteria, all assignments must be uploaded via Moodle prior to the due date for submission.

• Assignments/lab reports submitted after the due date for submission will receive a 10% of maximum grade penalty for every day late, or part thereof.

• Students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course coordinator prior to, or at the commencement of, their course, or with the Equity Officer (Disability) in the
Equity and Diversity Unit: https://student.unsw.edu.au/disability. Early notification is essential to enable any necessary adjustments to be made.

**Rules for Exams**

Rules governing conduct during exams are given at: https://student.unsw.edu.au/exam-rules