PHYS 6/8540: Structure, Defects, and Diffusion  
CHEM 4/6/8810: Materials Science 1  
The University of Toledo  
College of Natural Sciences and Mathematics  
PHYS 6540 – 001 CRN 40844  
PHYS 8540 – 001 CRN 40847  
CHEM 4810 – 001 CRN 47569  
CHEM 6810 – 001 CRN 40845  
CHEM 8810 – 001 CRN 40846  

Instructor: Nikolas Podraza  
Email: Nikolas.Podraza@utoledo.edu  
(Email is Preferred Means of Communication)  
Office Hours: By Appointment  
Office Location: McMaster Hall Room 4023  
Instructor Phone: 419 530 4905  
Offered: Fall 2020  

Course Website: https://blackboard.utdl.edu/  
Class Location: See Teaching Methodology and Course Location Below  
Class Day/Time: Tuesday and Thursday  
10:00-11:50 AM  
Credit Hours: 4  

SPECIAL COURSE EXPECTATIONS DURING COVID-19  
ATTENDANCE  
The University of Toledo has a missed class policy. It is important that students and instructors discuss attendance requirements for the course. Students must perform a daily health assessment, based on based on CDC guidelines, before coming to campus each day, which included taking their temperature. Students who are symptomatic/sick should not come to class and should contact the Main Campus Health Center at 419-530-3451. Absences due to COVID-19 quarantine or isolation requirements are considered excused absences. Students should notify their instructors and these absences may not require written notice.  

FACE COVERINGS  
All students must wear face coverings while on campus, except while eating, alone in an enclosed space, or outdoors practicing social distancing. NO students will be permitted in class without a face covering. If you have a medical reason that prevents you from wearing a face covering due to a health condition deemed high-risk for COVID-19 by the Centers for Disease Control and Prevention (CDC), you should submit a request for an accommodation through the Student Disability Services Office (SDS) by completing the online application. Students will need to provide documentation that verifies their health condition or disability and supports the need for accommodations. If a student is already affiliated with SDS and would like to request additional accommodations due to the impact of COVID-19, should contact their accessibility specialist to discuss their specific needs.  

SOCIAL DISTANCING  
Students should practice social distancing inside and outside the classroom please follow signage and pay attention to the seating arrangements. Do not remove stickers or tape from seats and/or tables, this is there to provide guidance on the appropriate classroom capacity based on the recommended 6 feet of social distancing between individuals. Please be conscious of your personal space and respectful of others. Also be cognizant of how you enter and exit the room; always try to maintain at least 6 feet of distance between yourself and others.  

DESKS AND WORK SPACES  
Students will need to sanitize their desks and/or work space before class with the University provided sanitizing spray and paper towels their desks.
SPECIAL NOTES
It’s important to note that based on the unpredictability of the COVID-19 virus things can change at any time so please be patient and understanding as we move through the semester. I also ask that you keep me informed of concerns you may have about class, completing course work/assignments timely and/or health concerns related to COVID.

CATALOG/COURSE DESCRIPTION
A generic materials science approach to the study of crystalline structure and defects (point, line and planar) in crystalline materials. The mechanisms and kinetics of diffusion in the condensed state.

COURSE OVERVIEW
Survey of topics relevant to Materials Science. This course is the first in a two semester sequence surveying topics in materials science for undergraduate (CHEM 4810) and graduate (CHEM 6180, CHEM 8810, PHYS 6540, PHYS 8540) students in physics, chemistry, or related fields.

Topical Outline:
1) Interatomic Bonding
2) Crystallography
3) Crystal Structures
4) Structure Determination
5) Structural Disorder
6) Point Defects
7) Line Defects
8) Planar Defects
9) The Effects of Defects on Structural, Electrical, and Optical Properties
10) Fundamental Equations of Diffusion
11) Mechanisms of Diffusion
12) Kinetics of Diffusive Processes
13) Structure Sensitive Diffusion Processes
14) Surface Diffusion
15) Experimental Methods
Assume about 1/3 of the semester for topics 1-5, 1/3 for topics 6-9, and 1/3 for 10-15.

TEACHING METHODOLOGY AND COURSE LOCATION
Teaching Methodology: Course notes, pre-recorded lectures, and recommended reading materials are available via Blackboard. Students are expected to review the course notes and / or pre-recorded lectures prior to the corresponding regularly assigned class time (10:00-11:50 AM, Tuesdays and Thursdays). During the regularly assigned class time, we will discuss questions contained within the course notes and any other questions generated during your review of the lecture material. The homework problem corresponding to a given lecture will be due before 5:00 PM the day following the regularly assigned class time. Students are strongly encouraged to ask questions during the regularly assigned class time and during office hour appointments. Engaging in discussion of the course material is vital in preparation for the exams. The exams will be oral and recorded with the exam grade based on your demonstrated understanding of the topics covered on that exam.

Course Location: At the time of writing this syllabus one week prior to the start of classes, there are 16 students registered for this course. The assigned classroom, McMaster Hall 4012 holds 7 students according to social distancing guidelines. The course location during regularly assigned course times will take place outdoors on the University Hall lawn when the weather is favorable. You may wish to bring a lawn chair to sit on and a laptop or phone with the course notes corresponding to that lecture topic downloaded for your reference. When the weather is unfavorable or should meeting on campus be otherwise unfeasible, a teleconference meeting will be established. Please note that when teleconferences are used, you should keep your microphone muted unless asking a question.
or directly engaging in conversation and use headphones instead of speakers to avoid audio feedback. Both in-person outdoor classes or teleconference classes will be recorded and posted on Blackboard.

**STUDENT LEARNING OUTCOMES**
The students will learn about the structure of condensed matter systems, the defects present in real materials, and how impurities can diffuse within condensed matter.

**PREREQUISITES AND COREQUISITES**
For PHYS 6540, PHYS 8540, CHEM 6810, and CHEM 8810 the student must be enrolled in a graduate program.

**TEXTS AND ANCILLARY MATERIALS**
There is no required text. Course notes, pre-recorded lectures, and recommended reading materials are provided on Blackboard via [https://blackboard.utdl.edu/](https://blackboard.utdl.edu/) or the myUT portal at [https://myut.utoledo.edu/](https://myut.utoledo.edu/) After entering the portal, click on Blackboard in the UT Online panel.

**TECHNOLOGY REQUIREMENTS**
Access to a computer and internet.

**ACADEMIC POLICIES**
[Undergraduate Policies](http://www.utoledo.edu/policies/academic/undergraduate/)
[Graduate Policies](http://www.utoledo.edu/policies/academic/graduate/)

**COURSE EXPECTATIONS**

**Attendance and Participation:** You are expected to attend regularly assigned classes, read or review any required materials prior to class, and participate in discussions. You are highly encouraged to consider how the topic matter applies to your own areas of interest. All regularly assigned class times and corresponding lecture discussion topics are noted on the Tentative Schedule at the end of this syllabus.

*Before Each Lecture:* You should read through the course notes provided for that lecture and/or listen to the pre-recorded presentation for that lecture. You may also wish to review the recommended reading for each of the topics provided.

*During Each Lecture:* You should participate in the discussion whether class is held on campus (outside) or via a teleconference. Any questions you have about the topic in general or how it relates to materials of your interest are welcome and will likely benefit your and your classmates’ understanding for the exams.

*After Each Lecture:* You will complete the homework problem corresponding to the lecture. When giving the lectures in person in class in previous years, a problem given in the last 10 minutes of each lecture was used to test your understanding of the material. Now they are due by 5:00 PM on the day following class to adjust to the new teaching format.

**Office Hours:** You can schedule an appointment for a teleconference meeting with me via email. Available times are limited to between 9:00 AM to 5:00 PM on Mondays through Fridays, except for the times already occupied by class. Note that since office hours are by appointment, I am not guaranteed to be free during these times. These are only acceptable times in which you can schedule an appointment. When you make an appointment with me, please suggest three time windows in which you are available so that we can find an option which fits both our schedules.

**Attendance and Your Grade:** There are 12 weeks of lecture classes and 3 weeks of exams throughout the semester. If I see you at least once during each of those 12 weeks of lecture classes either (1) when classes are held in a social distanced setting, (2) via teleconference software, or (3) in a separate teleconference equivalent to an office hour
visit, you will earn 0.5 points per week up to a maximum of 5 points contributing to your final grade (equivalent to the 5% of your final grade). If you are present at least once for at least 10 of those 12 weeks, you will earn the full points for attendance. Attending less than 10 of the 12 weeks will reduce your maximum obtainable grade.

**Homework Problems:** At the end of Lectures 1 through 22, there is a problem. You should spend about 10 minutes addressing this problem and email me your answer no later than 5:00 PM the day following the corresponding regularly assigned class. All homework problem due dates are noted on the Tentative Schedule at the end of this syllabus. There are 22 homework problems, one corresponding to each lecture (excluding Lecture 0) throughout the semester. You will be responsible for emailing me your response to those problems by 5:00 PM on the day following the lecture class. The subject lines of your emails should state: “Problem, Lecture X,” where “X” is the lecture number. Answers are expected to be brief. If you were to write your answer it should be no more than the size of a 3 inch by 5 inch index card. Problems will be graded and assigned a point value of 1 or 0, with 1 indicating an answer that is correct or demonstrated substantive understanding (even if not correct). Each homework problem should take less than 10 minutes to complete. You will earn 1 point for each successfully answered problem up to a maximum of 20 points contributing to your final grade (equivalent to the 20% of your final grade). If you answer at least 20 of those 22 problems satisfactorily, you will earn the full points for homework problems. Answering less than 20 of the 22 problems will reduce your maximum obtainable grade.

**Exam Review Days:** Prior to each exam, we will have a review day during the assigned in class time. The dates will be 9/15 for Exam 1 (Structure: Interatomic Bonding, Crystallography, Crystal Structures, Diffraction; Lectures 1-8), 10/15 for Exam 2 (Defects: Point, Line, and Plane Defects; Impact on Properties; Lectures 9-14), and 11/24 for Exam 3 (Diffusion: Drift and Diffusion, Mechanisms, Characterization; Lectures 15-22). During these review days, you should ask any questions you have on the course material covered in that exam. We will also review pertinent homework problems and related questions relevant to the exam material. Exam review days will be through teleconferencing only and recorded.

**Exams:** Each exam will be oral, by teleconferencing, and recorded. The exams will last 30 minutes, and we will discuss questions relevant to the topic matter of that exam. A week prior to each exam, I will assign each of you an example material which we will discuss as part of the content of your oral exam. You do not need to perform outside research on this material, but you may want to consider how the course topics may apply to it. Your exam time will be scheduled two weeks prior to the exam days noted on the Tentative Schedule at the end of this syllabus. The two exams on which you earn your highest grade will be weighted equally and contribute to 30% of your final grade each (30% for highest exam + 30% for second highest exam). The exam with the lowest score will be weighted half the value of the other two and only contribute 15% to your final grade. Combined, all three exam scores will be account for 75% of your final grade.

**OVERVIEW OF COURSE GRADE ASSIGNMENT**

Grades will be based on homework problems, three exams, and attendance weighted as:

- Attendance: 5%
- Homework Problems: 20%
- Highest Exam Score: 30%
- Second Highest Exam Score: 30%
- Third Highest Exam Score: 15%

**Attendance:** There are 12 weeks of lecture classes and 3 weeks of exams throughout the semester. If I see you at least once during each of those 12 weeks of lecture classes either (1) when classes are held in a social distanced setting, (2) via teleconference software, or (3) in a separate teleconference equivalent to an office hour visit, you will earn 0.5 points per week up to a maximum of 5 points contributing to your final grade (equivalent to the 5% of your final grade). If you are present at least once for at least 10 of those 12 weeks, you will earn the full points for attendance. Attending less than 10 of the 12 weeks will reduce your maximum obtainable grade.
Homework Problems: There are 22 homework problems, one corresponding to each lecture (excluding Lecture 0) throughout the semester. You will be responsible for emailing me your response to those problems by 5:00 PM on the day following the lecture class. The subject lines of your emails should state: “Problem, Lecture X,” where “X” is the lecture number. Answers are expected to be brief. If you were to write your answer it should be no more than the size of a 3 inch by 5 inch index card. Problems will be graded and assigned a point value of 1 or 0, with 1 indicating an answer that is correct or demonstrated substantive understanding (even if not correct). Each homework problem should take less than 10 minutes to complete. You will earn 1 point for each successfully answered problem up to a maximum of 20 points contributing to your final grade (equivalent to the 20% of your final grade). If you answer at least 20 of those 22 problems satisfactorily, you will earn the full points for homework problems. Answering less than 20 of the 22 problems will reduce your maximum obtainable grade.

Exams: The two exams on which you earn your highest grade will be weighted equally and contribute to 30% of your final grade each (30% for highest exam + 30% for second highest exam). The exam with the lowest score will be weighted half the value of the other two and only contribute 15% to your final grade. Combined, all three exam scores will be account for 75% of your final grade.

Letter grade scale is:
A: 93-100%  D+: 67-69%
A-: 90-92%  D: 63-66%
B+: 87-89%  D-: 60-62%
B: 83-86%  F: 0-59%
B-: 80-82%
C+: 77-79%
C: 73-76%
C-: 70-72%

Midterm Grading
The university has set a midterm grade deadline of 10/9. Your midterm grades will be calculated based on attendance, homework problems, and exams up to that point weighted according to:
- Attendance (Weeks 1-7): 5%
- Homework (Problems 1-11): 20%
- Exam 1 Score: 75%
Note that only the final grading metric (below) accounts for all attendance, homework problems, and the three exams throughout the semester, therefore the midterm grade is only reflective of an estimation of performance up to 10/9.

Final Grading
At the end of the semester will be calculated according to:
- Attendance: 5%
- Homework Problems: 20%
- Highest Exam Score: 30%
- Second Highest Exam Score: 30%
- Third Highest Exam Score: 15%

UNIVERSITY POLICIES
Policy Statement on Non-Discrimination on the Basis of Disability (ADA) The University is an equal opportunity educational institution. Please read The University’s Policy Statement on Nondiscrimination on the Basis of Disability Americans with Disability Act Compliance. Students can find this policy along with other university policies listed by audience on the University Policy webpage (http://www.utoledo.edu/policies/audience.html/#students).
**Academic Accommodations** The University of Toledo embraces the inclusion of students with disabilities. We are committed to ensuring equal opportunity and seamless access for full participation in all courses. For students who have an accommodations memo from Student Disability Services, I invite you to correspond with me as soon as possible so that we can communicate confidentially about implementing accommodations in this course. For students who have not established affiliation with Student Disability Services and are experiencing disability access barriers or are interested in a referral to healthcare resources for a potential disability or would like information regarding eligibility for academic accommodations, please contact the [Student Disability Services Office](http://www.utoledo.edu/offices/student-disability-services/) by phone: 419.530.4981 or email at [StudentDisability@utoledo.edu](mailto:StudentDisability@utoledo.edu).

**ACADEMIC AND SUPPORT SERVICES**
Please follow this link to view a comprehensive list of [Student Academic and Support Services](http://www.utoledo.edu/studentaffairs/departments.html) available to you as a student.

**SAFETY AND HEALTH SERVICES FOR UT STUDENTS**
Please use the following link to view a comprehensive list [Campus Health and Safety Services](http://www.utoledo.edu/studentaffairs/departments.html) available to you as a student.

**INCLUSIVE CLASSROOM STATEMENT**
In this class, we will work together to develop a learning community that is inclusive and respectful. Our diversity may be reflected by differences in race, culture, age, religion, sexual orientation, gender identity/expression, socioeconomic background, and a myriad of other social identities and life experiences. We will encourage and appreciate expressions of different ideas, opinions, and beliefs so that conversations and interactions that could potentially be divisive turn, instead, into opportunities for intellectual and personal development.
TENTATIVE COURSE SCHEDULE
Dates by topic and learning objective. Assessment methods (exams and homework problems) are listed.

Before 8/18: Lecture 0: Course Syllabus and Introduction—introduction to course objectives, format, and expectations.

Part 1: Structure (Lectures 1-8)

8/18: Lecture 1: Interatomic Bonding—bonding types and fundamentals. Problem 1 due before 5:00 PM on 8/19.

8/20: Lecture 2: Interatomic Bonding—bonding types and fundamentals. Problem 2 due before 5:00 PM on 8/21.

8/25: Lecture 3: Crystallography—lattice systems, point groups, space groups, symmetry. Problem 3 due before 5:00 PM on 8/26.

8/27: Lecture 4: Crystallography—lattice systems, point groups, space groups, symmetry. Problem 4 due before 5:00 PM on 8/28.

9/1: Lecture 5: Crystal Structures—bases and common structure types. Problem 5 due before 5:00 PM on 9/2.

9/3: Lecture 6: Crystal Structures—bases and common structure types. Problem 6 due before 5:00 PM on 9/4.

9/8: Lecture 7: Diffraction—characterization of crystal structures by diffraction methods. Problem 7 due before 5:00 PM on 9/9.

9/10: Lecture 8: Diffraction—characterization of crystal structures by diffraction methods. Problem 8 due before 5:00 PM on 9/11.


Part 2: Defects (Lectures 9-14)

9/24: Lecture 9: Point Defects—types and stability in crystal structures; impact on properties. Problem 9 due before 5:00 PM on 9/25.

9/29: Lecture 10: Point Defects—types and stability in crystal structures; impact on properties. Problem 10 due before 5:00 PM on 9/30.

10/1: Lecture 11: Line Defects—types and stability in crystal structures; impact on properties. Problem 11 due before 5:00 PM on 10/2.

10/6: Lecture 12: Line Defects—types and stability in crystal structures; impact on properties. Problem 12 due before 5:00 PM on 10/7.

10/8: Lecture 13: Plane Defects—types and stability in crystal structures; impact on properties. Problem 13 due before 5:00 PM on 10/9.
10/13: Lecture 14: Plane Defects—types and stability in crystal structures; impact on properties. Problem 14 due before 5:00 PM on 10/14.


**Part 3: Diffusion (Lectures 15-22)**

10/27: Lecture 15: Drift and Diffusion—theoretical formalism of how defects and impurities propagate within crystal structures. Problem 15 due before 5:00 PM on 10/28.

10/29: Lecture 16: Drift and Diffusion—theoretical formalism of how defects and impurities propagate within crystal structures. Problem 16 due before 5:00 PM on 10/30.

11/3: Lecture 17: Drift and Diffusion—theoretical formalism of how defects and impurities propagate within crystal structures. Problem 17 due before 5:00 PM on 11/4.

11/5: Lecture 18: Diffusion Mechanisms—types of diffusion involving specific defects. Problem 18 due before 5:00 PM on 11/6.

11/10: Lecture 19: Diffusion Mechanisms—types of diffusion involving specific defects. Problem 19 due before 5:00 PM on 11/11.

11/12: Lecture 20: Low Dimensional Diffusion—diffusion along line and plane defects. Problem 20 due before 5:00 PM on 11/13.

11/17: Lecture 21: Low Dimensional Diffusion—diffusion along line and plane defects. Problem 21 due before 5:00 PM on 11/18.


11/30-12/4: Exam 3 (Diffusion: Drift and Diffusion, Mechanisms, Characterization) exam times scheduled by appointment.