

ENGPYHS 3F03
Principles of Solid-State Materials and Devices
Undergraduate Studies
Fall 2021
Course Outline

CALENDAR/COURSE DESCRIPTION

Application of quantum and statistical mechanics to the electronic, structural and optical behaviour of solids. Topics will include crystal structures, diffraction, electrical conductivity, band theory, lattice vibrations and semiconductors.

PRE-REQUISITES AND ANTI-REQUISITES

Prerequisite(s): ENGPYHS 2QM3 or PHYSICS 2C03 and registration in an Engineering program
Antirequisite(s): None

INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION

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Office Hours:

By appointment

TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION

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COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION

<http://avenue.mcmaster.ca/>

This course will have live Zoom lectures. Attendance and participation in these is expected and will be worth up to 10% of the final grade. Be sure to have an identifiable (and consistent) Zoom username to receive credit for class attendance. The lectures will be recorded and uploaded to Avenue to Learn for review.

COURSE INTENDED LEARNING OUTCOMES

By the end of this course, students should be able to:

- Describe and quantify crystal structures
- Use diffraction theory to characterize crystals
- Demonstrate a conceptual understanding of reciprocal space and its application to waves in solids
- Solve problems relating to the Drude and free electron models of metals
- Understand band theory and how it gives rise to metals, semiconductors and insulators
- Demonstrate a conceptual understanding of the properties of semiconductors, dielectrics and superconductors

MATERIALS AND FEES

Required Texts:

“Solid State Physics: An Introduction” 2nd edition, by Philip Hofmann (Wiley-VCH, 2015)

Optional Reference Texts:

“Introduction to Solid State Physics”, by Charles Kittel. This is a classic undergraduate-level solid state physics textbook (first published in 1935). However, the book does not get great reviews from students and older versions are usually preferred

“The Oxford Solid State Basics”, by Steven H. Simon. This is an excellent book that is very concise. However, it presumes an understanding of the matrix mechanics formalism of quantum mechanics, which has not been covered in prerequisites for this course. A rough draft is available for free through the author’s website:
<http://www---thphys.physics.ox.ac.uk/people/SteveSimon/condmat2012/LectureNotes2012.pdf>

“Solid State Physics”, by N. W. Ashcroft and D. N. Mermin. This is another classic. It is at a higher level than Kittel and Hofmann. It goes into detail on almost everything and it is a great reference for anyone wanting further reading on a subject.

Calculator:

Only the McMaster Standard Calculator will be permitted in tests and examinations. This is available at the Campus Store.

COURSE FORMAT AND EXPECTATIONS

The course is organized as follows:

- 3 live online lectures per week delivered through Zoom. These lectures will be recorded and subsequently uploaded to Avenue to Learn
- 6 assignments
- 2 tests
- Final exam

COURSE SCHEDULE

Week	Topic	Readings
1	Crystal structure	Hofmann Ch. 1
2	More crystal structure, reciprocal space	Hofmann Ch. 1
3	Diffraction	Hofmann Ch. 1
4	More diffraction, lattice vibrations	Hofmann Ch. 4
5	Thermal properties	Hofmann Ch. 4
6	Midterm break	
7	Drude theory of metals	Hofmann Ch. 5
8	Free electron model, quantum statistics	Hofmann Ch. 6
9	Nearly free electron model, band theory	Hofmann Ch. 6
10	Semiconductors	Hofmann Ch. 7
11	More semiconductors	Hofmann Ch. 7
12	Dielectrics	Hofmann Ch. 9
13	Superconductivity	Hofmann Ch. 10
14	Review	

ASSESSMENT

Component	Weight
Class participation	x, up to 10%
Assignments	$(1-x)*40\%$
Tests	$(1-x)*25\%$
Final Exam	$(1-x)*35\%$
Total	100%

Students can earn a class participation mark of up to 10% of the final grade by attending and participating in the live lectures (i.e., taking part in polls, breakout room discussions, etc.). A student's participation mark will be 10% times the fraction of lectures participated in. Other course assessments (assignments, tests, exam) will be reweighted to make up the remaining portion of the final grade. For example, if a student attends 70% of the live components they will receive 7% towards the final grade, with the other assessments reweighted to make up the remaining 93%. This is intended to encourage lecture and tutorial attendance without penalizing those who cannot or choose not to attend.

You are encouraged to discuss assignments with your classmates. However, posting, sharing and searching questions/answers on chegg.com and similar sites for is strictly forbidden. The calculations and the assignment that you hand in must be your own work. In carrying out calculations on tests or assignments, it is important to explain what you are doing. In addition to helping with learning, explaining a rational thought process will score points even if the calculation is incorrect.

ACCREDITATION LEARNING OUTCOMES

The Learning Outcomes defined in this section are measured for Accreditation purposes only and will not be directly taken into consideration in determining a student's grade in the course.

Outcomes	Indicators
Describe and quantify crystal structures	1.1, 1.3
Use diffraction theory to characterize crystals	1.1, 1.2, 1.4
Demonstrate a conceptual understanding of reciprocal space and its application to waves in solids	1.1, 1.2, 1.4
Solve problems relating to the Drude and free electron models of metals	1.2, 1.4
Understand band theory and how it gives rise to metals, semiconductors and insulators	1.2, 1.4
Demonstrate a conceptual understanding of the electronic properties of semiconductors	1.2, 1.4

For more information on Accreditation, please visit: <https://www.engineerscanada.ca>

EQUITY, DIVERSITY, AND INCLUSION

Every registered student belongs in this course. Diversity of backgrounds and experiences is expected and welcome. You can expect your Instructor to be respectful of this diversity in all aspects of the course, and the same is expected of you.

The Department of Engineering Physics is committed to creating an environment in which students of all genders, cultures, ethnicities, races, sexual orientations, abilities, and socioeconomic backgrounds have equal access to

education and are welcomed and treated fairly. If you have any concerns regarding inclusion in our Department, in particular if you or one of your peers is experiencing harassment or discrimination, you are encouraged to contact the Chair, Associate Undergraduate Chair, Academic Advisor or to contact the [Equity and Inclusion Office](#).

PHYSICAL AND MENTAL HEALTH

For a list of McMaster University's resources, please refer to the [Student Wellness Centre](#).

ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. **It is your responsibility to understand what constitutes academic dishonesty.**

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the [Academic Integrity Policy](https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/), located at <https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/>

The following illustrates only three forms of academic dishonesty:

1. plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
2. improper collaboration in group work.
3. copying or using unauthorized aids in tests and examinations.

COURSES WITH AN ON-LINE ELEMENT

McMaster is committed to an inclusive and respectful community. These principles and expectations extend to online activities including electronic chat groups, video calls and other learning platforms.

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure, please discuss this with the course instructor.

CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the [Code of Student Rights & Responsibilities](#) (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online.**

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable

participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

ACADEMIC ACCOMMODATION OF STUDENTS WITH DISABILITIES

Students with disabilities who require academic accommodation must contact [Student Accessibility Services \(SAS\)](#) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's [Academic Accommodation of Students with Disabilities](#) policy.

COURSE POLICY ON MISSED WORK, EXTENSIONS, AND LATE PENALTIES

1. It is the students' responsibility to regularly check the course webpage (Avenue to Learn) for updates and announcements.
2. Work handed in 0–24 h after a deadline will receive a 50% late penalty. Work submitted > 24 h after a deadline will receive an automatic mark of 0.

SUBMISSION OF REQUEST FOR RELIEF FOR MISSED ACADEMIC WORK

In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar "Requests for Relief for Missed Academic Term Work".

1. **Relief for missed academic work worth less than 25% of the final grade resulting from medical or personal situations lasting up to three calendar days:**
 - Use the [McMaster Student Absence Form \(MSAF\)](#) on-line self-reporting tool. No further documentation is required.
 - Students may submit requests for relief using the MSAF once per term.
 - An automated email will be sent to the course instructor, who will determine the appropriate relief. Students must immediately follow up with their instructors. Failure to do so may negate the opportunity for relief.
 - The MSAF cannot be used to meet a religious obligation or to celebrate an important religious holiday.
 - The MSAF cannot be used for academic work that has already been completed attempted.
 - An MSAF applies only to work that is due within the period for which the MSAF applies, i.e. the 3-day period that is specified in the MSAF; however, all work due in that period can be covered by one MSAF.
 - The MSAF cannot be used to apply for relief for any final examination or its equivalent. See *Petitions for Special Consideration* above.
2. **For medical or personal situations lasting more than three calendar days, and/or for missed academic work worth 25% or more of the final grade, and/or for any request for relief in a term where the MSAF has been used previously in that term:**
 - Students must report to their Faculty Office to discuss their situation and will be required to provide appropriate **supporting documentation**.
 - If warranted, the Faculty Office will approve the absence, and the instructor will determine appropriate relief.

ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the [RISO](#) policy. Students should submit their request to their Faculty Office **normally within 10 working days** of the beginning of term in which they anticipate a need for accommodation or to the

Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.