MSE 605 CRYSTALLOGRAPHY & CRYSTAL CHEMISTRY

Brief syllabus:
Bonding, atomic arrangements, and crystal structures of metals, ceramics, electronic materials and polymers; physical properties of solids; defects in solids; relationship between processing, microstructure and properties of materials.

Aims:
This course will introduce students to the language, nomenclature, and tools of crystallography and demonstrate how electronic structure determines bonding which in turn determines structure and properties in a variety of materials systems.

Course value: 4 cu
Semester: Autumn

Pre-requisites: N/A
Lectures: 35 hrs
Tutorials: 6.7 hrs

Overlap courses: MSE 245
Limits on number: 25

Examinations/Coursework Marks:
- Participation 5%
- Report/Presentation 5%
- Homework 21% (7 x 3%)
- Quizzes 21% (3 x 7%)
- Midterm Exams 28% (2 x 14%)
- Final Exam 20%

Texts:

Course organizer: Dr. R. Ubic
A+ 97 - 100% C+ 69 – 72%
A 90 - 96% C 64 – 68%
A- 87 - 89% C- 60 – 63%
B+ 84 - 86% D+ 57 – 59%
B 77 - 83% D 53 – 56%
B- 73 - 76% D- 50 – 52%
F 0 – 49%

Teaching Assistant: Evan Smith

Time: Tuesdays & Thursdays
8:35 - 10:15

Location: RUCH 213

Syllabus

Crystal Chemistry: bonding, coordination number, packing fraction, order-disorder

Noncrystalline State: short-range order, pair-distribution function, hard-sphere models, random-walk models, network models

Crystalline State: rotation, reflection, inversion, rotoinversion, glide, screw, lattices, unit cells, point groups, Laue groups, space groups, Miller indices, zone axes, the International Tables, relation of symmetry to properties

Crystal Defects: vacancies, interstitials, mobility of point defects, solid solutions
Participation
Credit will be awarded for attendance and participation during class and for submitting all required coursework. In addition, extra credit will be given to the whole class if a 100% response rate is achieved in the end-of-term course evaluations.

Homework
Seven homework assignments will be assigned throughout the semester. Students are encouraged to collaborate on homework assignments, but copying is not acceptable. A penalty of one point will be deducted from the course participation grade for each missed or substantially incomplete assignment.

Rules for Homework and Quizzes
1. Your homework solutions should be hand-written (i.e., not from Word, Excel, Powerpoint, Mathematica, etc.) and show ALL your work. Do NOT submit electronically-processed results unless otherwise instructed.
2. Physical quantities have a numerical value and a unit. Numerical results without an SI unit will not be graded (exceptions are dimensionless quantities).
3. Mark formal and numerical results only by double-underlining, boxing, or highlighting.
4. Diagrams and drawings must be labeled. Axes should have names and units. Diagrams without sufficient labeling will not be marked.
5. Do not use red ink in drawings or diagrams.
6. Use of textbooks, lecture notes, and calculators is allowed for homework.
7. All homework is to be done individually unless otherwise stated.
8. Homework sheets will be marked and returned within one week of their due date.

Late Homework
Late homework will not be accepted under ANY circumstances.

Reading Assignments
The content of reading assignments will have a significant overlap with the lectures but will also contain additional material to compliment the lectures.

Quizzes
There will be four short quizzes given in class, each including previously covered/assigned content (lectures and reading assignments). There will be no make-up quizzes under ANY circumstances, but one quiz may be dropped from the final quiz mark.

Midterm Exams
There will be two midterm exams. The midterm exams are scheduled for 9 October and 27 November in RUCH 213. The exams are closed-book, but necessary reference materials will be provided. Each exam will cover roughly one third of the course content.

Final Exam
There will be a comprehensive final exam for this course on Tuesday, 11 December from 9:30 – 11:30 in RUCH 213. The exam will be closed-book, but necessary reference materials will be provided.
Learning Outcomes
1. Demonstrate an understanding of the fundamental principles that govern the assembly of crystal and glass structures (chemical bonding, atomic size, valence, electronegativity, coordination number and polyhedra, bond strength, bond valence, lattice energy, etc.).

2. Demonstrate an understanding of point symmetry and improper translations by enumerating and describing both crystal systems and lattice systems in terms of symmetry and unit-cell constraints, recognizing symmetry elements in natural and artificial structures, and identifying the unit cells and plane groups of such patterns.

3. Demonstrate a command of mathematical crystallography and the basics of group theory (multiplication tables, metric/reciprocal metric tensors, structure factor, order parameter, etc.).

4. Interpret diffraction data in terms of crystalline structure and microstructure.

5. Demonstrate an understanding of the effect of crystal structure and defects on the fundamental mechanisms responsible for various physical properties. Specifically, use Kröger-Vink notation to describe point defects and discuss their effects on properties, e.g., ionic conductivity.

6. Explain the crystallographic implications of various line defects; differentiate the behaviors of glissile and sessile dislocation loops; and discuss both slip and climb mechanisms.

7. Quantitatively describe continuous random networks and predict their topology using Zachariasen's rules.

8. Use advanced software tools to render crystal structures and perform crystallographic computations.

Academic Integrity
The BSU policy on academic integrity is covered on p. 17 of the 2018-19 graduate catalog and can be found on-line here:


Office Hours
My office is in MEC 403K. If you would like to discuss the class outside of class time, please come to my office during my office hours:

- Tuesdays 10:15 – 11:15
- Wednesdays 3:30 – 4:30
- Thursdays 10:15 – 11:15

I may also be able to help you at other times. Stop by my office or email me for an appointment.
Repeats/Withdrawals
Effective Spring 2014, students may register for a course a maximum of two times. Graded courses and withdrawals (Ws) count as attempts. If you need to enrol in a course for a third time, you are required to seek approval from the academic advisor of your major and the chair of the department offering the course.

The university allows for a maximum number of six repeats on your official academic record. Courses you have repeated prior to Spring 2014 do not apply to the maximum. The official count of repeats begins Spring 2014.

The university allows for a maximum number of ten Ws on an academic record exclusive of Complete Withdrawals (CWs). If you have withdrawn from a course prior to Spring 2014, it does not apply to the maximum. The official count of Ws begins Spring 2014.
Review – Just a Minute

On 4 October, 15 November, and 6 December an exercise will be played like a panel game in which students will be challenged to speak on a subject for one minute without hesitation, repetition, or deviation. Subjects relevant to the content of MSE 605 will be chosen by the instructor. Students score a point for making a correct challenge against whomever is speaking, while the speaker wins a point if the challenge is deemed incorrect by the instructor; however, if a particularly insightful, obscure, or witty remark sufficiently enlightens or amuses the class, even if not a correct challenge, both the challenger and speaker may gain a point, at the instructor’s discretion. A student who makes a correct challenge takes over the subject for the remainder of the minute, or until he or she is correctly challenged. The person speaking when the 60 seconds expires also scores a point. An extra point is awarded when a student speaks for the entire minute without being challenged.

For the purposes of this exercise:

- "Hesitation" can be a momentary pause before resumption of the subject, tripping over one's words, pausing for dramatic/comic effect, or waiting during laughter (or applause!).
- "Repetition" means the repeating of any word or phrase, although challenges based upon very common words such as "and" will generally be rejected except in extreme cases. Words contained in the given subject are exempt unless repeated many times in quick succession.
- "Deviation" means straying from the subject but can also be interpreted as deviation from the English language as we know it, deviation from grammar as we understand it, deviating from the truth, or deviation from logic, although leaps into the surreal may sometimes be allowed.

Points scored during Just a Minute will not be counted towards your final grade, but participation in the game will be considered as part of your participation mark. Even if there isn’t time for everyone to actually play on a given day, attendance on both days is required to satisfy the requirement for participation.

Come prepared for these panel games! The game is only effective as a review if students come prepared. If no one knows anything about a given topic, then no one listening learns anything!

YOUR LEVEL OF PREPAREDNESS WILL BE REFLECTED IN THE PARTICIPATION MARK YOU RECEIVE.
Report & Presentation – The Unbelievable Truth
This exercise will be played like a panel game in which students are encouraged to tell lies and compete against one another to see how many items of truth they are able to smuggle past their classmates, who are their opponents. The object is to lie on a subject whilst also trying to include truths without being detected.

Each student will be assigned a brief account of the life and work of a person relevant to the course by 13 September. Accounts will include exactly five true facts, the remainder being false. On 8 November students will submit a report identifying each true statement. Written reports should be typed in 12-point Arial or Helvetica font with 1.5 line spacing. Your name should appear in the heading at the top-left of the page, and the subject of your report should appear centered on the first line. All facts must not only be precisely referenced and in bold font, but the actual sources themselves (in electronic form) must be submitted with the relevant truths highlighted along with the report itself. In the case of a book, the title page (including all bibliographic information) should also be provided. Citations should be in the style appropriate to the Journal of the American Ceramic Society:


On 4 December the accounts must be read aloud and verbatim in class as part of the panel game.

During a presentation, another student may challenge by buzzing in when they believe that what the speaker is saying is true, and they must state what they believe the fact was. If they are correct, the challenger is awarded one point. If not, then one point is deducted from their score. One point is given to the speaker for each truth they smuggle successfully past the panel. Additional points will be awarded for participation. The overall score for the exercise will be calculated as follows:

Score in game:
- Speaking: 50%
  quality of spoken report (including number of truths smuggled)
- Panel: 25%
  score as panellist (as per the point system described above)
- Participation: 25%
  Students must be present at their prescribed session on 4 December to receive participation credit. No exceptions! While playing the game they are expected to contribute towards the proceedings.

All scores will be moderated by me.

Note, this game is not intended as a review but as a fun exercise to broaden students’ views of both structural science and scientists.
What if the unexpected happens – to you
How do you respond?

1- Fire/Evacuation
   a. Get out through nearest exit!
   b. Gather in Safe Assembly Location. Consult a building evacuation map (typically near elevators) to determine your Safe Assembly Location. (For all COEN buildings this is the RUCH Building Parking Lot)
   c. If you have any information concerning the incident—injured people, imminent threats, nature of incident—be sure to notify first responders in safe assembly location.
   d. Occupants that cannot descend stairs should stay in the evacuation assistance area(s) of each building and wait for first responders to move them.
   e. Know your building address:
      i. RUCH: 1375 West University Drive
      ii. MEC: 1020 South Manitou Avenue
      iii. HML: 1019 South Euclid Avenue
      iv. ERB: 1295 West University Drive

2- Active Shooter
   a. Run: Can you safely escape?
      i. Leave your belongings and keep your hands visible as you flee.
      ii. Prevent others from entering the area.
      iii. Call 911 when you are safe.
   b. Hide: Is there a good place to hide?
      i. Lock door and block entry to your hiding place.
      ii. Silence your cell phone (including vibrate mode). Opt-in now, and use, BroncoALERT.
   c. Fight: Will you engage the shooter?
      i. Fight only as a last resort and when your life is in imminent danger.
      ii. Fight as a group using improvised weapons and with as much physical aggression as possible.
      iii. Commit to your actions... your life depends on it.

3- Personal Injury
   a. Call 911 for life threatening emergencies.
   b. Call 426-6911 to reach Campus Security for all non-life threatening emergencies (66911 from any campus phone).
   c. Know the address of your location. Posted on Emergency Information Sheets near exits.
   d. Know the nearest AED location:
      i. MEC building, 2nd floor, across from elevator
      ii. ERB building, 2nd floor, across from elevator
   e. For Non-Emergency, Urgent Care visit the Health Sciences Norco Building on campus at 1529 Belmont St.—208-426-1459
EVACUATION PROCEDURE

EVACUATING YOUR BUILDING OR WORK AREA:

- When ordered to evacuate or when alarms are activated, always leave immediately.
- Exit quickly and calmly using nearest emergency escape routes and marked exits and proceed to safe assembly locations as identified in the evacuation map for your classroom.
- **Do not use elevators.**
- Be alert for trapped, injured or other persons needing assistance. See EVACUATION ASSISTANCE below.
- Do not return to an evacuated building unless directed to do so by authorities.

EVACUATION ASSISTANCE

- Be alert for mobility-impaired, trapped, injured or other persons needing assistance.
- **Help those persons requiring assistance to get to a designated Evacuation Assistance Area if it is safe to do so.** These areas are identified in COLLEGE OF ENGINEERING BUILDING EVACUATION AND SAFETY EQUIPMENT MAPS on following pages. First responders will tend to those in evacuation assistance areas as soon as possible after arriving.
- Transporting of individuals requiring evacuation assistance up or down stairwells must be avoided unless imminent life-threatening conditions exist.
- Notify emergency personnel immediately upon their arrival of the exact location of any injured or trapped persons, those waiting in designated Evacuation Assistance Areas and any others who may be anywhere in the building.

MEETING FIRST RESPONDERS

If first responders are summoned and you have specific knowledge relating to the emergency, meet with them upon arrival. The first responders will typically stop at the following locations:

- **Engineering and Technology Building- University Dr.**
- **Micron Engineering Center- Manitou Ave.**
- **Harry Morrison Civil Engineering Building- Euclid Ave.**
- **Construction Management Lab Bldgs- Belmont St. or Manitou Ave.**

The College of Engineering Emergency Response Guide can be found on-line at:

http://coen.boisestate.edu/safety/coen-emergency-response/
Evacuation and Safety-Equipment Map

RUCH Building, 2nd Floor

Safe Assembly Location:
RUCH Building Car Park

You are here.

Fire Alarm Pull Station
Fire Extinguisher
AED- MEC 2nd Floor, Opposite Elevator
Emergency Phone
Evacuation Assistance Area
Top Ten No-Sympathy Lines (Plus a Few Extra)

Steven Dutch, Natural and Applied Sciences, University of Wisconsin - Green Bay
http://www.uwgb.edu/dutchs/nosymp.htm

This Course Covered Too Much Material...

Great! You got your money's worth! At over $100 a credit, you should complain about *not* getting a lot of information. If you take a three credit course and get $200 worth of information, you have a right to complain. If you get $500 worth, you got a bargain.

The Expected Grade Just for Coming to Class is a B

This belief seems to be making the rounds in some college circles. The expected grade for just coming to class and not doing anything else is a **D or an F**. The *average* grade is supposed to be **C** although grade inflation is a perennial problem.

Unlike Lake Wobegon, all the children in the real world are not above average.

I Disagreed With the Professor's Stand on ----

The time to deal with this issue is when it comes up in class. I have no respect for anyone who complains only on the course questionnaires.

*But the professor might put me down, or the students might laugh at me.* Not too likely, but even if it happens, so what? If you don't have courage in the safe setting of a classroom, when exactly are you planning to develop it? When your boss asks you to falsify figures or lie under oath? When someone throws rocks through your minority neighbor's windows? When the local hate group burns the synagogue?

Some Topics in Class Weren't on the Exams

The point of a class is the material, not the exam. The exam is a check to see whether you learned the material.

Do You Give Out a Study Guide?

Hmm. The textbook simplifies a vast amount of material, then I simplify it more in lecture. Then you want me to extract the most important ten per cent of *that* and put it on a study guide, so if you know most of it you can get an A.

So what you're saying is the cutoff grade for an A should be 10%, right?

How Am I Doing In Class?

You're failing.
If you don't know the class material well enough to assess your own progress, and you don't know enough math to estimate your grade given your progress to date, you're failing.

You may luck out and get something higher than an F, but as theologians say, don't confuse mercy with merit.

I Studied for Hours

How many? A college credit is defined as three hours’ work per week; one in class and two outside. That's why adding a three-hour lab to a class only results in one additional credit.

This means that 12 credits translates to an average of 36 hours' work a week. That's why 12 credits is considered full time (9 for a graduate student); it's the equivalent of a full-time job.

If this course doesn’t require eight hours of outside work per week to keep up, consider yourself lucky! Other courses may require more time. Also, individual students require different amounts of study time. It does no good to complain that three hours per week per credit is excessive, any more than it does to complain that 26 miles is too long for a marathon. They are what they are.

The one thing you can count on is that a few hours of cramming before the final will not give good results. I recently heard from a student who lamented that she stayed up until 2 A.M. studying, then got up at 6 A.M. and studied some more, and did poorly. And she was surprised? She'd have been better off getting a decent night's sleep.

I Know The Material - I Just Don’t Do Well on Exams

Leprechauns, unicorns, Bigfoot, the Loch Ness Monster, hobbits, orcs - and students who know the material but don't do well on exams. Mythical creatures.

I've met students who claim to know the material but not do well on exams, but when you press them, it turns out they don't know the material after all. If you can't answer questions about the material or apply the knowledge in an unfamiliar context, you don't know it. You might have vague impressions of specific ideas, but if you can't describe them in detail and relate them to other ideas, you don't know the material.

In addition to content, every type of exam used in college requires specific, vital intellectual skills. Essay exams require you to organize material and present it in your own words. Short-answer exams require you to frame precise, concise answers to questions. Multiple choice exams require you to define criteria for weeding out false alternatives and selecting one best answer. All of these are useful skills in themselves. If you can't do well on some specific type of test - learn the appropriate skill.
I Don't Have Time For All This

Life is about choices. We all have more to do than we can do completely, and we have to set priorities. So we may have to accept tradeoffs. Some options:

- Reduce your credit load and take longer to get through
- Cut back on social events
- Cut back on work hours and accept a lower standard of living and fewer possessions
- When you have two conflicting assignments, focus on the most important one
- Accept lower grades

The one option that is never on the table in life is to choose a course of action and choose the consequences. If you select a course of action, you also select the consequences. If you want to avoid or achieve a certain set of consequences, you select your course of action accordingly. So easier grading and fewer assignments to free up time for non-college activities are not an option. Don't waste time asking.

But you don't understand. I have a job

No, you don't understand. This is your job. If you don't believe me, just go out with what you have on your resume now and try to launch a career.

I got a message from one guy who did just that - dropped out of school and is now earning six figures as a Systems Administrator. This guy didn't finish college but still has a successful career. When he found out college wasn't for him, he quit and accepted the consequences. He didn't expect college to loosen its standards for him. (Of course, he was successful. If he hadn't made it and was earning minimum wage, I wonder if he'd have taken full responsibility?) So if college is cramping your style, go and do likewise. Get a job as a Systems Administrator, or buy a foreclosed property and sell it for a huge profit, or get in on the ground floor of some new business, or invent a perpetual motion machine. Or start a company to topple Microsoft. Instead of saying that Bill Gates didn't finish college, show me that you're a Bill Gates (would Windows be the mess it is if Gates had spent a few more years learning to think coherently?). Einstein and Edison didn't finish school either. Show us you're an Einstein or an Edison.

Just don't wake up on your fortieth birthday, say "my life sucks," and blame your lack of life satisfaction on your school taxes.

Students Are Customers

True. Students are customers, and they have every right to complain about poor service, unprofessional behavior, and out-of-date material. They also have a right to complain about low standards that water down their credentials.

Students are also products, and employers outside the University are also our customers. These customers have a right to complain if our graduates are lacking in skills, knowledge, and motivation. They have a right to complain if we certify someone as being a potentially good employee and that person turns out to be unqualified.

Despite the rising share students pay for their college education, students still only pay 40 per cent of the total cost. That means the University's responsibility is 40 per cent to students, and
60 per cent to the community. And our customers in the community want people who can communicate, reason, and have a good general stock of knowledge they can call on for unexpected needs. They also want us to provide an assessment that accurately reflects the quality of work students are likely to turn out as employees.

**Pretentious Twit of the Year Award**

Background: A philosophy professor at Syracuse University has a policy that if even one student in a class reads a newspaper or texts during class, he ends the class on the spot and walks out. One student complained:

“We the students are the customers, the consumers, the ones who make the choice every day to pay attention or not. I pay approximately $30,000 to go here, whether I text in class or not. Get real here.

Get real here. I pay $30K a year? Not very likely. If this student *does* have that kind of personal wealth, he's too dumb to keep it for very long. But I seriously doubt that. More likely Mummy and Daddy are paying it, or he's getting financial aid, in which case donors to the university and taxpayers are paying it. Or maybe he's taking out loans, which he will pay back, maybe. Unless it becomes inconvenient and he files for bankruptcy. But it's virtually certain this student himself is not the paying customer.

**Do I Need to Know This?**

You can survive without the things you learn in college. People *survive* scrounging out of dumpsters and sleeping in doorways. If you want to talk about quality of life, we need to be a bit more demanding.

**There Was Too Much Memorization**

Sad to say, students have been victims of a cruel hoax. You've been told ever since grade school that memorization isn't important. Well, it is important, and our system wastes the years when it is easiest to learn new skills like the ability to memorize.

Memorization is not the antithesis of creativity; it is *absolutely indispensable* to creativity. Creative insights come at odd and unpredictable moments, not when you have all the references spread out on the table in front of you. You can't possibly hope to have creative insights unless you have memorized all the relevant information. And you can't hope to have really creative insights unless you have memorized a vast amount of information, because you have no way of knowing what might turn out to be useful.

Rote memorization is a *choice*. If you remember facts and concepts as part of an integrated whole that expands your intellectual horizons, it won't be rote. If you merely remember things to get through the next exam, it will be rote, and a whole lot less interesting, too. But that is solely your choice.

It is absolutely astonishing how many people cannot picture memorization in any other terms than "rote memorization," - *even after reading the paragraph just above.*
This Course Wasn't Relevant

If something as vast as mathematics or science or history can pass through your brain without even scraping the sides on the way through, that's a pretty big hole. Are you sure it's the course that doesn't relate to anything?

Our other customers in the community want people who have a good general stock of knowledge they can call on for unexpected needs. Being able to cope with unexpected needs means learning things that may not be immediately needed. You need to stop worrying about whether you need it now and begin worrying about whether your boss might need it later. A ten year old girl in Thailand saved hundreds of lives on December 26, 2004. She had just learned about tsunamis in school, recognized the warning signs, and convinced her parents to warn the resort management. As a result there were almost no casualties at her resort. In all likelihood none of her classmates will ever have need to know about tsunamis. A number of indigenous groups in the region escaped the tsunami with almost no casualties. They recognized the warning signs, which had been passed along through generations with no tsunamis, until finally that "irrelevant" knowledge became relevant.

Exams Don't Reflect Real Life

Some critics of education have said that examinations are unrealistic; that nobody on the job would ever be evaluated without knowing when the evaluation would be conducted and what would be on the evaluation.

Sure. When Rudy Giuliani took office as mayor of New York, someone told him "On September 11, 2001, terrorists will fly airplanes into the World Trade Center, and you will be judged on how effectively you cope."

Examinations are unrealistic. On the job evaluations where people are told in advance when they will be evaluated and exactly what will be covered are even more unrealistic. They're utterly artificial, carefully neutered attempts to be as fair as possible. The most meaningful evaluations in life are:

- Completely unexpected.
- Totally comprehensive. Absolutely everything you ever learned could be included.
- Include material you never studied and maybe never even heard of.

When you skid on an icy road, nobody will listen when you complain it's unfair because you weren't warned in advance, had no experience with winter driving and had never been taught how to cope with a skid.
I Paid Good Money for This Course and I Deserve a Good Grade

Right on! And ---

- I paid good money to get on this golf course and I have a right to shoot par. Anyone can enter the U.S. Open - that's what "open" means. But if you don't make the cut, you don't play in the tournament. Nor do you get a refund of your entry fee.
- I paid good money for a lawyer and I have a right to win my case.
- I paid good money for a house and I have a right to see it increase in value, even if I haven't lifted a finger to maintain it in ten years.
- I paid good money for this stock and I have a right to see it go up, even if I haven't bothered to watch the stock market. (I just know the XYZ Beta Video and 8-Track Tape Company is poised for growth!)

Almost everything you pay for in life is an entry fee. What happens next is up to you. Buy a Lexus and never change the oil and see what happens. Get a triple bypass and keep on smoking and snorking down the cholesterol - you'll be back.

All I Want is the Diploma

The work force is full of people who do the minimum necessary to get by. Give me one reason why I, as a citizen or consumer, should help create more of them.

Call me elitist, but there are a lot more people who want good jobs than there are good jobs to go around. I think society has a perfect right to reserve those positions for people who demonstrate a commitment to excellence.

For people who want to get by on the minimum, there's a reward already established. It's called the *minimum wage*. 