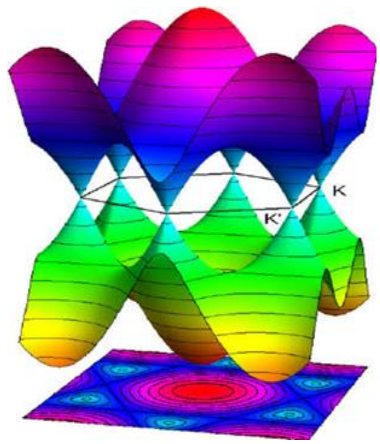
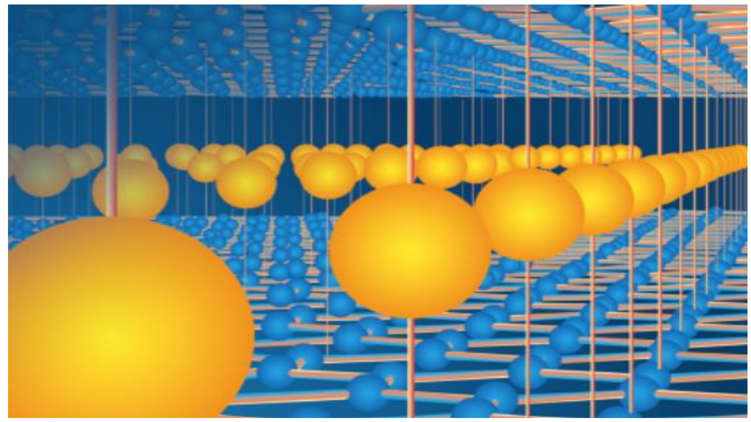
BU Electrical & Computer Engineering





Welcome to EC 577/MS 577 Electrical, Optical and Magnetic Properties of Materials!

This course provides an introduction to the rich field of solid state physics as it pertains to materials science and electrical engineering applications. You will develop an understanding of the theory of crystal structures and their determination via diffraction, as well as the thermal, electrical, optical properties of materials that arise from these structures. You are encouraged to explore a broader array of topics through miniprojects in the form of brief presentations or posts. Ultimately I hope you will develop a solid basis for further exploration, and that you will appreciate the many facets of the field.

Prerequisites This course does not have any graduate level prerequisites but require that you have an adequate undergraduate level preparation in several related areas: **Math:** differential equations such as wave equation, integrals, complex variables, (especially Euler's Equations to express sine and cosine in polar notation). **Classical Physics:** Newton's laws, Coulomb's law, Ohm's laws, waves, simple harmonic oscillators. **Modern Physics:** Waves, Schrödinger equation, particle-wave duality. **Chemistry:** Atomic structure, bonds, periodic table. **Thermodynamics/stat-mech:** Heat-energy, heat capacity, kinetic gas theory, equipartition theorem, Fermion- and Bose-Einstein statistics. **Fourier transforms (FT):** Much of the course relates the periodicity in real space to reciprocal space; hence, familiarity with FT will be helpful for you.

LEARNING AND LEARNING COMMUNITY

Our combined input and participation is crucial to create a supportive learning community. In order to learn succesfully, the aim is to work together as a team, in the **classroom**, on the **Piazza** discussion board, in **homework groups** and in **office hours**.

Classroom: Make an attempt at getting to know your classmates. Before class, talk to your classmates. Contribute to the class by following, asking and answering questions. If you don't follow, please ask- certainly other people will be in the same situation.

Homework groups: You will have the option to work in a HW group and meet 1-3 times a week. You could start by ensuring the group understands the questions and have an idea of the path towards solving it.You can work on HW solutions together or apart, compare and discuss solutions and or answers. (see below regarding cheating).

Homework: The 10 HWs will help you learn the material by engaging with it at least twice; you will work through it (with others) and hand it in, and *you* will check the accuracy with the help of posted solutions. You will be graded on your knowledge on the tests.

Questions, information and suggestions: We will use **Piazza** as the communications platform. If something is unclear to you, or you found a good online resource, it is likely that many students will benefit from knowing the answer. If you have a question about the course, please post your question and other inputs *to the whole class* on piazza. If you have a question/comment of a personal nature, you can post to a specific instructor privately.

Miniprojects: You are encouraged to research a topic (not your own research) related to the course to broaden the exposure to solid state physics. You can either give a very brief presentation or make a post on Piazza and earn extra points. Sign up on the google sheet if you want to present

Learning resources: There will be instances where it would be useful to have background material available. When you find something useful, please post it on Piazza to help everyone and earn extra points.

Student hours: Both I and your TAs will hold weekly student hours. Times to be determined afer you fill out the Whentomeet link,

COURSE ORGANIZATION

Instructor:	**Prof Anna Swan** office PHO 828
TAs	**Yuyang Gu**
	Umut Yazlar MW 11-12 PHO822
Communication:	**Piazza:** Course communication will take place on Piazza. You are responsible for keeping up-to-date with the course on Piazza, e.g. change of office hours, clarifications on homework, deadlines etc. Use Piazza for questions and comment to me and your peers, i.e., do not email me a general question, instead **post questions on Piazza**. (You can sign up for email notification) **Blackboard** will be used for turning in homework, posting of materials, and grades.
Lectures:	MW 12:20- 2:05 pm in CAS216
Student hours:	To be determined by you when ou fill out When2meet.
Course Book	The Oxford Solid State Basics by Steven Simon, Oxford University Press. Copies at the BU bookstore. There are lectures from the author, Steven

Simon, posted online that are very good, and you are encouraged to listen to them.

Other books:

- Solid State Physics, an Introduction by Philip Hofmann 2nd edition, online resources
- Kittel, Introduction to Solid State Physics (Wiley and Sons- 8th Ed.) (More topics than covered in this course)
- Ashcroft and Mermin, Solid State Physics (Thomson Learning) (more advanced, but starts out with classical models, like Simon, and goes deeper in several stages.)

GRADING

- Homework 10%.
- Midterms 45%
- Final 45%
- Up to 2 extra points total
  - Learning resource Piazza posts 0.25 points
  - Miniproject Piazza posts. 0.5 points
  - Mini-project presentations (3-4 minutes): 1.0 points
    MAX 2 presentations per lecture. Only 1 presentation per student.

F<55, D<70, Cs <80, Bs<90, A-<93, A[93,100] X-[90-<93],X[93,<97], X+[97<90]
Your grade will be based on your performance, not on how well or poorly other students do. Let's collaborate!

Life happens: If you have questions and concerns about assignments, deadlines, learning community or anything else, please contact me.

UNIVERSITY POLICIES AND RESOURCES

Academic conduct
Please see the university policy on proper academic conduct and what constitutes academic misconduct. In the case of academic misconduct in this class, established academic discipline procedures will be followed. http://www.bu.edu/ceit/university-policies/academic-conduct/

Midterms and exams: No help from other sources than authorized material is allowed. Helping someone else also is considered cheating.

Homework and Study Collaboration: Discussion with your peers and instructors of homework and projects are strongly encouraged. However, homework solutions has to be your own work; copying a homework solution is cheating.

Use of generative AI in the course I invite you to use AI tools and resources to support your learning. These tools can be helpful for quizzing your knowledge and understanding, brainstorming, drafting, editing, and revising your work. However, it is important to use them ethically and responsibly. Here are some ethical considerations:

- AI tools can perpetuate biases and stereotypes. Be critical of the output of AI tools and be aware of your own biases.
- Do not use AI tools to plagiarize or to generate content that is not your own.
- Be transparent about your use of AI tools. Cite AI tools in your work and explain how you used them.
- You are welcome to use AI tools to brainstorm ideas and to draft your assignments. However, you must revise and edit your work carefully before submitting it.
- You are not allowed to use AI tools to generate content for assignments that require you to demonstrate your original thinking and analysis.
- If you are unsure whether or not you can use AI tools for a particular assignment, please ask me.

Follow the the BU CDS generative AI assistance policy: Add an appendix showing
(a) the entire exchange, highlighting the most relevant sections;
(b) a description of precisely which AI tools were used (e.g. ChatGPT private subscription version or DALL-E free version),
(c) an explanation of how the AI tools were used (e.g. to generate ideas, turns of phrase, elements of text, long stretches of text, lines of argument, pieces of evidence, maps of conceptual territory, illustrations of key concepts, etc.);
(d) an account of why AI tools were used (e.g. to save time, to surmount writer's block, to stimulate thinking, to handle mounting stress, to clarify prose, to translate text, to experiment for fun, etc.).

Student resources

The Provost office of graduate affairs resources The provost office has a wealth of resources for students, both for academic, professional, health and "good to know" resources. Check it out.

Tentative Syllabus

date	L#	Topic	Chapter	
3-Sep	1	Introduction to course	1	
9-Sep	2	Metals: free electron system: Drude model	3	
11-Sep	3	Metals: Free electron system Sommerfeld model	4	
16-Sep	4	Metals: Free electron system Sommerfeld model	4	
18-Sep	5	Periodic table, atomic bonds (should be mostly review)	5-7	
23-Sep	6	Practice problems	4	
25-Sep		MIDTERM 1	1,3,4	
30-Sep	7	Thermal properties without considering crystal structure	2	
2-Oct	8	Thermal properties without considering crystal structure	2	
7-Oct	9	Crystal lattice vibrations: Classical and quantum properties	8-10	
9-Oct	10	Crystal Lattice vibrations: Thermal properties	8-10	
15-Oct	11	Crystal structure, lattices	12	
16-Oct		MIDTERM 2	2,5-10	
21-Oct	12	Reciprocal Lattice, Brillouin zones, and electronic and vibrational modes	13	
23-Oct	13	Bragg's law and wave scattering in periodic structures	14	
28-Oct	14	Scattering, continued.	14	
30-Oct	15	1D tight binding chain for electrons	11	
4-Nov	16	Electron energy bands, Bloch theory, Nearly free electron model	15	
6-Nov		MIDTERM 3 (lattice, reciprocal lattice, scattering)	12-14	
11-Nov	17	Insulators, Semiconductors and Metals	16	
13-Nov	18	Fermi surfaces	16	
18-Nov	19	Band structure and Optical Properties	16	
20-Nov	20	Theory of Semiconductors: carriers & conductivity, effective mass		
25-Nov	21	Semiconductor devices	17	
27-Nov		Thanksgiving break		
2-Dec	22	Quasi-particles excitons, plasmons, polarons, polaritons	notes	
4-Dec	23	Quasi-particles excitons, plasmons, polarons, polaritons	notes	
9-Dec	24	Final Review		