

## Course Syllabus

PC454 Solid State Physics

Department of Physics and Computer Science, Faculty of Science, Waterloo Campus

Fall | Year 2018

### Instructor Information

Marek S. Wartak | Office N 2076 D

Contact Information (x. 2436/mwartak@wlu.ca)

Weekly Office Hours (M 2:00 -3:00 pm) or By Appointment

### Course Information

The purpose of this course is to acquaint the student with the fundamentals of solid state physics. This emphasis is on understanding the behavior of electrons in metals and semiconductors. Topics discussed: crystal structure, reciprocal lattice, crystal binding and elastic constants, phonons, free-electron Fermi gas, energy bands, semiconductor crystals and Fermi surfaces.

Credit: 0.50

Prerequisite: PC321

Course location: MWF 12:30-1:20 pm in N1058

### Course Overview and Approach

Quoting Wikipedia:

*Condensed matter physics is the field of physics that deals with the macroscopic and microscopic physical properties of matter. In particular, it is concerned with the “condensed” phases that appear whenever the number of constituents in a system is extremely large and the interactions between the constituents are strong. The most familiar examples of condensed phases are solids and liquids, which arise from the electromagnetic forces between atoms.*

This is a fourth year introductory course in solid state/condensed matter science. The course is structured in terms of thematic units which will help students study in a fair detail and understand the most important aspects of metals, semiconductors and isolators. The course is lecture based. During each class I would ensure that students will find the topics interesting and ask questions if they need more clarification. After the lecture I would expect students to have at least basic understanding of the most important parts of the topics discussed. Furthermore, I would like to provide students with the opportunity to develop an interest in this very important subject area.

Solid state physics is my specialty and field of the research. Next, I want to help students with helpful responses and guidance during the teaching of the course. As an instructor I will try to provide students with an opportunity to engage in this exciting learning process, and provide them with a constructive feedback that can help them improve their understanding of the subject.

## Course Goals and Learning Outcomes

**Pre-requisites:** Basic knowledge of calculus, classical mechanics, electricity and magnetism, statistical mechanics, quantum mechanics.

After taking this course you will, among other things, be able to

- have basic understanding of solid state concepts
- understand basic mechanisms of flow of current
- understand concept of the reciprocal lattice
- understand the Bravais lattices

## Course Tools and Learning Materials

- Principal course textbook is: M.S. Rogalski and S.B. Palmer, "Solid State Physics", Gordon and Breach Science Publishers, 2000.
- Lecture notes on some of the topics will also be available and distributed to students electronically.
- Useful References:
  1. Charles Kittel, "Introduction to Solid State Physics. Eight Edition", John Wiley 2005.
  2. Solid State Physics, N. W. Ashcroft and N. D. Mermin, Harcourt College Publishers (1976). This is an excellent text that covers most of the key material in the course. However, much of it is at a higher (graduate) level. Despite this, I think that all students would benefit from many of the excellent presentations in it.

## Student Evaluation

Evaluation will be done according to a table below.

Assessment	Weighting	Due Date
Assignment 1	10%	Sept. 28, 2018
Assignment 2	10%	Oct. 19, 2018
Assignment 3	10%	Nov. 16, 2018
Midterm	30%	In class, in mid-October
Term Project	30%	November 30, 2018
Research Paper Presentation	10%	In class, week 12
<b>Total</b>	<b>100%</b>	

## Tentative Weekly Schedule

Week # and Dates	Topic	Comments
Sept. 7, 2018	General info	
Week 1. Sept.10-Sept.14	Crystal structure	Bravais lattice, primitive cell, lattice with a basis, common crystal structures (simple cubic, face centered cubic, body centered cubic, diamond, and hexagonal), Miller indices, and classification of Bravais lattice.
Week 2. Sept.17-Sept.21	X-ray diffraction	

Week # and Dates	Topic	Comments
Week 3. Sept.24-Sept.28	Drude model	Basic assumptions of Drude model, DC electrical conductivity of a metal, Hall effect magnetoresistance, and AC electrical conductivity of a metal.
Week 4. Oct.1-Oct.5	Collisions, Hall effect	
Week, Oct. 9 -Oct.12	Reading Week	No classes
Week 5. Oct.15-Oct.19	Lattice vibrations	Lattice vibration, quantization of elastic waves, phonon momentum, and phonon heat capacity.
Week 6. Oct.22-Oct.26	Phonons	
Week 7. Oct.29-Nov.2	One-electron theory	Ground state properties of electron gas, periodic boundary conditions, Fermi sphere and Fermi surface, thermal properties of free electron gas, and electronic specific heat.
Week 8. Nov.5-Nov. 9	Band structure	
Week 9. Nov.12-Nov. 16	Carrier transport	Drift-diffusion theory, Boltzmann equation
Week 10. Nov.19-Nov. 23	Semiconductors	Band structures of semiconductors, intrinsic carrier concentration, and impurity conductivity
Week 11. Nov.26-Nov. 30	Superconductivity	Critical temperature, Meissner effect, BCS theory, Josephson effect
Week 12. Dec.3-Dec. 5	Student's presentations	

### University and Course Policies (proposed and required text)

Laurier has several senate approved policy statements it requires instructors to include in their syllabus. Those with specific wording approved by senate are indicated specifically below.

- 1. Academic Calendars:** Students are encouraged to review the [Academic Calendar](#) for information regarding all important dates, deadlines, and services available on campus.
- 2. Special Needs:** Students with disabilities or special needs are advised to contact Laurier's Accessible Learning Centre for information regarding its services and resources.
- 3. Plagiarism:** The University has approved the following wording for inclusion on all course syllabi about the use of the institutionally supported plagiarism software tool. "Wilfrid Laurier University uses software that can check for plagiarism. If requested to do so by the instructor, students are required to submit their written work in electronic form and have it checked for plagiarism." (Approved by Senate May 14, 2002) .

In addition to the statement above you may wish to add the following text about academic integrity.

- 4. Academic Integrity:** Laurier is committed to a culture of integrity within and beyond the classroom. This culture values trustworthiness (i.e., honesty, integrity, reliability), fairness, caring, respect, responsibility and citizenship. Together, we have a shared responsibility to uphold this culture in our academic and nonacademic behaviour. The University has a defined policy with respect to academic misconduct. As a Laurier student you are responsible for

familiarizing yourself with this policy and the accompanying penalty guidelines, some of which may appear on your transcript if there is a finding of misconduct. The relevant policy can be found at Laurier's [academic integrity](#) website along with resources to educate and support you in upholding a culture of integrity. Ignorance is not a defense.

5. **Classroom Use of Electronic Devices:** State your classroom practice and any consequences for student failure to comply – see [Policy 9.3](#) (Approved by Senate March 8, 2012).
6. **Late Assignment Policy:** Specify any penalties that will be assessed when deadlines for the completion of course components are not met (Approved by Senate May 23, 2012). Refer to the Handbook on Undergraduate Course Management for more information.
7. **Final Examinations:** Students are strongly urged not to make any commitments (i.e., vacation) during the examination period. Students are required to be available for examinations during the examination periods of all terms in which they register. Refer to the Handbook on Undergraduate Course Management for more information.
8. **Foot Patrol, the Wellness Centre, and the Student Food Bank:** The University approved the inclusion of information about select wellness and safety services and supports on campus in the course information provided to students. (Approved by Senate November 28, 2011.) Specific language (by campus) is provided below.

**Multi-campus Resource:**

- Good2Talk is a postsecondary school helpline that provides free, professional and confidential counselling support for students in Ontario. Call 1-866-925-5454 or through 2-1-1. Available 24-7.

**Kitchener/Waterloo Resources:**

- [Waterloo Student Food Bank](#): All students are eligible to use this service to ensure they're eating healthy when overwhelmed, stressed or financially strained. Anonymously request a package online 24-7. All dietary restrictions accommodated.
- [Waterloo Foot Patrol](#): 519.886.FOOT (3668). A volunteer operated safe-walk program, available Fall and Winter daily from 6:30 pm to 3 am. Teams of two are assigned to escort students to and from campus by foot or by van.
- [Waterloo Student Wellness Centre](#): 519-884-0710, x3146. The Centre supports the physical, emotional, and mental health needs of students. Located on the 2<sup>nd</sup> floor of the Student Services Building, booked and same-day appointments are available Mondays and Wednesdays from 8:30 am to 7:30 pm, and Tuesdays, Thursdays and Fridays from 8:30 am to 4:15 pm. Contact the Centre at x3146, [wellness@wlu.ca](mailto:wellness@wlu.ca) or @LaurierWellness. After hours crisis support available 24/7. Call 1-844-437-3247 (HERE247).

**Brantford Resources:**

- [Brantford Student Food Bank](#): All students are eligible to use this service to ensure they're eating healthy when overwhelmed, stressed or financially strained. Anonymously request a package online 24-7. All dietary restrictions accommodated.

- [Brantford Foot Patrol](#): 519-751-PTRL (7875). A volunteer operated safe-walk program, available Fall and Winter, Monday through Thursday from 6:30 pm to 1 am; Friday through Sunday 6:30 pm to 11 pm. Teams of two are assigned to escort students to and from campus by foot or by van.
- [Brantford Wellness Centre](#): 519-756-8228, x5803. Students have access to support for all their physical, emotional, and mental health needs at the Wellness Centre. Location: Student Centre, 2nd floor. Hours: 8:30 am to 4:15 pm Monday through Friday. After hours crisis support available 24/7. Call 1-884-437-3247 (HERE247).