MATS6104

Physical Properties of Materials

Course Outline
Session 1, 2016
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Course staff

<table>
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<tr>
<th>Dr Anh Pham</th>
<th>Room 322 Materials Science and Engineering (Bldg E10)</th>
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<tbody>
<tr>
<td>Lecturer (Weeks 7-12)</td>
<td>Phone: 9385 4427</td>
</tr>
<tr>
<td>Course Coordinator</td>
<td><a href="mailto:Anh.pham@unsw.edu.au">Anh.pham@unsw.edu.au</a></td>
</tr>
<tr>
<td>Consultation hours: by appointment</td>
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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:

- Physics in 2D materials (mainly graphene)
- Topological properties in materials (quantum hall effect, topological insulators and semimetals)
- Strongly correlated systems (Mott transition, (un)conventional superconductivity and magnetism).

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

Timetable

<table>
<thead>
<tr>
<th>Type</th>
<th>Day</th>
<th>Weeks</th>
<th>Time</th>
<th>Location</th>
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<tbody>
<tr>
<td>Lecture</td>
<td>Wednesday</td>
<td>7 - 13</td>
<td>11:00-13:00</td>
<td>Quadrangle Building E15 Rm 1001</td>
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Detailed Timetable

<table>
<thead>
<tr>
<th>WEEK</th>
<th>TOPIC*</th>
<th>ASSESSMENT</th>
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| 7    | • Introduction to the course  
      • Physics of 2D materials:  
         • Basic introduction to tight binding method  
         • Crystal structure of graphene  
         • Simple derivation of graphene’s band structure via tight binding model  
         • Novel properties due to the graphene’s relativistic property  
         • Potential applications of graphene as electronic devices | 3x Short reports |
| 8-9  | • Topological properties of band structure:  
      • Introduction to the integer quantum Hall effect  
      • How topology is related to conductivity  
      • Graphene as a prototypical topological insulator: introduce the spin-orbit effect  
      • Examples of real topological insulator materials  
      • Topological semimetals  
      • Examples of real materials  
      • Their novel properties: how quantum field theory can be studied with real materials. | |
| 10   | • Introducing the electron-electron interaction in materials:  
      • The short coming of the nearly free electron theory, why electron-electron interaction is important in certain cases  
      • Introducing a simplified 1D Hubbard model  
      • The metal-insulator transition (Mott insulator)  
      • Superconductivity pairing  
      • High-temperature superconductor | |
| 11   | • Student Presentation | Final Presentation |
| 12   | • Student Presentation | |

Course Information

| Units of credit | 6 |
| Parallel teaching | None |
| How the course relates to other course offerings and overall program(s) in the discipline | • 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 the latest research. |
| Course aims | • To generate a sound understanding of the fundamentals of Modern Electron Theory in order to understand the recent development in materials theory research |
Graduate attributes which will be gained through the course

- 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

_Students should gain:_

- Enhanced critical thinking, analytical and problem solving skills in materials science and engineering
- A basic understanding of advanced quantum physics and its application to a broad range of novel materials
- An enthusiasm in engaging the latest research in materials physics

Teaching strategies

- Simple mathematical derivation from basic physical model to demonstrate how quantum physics can be applied to understand complex materials.
- Teaching material, including the course outline, lectures, and reading materials from peer-review journal available on Moodle.

Assessment

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<tr>
<th>Assessment Task</th>
<th>Fraction</th>
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<tr>
<td><strong>Short reports</strong>: Students are expected to summarize their understanding the topics presented in week 7-10 in 3 short reports ( &lt; 1000 words)</td>
<td>30%</td>
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<tr>
<td><strong>Due dates</strong>: The short reports need to be submitted no later than the end of class in week 12.</td>
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<tr>
<td><strong>Long report</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 7-10. Students can also choose their own topic based on materials from MATS2001 with prior consultation. The reports are expected to be ~ 3000 words and they need to be in professional format similar to a peer-review journal</td>
<td>30%</td>
</tr>
<tr>
<td><strong>Due dates</strong>: week 12</td>
<td></td>
</tr>
<tr>
<td><strong>Final presentation</strong>: Student is expected to present their literature review in a 10-15 mins presentation+questions/answers to demonstrate their critical understanding of their own research topics.</td>
<td>40%</td>
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<tr>
<td><strong>Held</strong>: weeks 11-12</td>
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**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.
Recommended Reference Materials

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.

**Preferred textbook:**

Electronic Properties of Materials  
Hummel, Rolf E.  

**Other suitable books**

The 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.

**Academic honesty and plagiarism**

<table>
<thead>
<tr>
<th>What is Plagiarism?</th>
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<tr>
<td>Plagiarism is the presentation of the thoughts or work of another as one's own.* Examples include:</td>
</tr>
<tr>
<td>• direct duplication of the thoughts or work of another, including by copying material, ideas or concepts from a book, article, report or other written document (whether published or unpublished), composition, artwork, design, drawing, circuitry, computer program or software, web site, Internet, other electronic resource, or another person’s assignment without appropriate acknowledgement;</td>
</tr>
<tr>
<td>• paraphrasing another person’s work with very minor changes keeping the meaning, form and/or progression of ideas of the original;</td>
</tr>
<tr>
<td>• piecing together sections of the work of others into a new whole;</td>
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<tr>
<td>• presenting an assessment item as independent work when it has been produced in whole or part in collusion with other people, for example, another student or a tutor; and</td>
</tr>
<tr>
<td>• claiming credit for a proportion a work contributed to a group assessment item that is greater than that actually contributed.†</td>
</tr>
</tbody>
</table>

For the purposes of this policy, submitting an assessment item that has already been submitted for academic credit elsewhere may be considered plagiarism.

Knowingly permitting your work to be copied by another student may also be considered to be plagiarism.

Note that an assessment item produced in oral, not written, form, or involving live presentation, may similarly contain plagiarised material.

The inclusion of the thoughts or work of another with attribution appropriate to the academic discipline does *not* amount to plagiarism.
The Learning Centre website is main repository for resources for staff and students on plagiarism and academic honesty. These resources can be located via:

www.lc.unsw.edu.au/plagiarism

The Learning Centre also provides substantial educational written materials, workshops, and tutorials to aid students, for example, in:

- correct referencing practices;
- paraphrasing, summarising, essay writing, and time management;
- 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.

* Based on that proposed to the University of Newcastle by the St James Ethics Centre. Used with kind permission from the University of Newcastle
† Adapted with kind permission from the University of Melbourne.

### Continual course improvement

- Students will be asked to provide evaluative feedback through the UNSW's Course and Teaching Evaluation and Improvement (CATEI) process at the end of the course
- 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://my.unsw.edu.au/student/atoz/SpecialConsideration.html). Medical certificates or other appropriate documents must be included. Students should also advise the lecturer of the situation.
- Assignments/lab reports submitted after the deadline 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 (www.studentequity.unsw.edu.au). Early notification is essential to enable any necessary adjustments to be made.
Rules for Exams

Rules governing conduct during exams are given at:

Note that the use of mobile phones or music players in an exam room will constitute Academic Misconduct.