UNIVERSITY of MARYLAND
College Park

**Engineering Courses in Maryland’s Current I-Series**

Managing Natural Disasters: Hurricanes, Floods Earthquakes Tornadoes, Tsunamis, and Fires. *G. Galloway and E. Link*

Engineering in the Developing World, *D. Lovell*

Transportation innovation: Planes, Trains, and Automobiles and their Role in the Advance of Science. *D. Lovell*

The Future of Technology: Sustainable Development or Sensational Disaster?

Engineering and Modern Medicine, *Wesley Lawson*

Technology Choices, *Wesley Lawson*

Engineering and Modern Medicine: The Body as a Machine, *Romel Gomez*


Materials of Civilization, Rob Briber

Bigger Faster, Better: The Quests for Absolute Technology, *G. Oehrlein*

Building Projects that Last: Failure is not an Option, *P. McCluskey*

Listed above are the 12 current I-Series (General Education) courses contributed by Maryland’s College of Engineering to the university as a whole. How the College of Engineering came to participate in the design and teaching of General Education is critical to understanding whether and if so, how, Engineering-Enhanced General Education is to take hold in U.S. Colleges and Universities overall.

Thus, in what follows attention focuses on three antecedents so critical to the current offerings that one is tempted to call them *co-determinants*. The story follows.
I Participation of Professional Schools in General Education of Undergraduates

The first was a radical “new idea” proposed in Maryland’s ten-year strategic planning process, by the then provost, Nariman Farvardin, an engineer. Farvardin believed that the professional schools (and not just engineering) should be wholly involved in general education. His rationale: that Maryland’s professional schools deserved to be recognized not just as “research engines” but for their excellence in education. His challenge: that they be asked to contribute more substantially to the undergraduate population overall.

Typical of many institutions, Maryland’s Gen Ed courses were traditionally focused in the arts and the humanities. The natural sciences needed a significant boost, which would involve what was taught and who was teaching, as well as a focus on subjects at the intersection of disciplines and those that would embed “scholarship and practice.” Where to look for subject matter? How to enable experimentation? What would excite faculty about teaching non-majors, particularly in STEM?

II Marquee Courses

Enter in 2006 the so-named Marquee courses (intended to meet non-STEM students’ need for exposure to STEM). In place of STEM “distribution requirements” to already existing introductory courses, the College of Computer Math/Science and Engineering committed itself to designing altogether new courses, hence “Marquee,” featuring non-standard curricula and pedagogy, together with a conscious and intentional re-education of its own faculty through learning communities and other means.

The resulting courses, which boasted their own mini-catalog, were openly experimental, designed and taught entirely by senior faculty and, perhaps most importantly, involving faculty in self-organized learning communities, during which they would discuss challenges and means of reaching undergraduate students unlike their own. Everyone I’ve interviewed at Maryland points to the popularity (with students and faculty alike) of the Marquee courses as having provided a kind of on ramp and rationale for engineering to participate in the expansion of Maryland’s revised general Education “I” courses, half a decade later.
Marquee Courses in STEM/Engineering: Short List

Materials of Civilization (Robert Briber, Materials Science & Engineering)

Engineering in Medicine: The Body as a Machines (Mel Gomez, Electrical & Computer Engineering)

Engineering and Modern Medicine (Wes Lawson, Electrical & Computer Engineering)

What motivates senior faculty to participate in a STEM program for students unlike their own? Donna Hamilton, then Dean of Undergraduate Studies, who worked closely with Rob Briber, now Associate Dean of Engineering on the development of Marquee courses, refers to “the usual range of motives” from faculty having children in school, the publication of Rising Above the Gathering Storm, and to the organizers’ decision to bring in faculty leaders in each of the several STEM fields (physics, mathematics/computer science, engineering, biology, and agriculture) to lead. Also, and this may have been crucial to the influence campus wide of the courses: to restrict participation to professors at the levels of Associate and Full.

For the first round of Marquee Courses, there was course-development support at $8k paid to the department but to be used by the faculty members volunteering to develop and teach the new course, together with support for a TA for courses attracting 60 or more students.

Not to underestimate faculty commitment! Teaching in the Marquee Program was intensive. Faculty were obliged not only to create and organize new subject matter, but also to attend regularly-scheduled discussions (elsewhere called “learning communities”) dealing with content and pedagogy. Nor was selection into the Marquee program automatic. Faculty had to write individual course proposals, detailing source materials, group work, at-home labs, requirements for oral presentations on the part of students; even list “learning outcomes” (a phrase at which they first balked but soon found they wanted to do.)

The initial proposals were reviewed by three college deans (engineering; computer/math/and physical sciences; and life sciences), who made the initial selection of which courses to move forward.

As said, an essential component of the Marquee model was faculty participation in Marquee seminars on curriculum and pedagogy. The Dean for Undergraduate Studies attended all meetings and provided lunch but the Marquee faculty set their own 2-hour agenda for three gatherings per semester. At their meetings, the faculty spent a lot of time talking about how to adjust a course to accommodate non-STEM majors and methods for enriching student-faculty engagement and teamwork. They were also keen to consider best practices for “oral presentation” (to exercise their own with greatest
impact, to help their students give better oral presentations in class, and to teach their students how to interact with and influence persons in the social/political realm.) They may have balked at the term, but they were eager to discuss learning outcomes and how these might be measured and assessed.

So meaningful and essential were these discussions that, by the second year of the Marquée course offerings, participating faculty insisted that anyone proposing to teach in the program had to have sat in on the discussions the semester before. Another innovation: reward certificates for teaching assistants in Marquée courses designating their competence in cutting-edge pedagogy.

While there was some overall assessment of students, neither the Marquée faculty nor the Administration tracked students' later course-taking behavior, their selection of majors, or any changes in their choice of a profession. The University’s goal was not to convert non-STEM students or have them change their professional destinations, but rather to have them tackle important topics that had and would continue to elude them if they did not broaden their skills sets and their perspective.

Conversions seem to have occurred, rather, for some STEM faculty, who had once believed that liberal arts students couldn’t learn STEM subjects without requisite math skills and found, instead, that important material could be taught without relying on those techniques. Marquée courses generated publicity inside and outside of Maryland but the innovation’s most lasting effect would be the incorporation of the Marquée model as newly configured I-series courses at the heart of Maryland’s current General Education offerings.

III Gen Ed Task Force. 2010-2013

After the Marquée courses had been on the boards for 4-6 years, the Provost appointed a special task force to overhaul the entire General Education program under the leadership of Elizabeth Beise, Physics and Ira Berlin, History.

The existing GenEd model had been in place for twenty years. Since GenEd impacts every undergraduate on campus, the review and redesign, starting in 2010, involved numerous committees of faculty and students and broad-ranging discussion. One thing was agreed upon from the outset: to diversify, modernize, and broaden the requirements. But how? And what models to import?

In the course of an early discussion, Jordan Goodman from Physics, was invited to talk about the Marquée courses (not as well known to faculty outside of STEM), and, not just about course titles, but about teaching styles, the mechanics of classroom operation, specific means of engaging students in active learning, and, above all, how the Marquée Faculty Learning Community had developed and operated. Goodman made the case that it was not just choosing an issues-oriented curriculum and limiting class size to 60 that enabled the Marquée courses to succeed. It was the participating professors’ involvement in learning from one another how to teach in new ways. The
regularly meeting learning community was, he made clear, the key. “There is a value,” Professor Goodman told his colleagues in other fields “in talking to people, who may be from a range of different disciplines, but who are teaching the same kind of students you are teaching.”

Another innovation was not to try to simplify “Physics 101.” Rather, to engage students from other fields of study in some overarching conceptual idea or issue and, after they were “engaged,” bring in the science to support the analysis. Goodman detailed how he treats the science and technology of energy production and energy storage as integral to students’ understanding of “the global energy crisis.”

Robert Briber, from Material Science, also addressing the Gen Ed committee, explained that he wanted his Marquee students to understand one overarching principle, namely that advances in technology start with advances in materials” whether, solar cells or silicon chips. The Marquee courses were not intended to be at all like the introductory course students would take if majoring in a field. And that’s why, he believed, the Marquee courses had succeeded.

IV Towards the I-Series Signature Courses at Maryland

The General Education committee responded to the idea that non-majors might best be introduced to a field through the lens of a topic that has more relevance. But could this be applied to fields outside STEM? And how was the College to convey to students that the new Gen Ed were not the “old” Gen Ed, but different and distinctive? Out of their deliberations came the idea of naming the new elements in the Gen Ed offerings the I-Series – (I for innovation, imagination, integration – what you will). The “I” courses would, once the new gen ed was adopted, replace the Marquee courses expanded to other fields.

Today, I-Series faculty stay current and committed to teaching non-majors by participating in an I-Series learning community, with approximately 30 out of 80 participating faculty attending each of 5 meetings across two semesters. This learning community is limited to those who are currently teaching, with lunch provided by the Dean for Undergraduate Studies. Each session lasts one hour, features one or two presentations by I-Series course instructors currently teaching, and 20 minutes for open discussion. Significantly, the size of the audience of 30 remains constant, although there is some change in which of the possible I-Series faculty attend from one meeting to the next. Faculty—and these include full and associate professors in engineering, according to their Associate Dean Briber—are fully involved.

Just as important as the new “I” course designation was that the General Education task force stipulated, as per Provost Farvardin’s original intention, that all professional schools (including but not limited to Engineering) be required to contribute courses to the general Education program. From that point on, what had been “Marquee” with voluntary participation now became I-Series with required contributions
from every college. Thus, the pattern established by Marquee, that *professional colleges* would teach students who were not their majors was pressed forward as a constitutive aspect of the new General Education program.

Add to that a very strong commitment on the part of the engineering faculty to the Maryland undergraduates as a whole. As I was reminded by the Associate Dean in a recent interview:

The best students at Maryland are equal to the best undergraduates in the country. They will be leaders or play leadership roles in their respective professions, and we want to provide them with the tools that will stick with them: specifics as to how base line energy relates to peak demand, and more generally how technologies interplay. We see ourselves as responsible for fashioning the tools kits of future leaders.

MARYLAND ATTACHMENTS

1 Overall Implementation of the New General Education at Maryland

To convey both the range and what is common to the I-Series component of General Education at Maryland, it may be useful to start outside of engineering with a selection I-Series courses from other fields:

**From Architecture: Design in Place**

**From Business: How do innovators think?**
- Frauds, Scams, and Thefts: How, when, why?
- Entrepreneurial Thinking for Non-Business Majors
- Why Good Managers Make Bad Decisions

**From Education: Forbidden Books: Censorship of Literature**
- Good Stories: teaching narratives for Peace and Justice
- Disability: From Stigma and Sideshow to Mainstream

**From Public Policy: Leading and Investing in Social Change**

Then to turn to excerpts of what is expected of students: [From the Catalogue]:

An [I-series] signature course could take students inside a new field of study, where they may glimpse the utility, elegance and beautiful of disciplines that were previously unknown, unwanted, disparaged, or despised... By addressing both contemporary problems and the enduring issues of human existence, the signature courses will speak to the University’s historic role both as a timeless repository of human knowledge and as a source of solutions to burning issues of the day.
Another source is the list of Learning Outcomes that every I-Series course must aim to achieve (at least 4 from the following 6):

- Identify the major questions and issues in their I-series course topic
- Describe the sources the experts on the topic would use to explore these issues and questions
- Demonstrate an understanding of basic terms, concepts, and approaches that experts employ in dealing with these issues.
- Demonstrate an understanding of the political social, economic, and ethical dimensions involved in the course
- Communicate major ideas and issues raised by the course through effective written and/or oral presentations.
- Articulate how this course has invited them to think in new ways about their lives, their place in the University and other communities, and/or issues central to their major disciplines or other fields of interest.

2 Examples of Engineering I-Series Course Titles and Enrollments

Enrollments in the Engineering I-Series courses track those in other fields. They range from 25 to 120 and are determined both by how many students want the course and how many seats a college is required to fill. (The Gen Ed categories in the list below are only relevant to Maryland’s groupings.)

1. Engineering and Modern Medicine, Wesley Lawson
   GenEd category: I-Series/Scholarship in Practice

2. Technology Choices, Wesley Lawson
   GenEd category: I-Series/Scholarship in Practice
   Offered fall 2013, 43 seats, 41 filled

An exploration of the positive and negative effects of technology on society, via diverse criteria to assess the relative well-being of individuals and society; an examination of how society can help shape the future of technology and the tools that can be used to make wise technology choices.
3. **Engineering and Modern Medicine: The Body as a Machine**, Romel Gomez  
   GenEd category: I-Series/Natural Science  
   
   *A Marquee Science and Technology Course designed for Non-Science Majors: [http://www.marqueecourses.umd.edu](http://www.marqueecourses.umd.edu)*

   GenEd category: I-Series/Scholarship in Practice  
   
   This multi-disciplinary course helps students learn the principles of entrepreneurial opportunity analysis and decision-making in an increasingly dynamic and technically-inclined society. Emphasis is placed on how aspiring technology entrepreneurs can develop their entrepreneurial perspectives to develop winning entrepreneurial plans for their future ventures.

5. **Materials of Civilization**  
   GenEd category: I-Series/Natural Science  
   Offered fall 2015; 80 seats, 74 filled  
   
   The discovery of new materials has shaped history and built civilizations. The utilization, properties and production techniques of materials from the Bronze Age up through modern times and into the future will be traced. These materials are explained by considering their atomic structure, the binding forces between atoms and their arrangement, and how controlling the structure controls the materials properties.  
   
   *A Marquee Science and Technology Course designed for Non-Science Majors: [http://www.marqueecourses.umd.edu](http://www.marqueecourses.umd.edu)*

6. **Bigger, Faster, Better: The Quest for Absolute Technology**, G. Oehrlein  
   GenEd category: I-Series/Natural Science  
   Offered fall 2015, offered 125 seats, 118 filled  
   Offered spring 2014, 50 seats, 48 filled

7. **Building Products that Last: Failure is not an Option**, P. McCluskey  
   GenEd category: I-Series/Natural Science  
   Offered spring 2015, offered 60 seats, 59 filled
The Future of Technology: Sustainable Development or Sensational Disaster?

Course Description
Life in society today is radically different than it was only a few decades ago, and many of the changes were enabled by advances in technology. Whether the quality of life has improved during that time frame is a matter for debate, and depends greatly on your perspective, culture, economic status, national origin, etc. This course looks at the question, “How can we shape the future of technology, so as to improve the quality of life as much as we can, for as many people as we can?” We look at specific criteria to measure the positive and negative effects of technology, via questions like: How has it changed our levels of financial, personal, and physical security? What is its impact on cultural diversity? What is its impact on interpersonal relationships? Is our current technological level sustainable? Given these criteria, we will examine how to shape the future, by asking questions such as: Can we predict technological advances? Who should control these advances? Students who take this class will gain insight into the interactions between society and technology and will understand how everyone can help shape their own future. Emphasis will be on emerging technologies in Electrical and Computer Engineering.

Course Objectives:
1. To enable students to make informed technology choices via the investigation and critical analysis of all dimensions, issues, and problems involved in developing, implementing, and/or using technology.
2. To inspire students to innovate new solutions to current technological shortcomings and to use their imaginations to look for new directions that can lead to sustainable and environmentally compatible technologies.
3. To empower students to draw on material from diverse disciplines such as history, ethics, politics, economics, sociology, etc. to evaluate the impact of technology in both a societal and global context.
4. To ensure students can effectively present sustained, critical analyses through both oral and written communication.

Semester Outline/Topics
1. How should we define technology?
2. Does technology control us?
3. Can we predict technological advances?
4. How do historians look at technology?
5. What is the effect of modern technology on cultural diversity?
6. Is modern technology on the right path to sustainability?
7. What is the effect of modern technology on the workforce?
8. Who should select new technologies?
9. Is technology making our lives more or less secure?
10. Does technology help to expand our consciousness?
11. How can we help change modern momentum and prove the technological pessimists wrong?
Grading Method:

In-class participation: 15%  
A: 90 – 100%
Homework & three papers: 20%  
B: 80 – 89.9%
Two Midterm exams: 20%  
C: 70 – 79.9%
Final Exam: 20%  
D: 60 – 69.9%
Two Group Presentations/Projects: 25%  
F: 00 – 59.9%

Textbooks

Course Prerequisites
None

Class attendance
This class involves significant class participation every day, so attendance is required.

On completion of an I-Series course, student will be able to:
• Identify the major questions and issues in their I-series course topic.
• Describe the sources the experts on the topic would use to explore these issues and questions.
• Demonstrate an understanding of basic terms, concepts, and approaches that experts employ in dealing with these issues.
• Demonstrate an understanding of the political, social, economic, and ethical dimensions involved in the course.
• Communicate major ideas and issues raised by the course through effective written and/or oral presentations.
• Articulate how this course has invited them to think in new ways about their lives, their place in the University and other communities, and/or issues central to their major disciplines or other fields of interest.
Instructor: Name: W. Lawson
Office: AVW 2325
Phone: x54972
E-mail: lawson@umd.edu
Office Hours: Friday 1 – 2:50PM

Textbook: NONE, but there will be material posted on ELMS and other suggested readings.

Recitations: Will be held every week!

Prerequisites: none

COURSE OBJECTIVES

This course provides a non-technical introduction to the role of electrical and computer engineering in modern medicine, by presenting an overview of the types of biomedical devices currently used to diagnose and treat medical conditions. All aspects of the process of bringing a new product or technology to market are examined and discussed, and the roles of government, industry, as well as financial, legal, ethical and social considerations are critically explored. Taking this class will improve your awareness of:

1. Scientific and technical basics related to medical devices.
2. The capabilities and limitations of modern technology in the medical field.
3. The path traveled to convert an idea for a medical device into reality.
4. The evaluation process for experimental/clinical data.
5. Ethical considerations in the medical device field.
6. Teamwork and group dynamics.
7. The importance of good written and oral communication skills.

Course Topics

1. Introduction to the state of the medical device industry in the USA and the rest of the world.
2. Classic Clinical Diagnosis Devices (Electrocardiogram, Electroencephalogram, Sphygmanometer, and Oximeter)
3. Personal Diagnosis Devices (heart monitors, blood sugar monitors)
4. Modern Medical Imaging Technology (Ultrasound detection, Magnetic Resonance Imaging (MRI), Positron Emission Tomography, X-rays, Computed tomography (CT) or Computed Axial Tomography (CAT) Scanner)
5. Standard Therapeutics and Life-extending technologies (Laser surgery, LASIK procedure, Radiation therapy)
6. Emerging Therapeutics and Life-extending technologies (DNA therapy, Nanoparticle directed drug delivery)
7. Electrical processes in the body/brain and related current/emerging treatments (ECT, TMS for treatment of depression and headaches, epilepsy monitoring and intervention, Pacemakers)
8. The role of non-technical factors in the medical device industry (government regulation, insurance company policies, ethics, finances)

9. The developmental path for new devices in the medical industry.

10. Future trends in the medical device industry.

**GRADING POLICY:**

**Team Grades**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral presentations</td>
<td>15%</td>
</tr>
<tr>
<td>Written presentation</td>
<td>10%</td>
</tr>
</tbody>
</table>

**Individual Grades**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class Participation</td>
<td>15%</td>
</tr>
<tr>
<td>Homework / Papers</td>
<td>20%</td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>20%</td>
</tr>
<tr>
<td>Final Exam</td>
<td>20%</td>
</tr>
</tbody>
</table>

Please note that the grading in this course will be based on relative performance. Therefore the widely held belief that there is a default grading scale such that an average of 90.0% equals an “A,” between 80.0% and < 90.0% equals “B,” etc. does not apply to the grading of this course.

Class participation – while attendance does not factor into your grade, this is a class where a significant part of the learning process takes part in class-wide discussions and in group projects and so attendance is very important. As such, 5% of your grade will come from evaluation by your peers and the other 10% will be determined by the professor and UTFs and will be based on the relative value of your contributions to classroom discussions and other in-class exercises.

**Academic Integrity**

You may collaborate on the homework, but all submitted individual work must be solely your own. Please refer to the University’s Code of Academic Integrity at

http://www.studenthonorcouncil.umd.edu/code.html#

You will be held accountable for adherence to this code.

**Attendance** is expected. If you miss class you are responsible for obtaining any of the information covered that day.

**Exams** will be held during the regular lecture time. In the event the University dismisses classes for a day on which the exam is scheduled, then the exam will be given on the very next class meeting.

**Homework** assignments are due at the beginning of the class period on the due date. It is recommended that homework be typed using a word processing software. Homework that is poorly
legible will not be graded. Late homework will not be accepted, except in unusual circumstances, such as due to ill health, upon submission of sufficient documentary evidence. Late homework will not be accepted, once the solutions are posted, under any circumstances.

**Accommodations**

Religious observances: Students shall be given an opportunity whenever feasible to make up in a reasonable time any academic assignment that is missed due to individual participation in religious observances. It is the student’s responsibility to inform the instructor of any intended absences for religious observances *in advance*.

Disabilities: The University has a legal obligation to provide appropriate accommodations for students with disabilities. If you have a university registered special need related to a disability, please inform the instructor *as soon as possible* to arrange accommodations.

**Academic Assistance**

If you are experiencing difficulties in keeping up with the demands of your classes and schedule, contact the Learning Assistance Services, 2201 Shoemaker Building, 301-314-7693, or on the web at [http://www.counseling.umd.edu/LAS/](http://www.counseling.umd.edu/LAS/) Their educational counselors can help with time management, reading, note taking, and exam preparation skills.

**Courtesies:** You can help make the classroom conducive to learning if you:
1. Arrive for class on time
2. Do not prepare to leave until the instructor indicates the lecture is over
3. Silence your cell phone
ENMA 150: The Materials of Civilization  
A University of Maryland I-Series Course in Science and Technology  
Course schedule:
Lecture: Tu/Th 3:30 – 4:45pm Rm CHE 2108 (Chemical and Nuclear Eng. Bldg)
Discussion section 0101: Wed 2:00pm – 2:50pm Chem/Nucl Bldg (CHE) 2136
Discussion section 0102: Thursday 11:00 – 11:50 Kim Eng Bldg (KEB) 2111

Course website: https://elms.umd.edu
Most course materials will be posted on the website and not handed out in class.

Instructor
R.M. Briber, Professor and Chair
Department of Materials Science and Engineering
(301) 405-7313 rbriber@umd.edu
Office Location: Room 1109 Chemical & Nuclear Engineering Building
Office hours for Prof. Briber:       Wednesday  3:00 – 4:00 PM
                                     Thursday  12:00 – 1:00 PM

Appointments can be scheduled via e-mail. Appointments are not required but strongly encouraged!

Discussion Sections
Discussion section 0101: Wed 2:00pm – 2:50pm Chem/Nucl Bldg. (CHE) Room 2136
Discussion section 0102: Thursday 11:00 – 11:50 Kim Engineering Bldg (KEB) Room 2111

Course Description
A general introductory course to the field of materials science at the 100 level designed primarily for non-science or non-engineering majors.

The discovery of new materials has shaped history and built civilizations. Materials have played such an important role that scholars have named periods of history including the Stone Age, the Bronze Age and the Iron Age.

The study of world history generally focuses on wars, the rulers who governed and the formation and (subsequent) downfall of empires. Little if anything is said about the materials that have often lead to the success (and sometimes failure) of these empires. This trend continues in modern civilization with the advances in materials preceding many of the leaps in technology that we have come to take for granted as part of our society. For example: plastics are so common in every day living and every consumer good that it would be difficult to imagine the modern world with only the more “traditional” materials of wood, stone, ceramic and metal, yet modern plastics have been in wide use for less than 75 years. The computer and electronic revolution is completely built upon silicon and our ability to change the electrical properties of this most unusual material. Rapid, reliable, modern air transportation is completely dependent on the use of aluminum and other lightweight and strong materials. What are the future changes in materials that will lead to revolutions in our society? Advances in health care, the promise of nanotechnology, energy sustainability and the colonization of space are all exciting ideas with tremendous potential that will be predicated in some part on advances in the materials that may make these things possible.
This course will trace the utilization, properties and production techniques of materials from the Bronze Age up through modern times and into the future. We will start with a description of properties of the first materials utilized by man such as stone, fiber and copper. These materials, are explained by considering their atomic structure, the binding forces between atoms and their arrangement. The properties of iron and steel are explained along with the history of iron and steel making. The electronic properties of materials are also covered from a historical as well as from a scientific point of view.

**Course Goals**

I-Series Course Goals

- Look at complex questions and identify the science in the question and how it impacts and is impacted by political, social, economic, and ethical dimensions
- Understand the limits of scientific knowledge
- Critically assess and formulate basic science arguments
- Find information using various sources and evaluate the veracity of the information
- Communicate scientific ideas effectively
- Relate science to a personal situation

Additional Course Goals Specific to ENMA150

- A general understanding of different classes of materials and their structure
- A general understanding of the role of materials on advances in technology, society and civilizations, including the current (modern) age.
- Basic familiarity with technical writing through the 3 take-home materials projects and the final poster group research project. Also, basic familiarity with simple data analysis using Microsoft Excel (or other spreadsheet)

**Text:**


**Additional Background reading:**


There will be 4-5 guest and special lectures during the semester on different topics of modern materials. Materials from Guest Lectures will be covered on the exams.
**Other Readings and Videos:**
The 4 “Making Stuff” produced by PBS NOVA will be shown in Discussion Section. These are also available for viewing on Canvas in the *Course Videos* section. A 2-3 page study guide for each video will be posted emphasizing the important points of the videos. Content from these videos is considered part of the course and may be on exams.

There will be other short reading posted on Canvas throughout the semester. These include:

“A Short History of Metals” by Alan Cramb


+ other readings as assigned.

**Guest and Special Lectures**

*IMPORTANT Note: Attendance at guest lectures during class time is mandatory and attendance may be taken. Material from in-class guest lectures may appear on exams.*

<table>
<thead>
<tr>
<th>Date</th>
<th>Speaker/Institution</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Th 9/3</td>
<td>Engineering and Physical Science Library – Nevenka Zdravkovska</td>
<td><em>Introduction to the Engineering and Physical Sciences Library</em></td>
</tr>
<tr>
<td>Thu 9/24</td>
<td>Dr. Timothy Foecke, National Institute of Standards and Technology</td>
<td><em>How Did The Twin Towers Come Down?</em></td>
</tr>
<tr>
<td>Tu 10/6</td>
<td>Dr. Matthew Trexler, Under Armour</td>
<td><em>Under Armour Materials and Innovation: Philosophy, Organization, and Select Examples</em></td>
</tr>
<tr>
<td>Thu 11/19</td>
<td>Prof. Ichiro Takeuchi, Materials Science and Engineering Department</td>
<td><em>Combinatorial Approach to Materials Discovery</em></td>
</tr>
<tr>
<td>Thu 12/10</td>
<td>Dr. Edward P. Vicenzi, Museum Conservation Institute, Smithsonian Institution</td>
<td><em>The Twin Paradox: A Study of Preservation &amp; Disfigurement of Southworth and Hawes Daguerreotype Photographs</em></td>
</tr>
<tr>
<td>Tues 11/10</td>
<td>Last name starts with the letters A-L; Project on Mechanical Properties; Class held in 1135 Kim Engineering Building (Last name starts with M-Z have no class on 11/10)</td>
<td></td>
</tr>
<tr>
<td>Thurs 11/12</td>
<td>Last name starts with the letters M-Z; Project on Mechanical Properties; Class held in 1135 Kim Engineering Building (Last name starts with A-L have no class on 11/12)</td>
<td></td>
</tr>
<tr>
<td>Tues 12/8</td>
<td>Poster Session – all groups will present their research poster on an advanced material during class time. The poster session will be held in: Chemistry Atrium (this is on the first floor outside the large Chemistry Lecture Rooms - room 1402).</td>
<td></td>
</tr>
</tbody>
</table>
# Grading

<table>
<thead>
<tr>
<th>Midterm</th>
<th>200 points (20%)</th>
<th>The midterm is based on materials presented up to and including the lecture before the midterm. Material from guest lectures and videos may be on the exam. <strong>The midterm will be on Thursday 10/29/15.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Thursday 10/29/2015 in class Review Sessions: Mon 10/26 5pm room EGR 1104 and Tues 10/27 5pm in EGR 1104 (note the room for these review sessions!)</td>
<td>100 points each (10% each)</td>
<td>Project reports must be computer generated (typed) and follow the format that will be discussed in class; additional instructions are at the end of the handout for each project. Graphs must be done using a computer.</td>
</tr>
<tr>
<td>Reports for 3 take home Projects</td>
<td>150 points (15%)</td>
<td>There will be a poster session during class time at end of the semester (Tu 12/8) in the Chemistry Atrium where all posters will be presented. The final posters are due as a stapled collection of PowerPoint slides in class on 12/10/2015 (last class of the semester).</td>
</tr>
<tr>
<td>Project 1 handed out Th 9/17; due T 9/29 Project 2 handed out T 10/6; due Th 10/15 Project 3 handed out 11/3; due: Tu 11/24 Data collection for Project 3: 11/10, 11/12 in Kim Eng. Bldg rm 1135</td>
<td>150 points (15%)</td>
<td>Final exam will be cumulative on all course materials. The time and date for the final exam is scheduled by the University and cannot be changed see: <a href="http://www.registrar.umd.edu/current/registration/exam%20tables%20fall.html">http://www.registrar.umd.edu/current/registration/exam%20tables%20fall.html</a> Sat. 12/19/15 10:30am-12:30pm Room CHE2108 (normal lecture room).</td>
</tr>
<tr>
<td>Team Based Poster Project on the characteristics of an advanced material. Possible subjects will be provided. Teams will be formed early to mid-semester by the instructor. Poster presentations (all groups) will be Tues 12/8 3:30-4:45pm Location: Chemistry Atrium – this is on the first floor outside the large Chemistry Lecture Rooms (room 1402).</td>
<td>4 Homework sets and short papers</td>
<td>All written assignments must be computer generated (typed). Calculations can be done by hand.</td>
</tr>
<tr>
<td>Final Exam Saturday, Dec. 19, 2015 10:30am-12:30pm Room CHE2108 (normal lecture room)</td>
<td>Final Exam review sessions: Tues 12/15 5-6pm Location TBA Wed 12/16 5-6pm Location TBA</td>
<td>Note: I realize this is the last day of final exams and campus graduation is that evening(!), the final exam date/time for the course is set by the University and not open to negotiation.</td>
</tr>
<tr>
<td>150 points (15%)</td>
<td>Note: Attendance at the invited lectures is mandatory (except were indicated). Attendance will be taken.</td>
<td>50 points each (5% each)</td>
</tr>
<tr>
<td>50 points (5% each)</td>
<td>Total</td>
<td>200 + 3*(100) + 150 + 150 + 4*(50) = 1000 points</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 1000 points | **Note:** Some assignments will be graded for a different number of points than listed above and then scaled to the number of points in this list and then entered into Canvas/ELMS.
Grading (cont.)

Some assignments may have extra credit parts to them. *There will be no individual extra credit assignments.*

Generally the course grades follow the standard grading curve by default, though the instructor reserves the right to change the overall curve depending on the grade distribution. The final curve will be posted on Canvas when final grades are submitted.

Typically in previous years the grading curve has been:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Score Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>A+</td>
<td>1000-960</td>
</tr>
<tr>
<td>A</td>
<td>959-930</td>
</tr>
<tr>
<td>A-</td>
<td>929-900</td>
</tr>
<tr>
<td>B+</td>
<td>899-860</td>
</tr>
<tr>
<td>B</td>
<td>859-830</td>
</tr>
<tr>
<td>B-</td>
<td>829-800</td>
</tr>
<tr>
<td>C+</td>
<td>799-760</td>
</tr>
<tr>
<td>C</td>
<td>759-730</td>
</tr>
<tr>
<td>C-</td>
<td>729-700</td>
</tr>
<tr>
<td>D+</td>
<td>699-660</td>
</tr>
<tr>
<td>D</td>
<td>659-630</td>
</tr>
<tr>
<td>D-</td>
<td>629-600</td>
</tr>
<tr>
<td>F</td>
<td>599 and below</td>
</tr>
</tbody>
</table>
Course Outline

I. Classification of Materials
   Metals, Ceramics, Polymers, Electronic Materials Course Notes

II. Historical Development of Materials
   The first materials: Stone and Clay Chapter 1 in Sass
   The first metals: Copper and Bronze Chapters 2 and 3 in Sass
   Gold and Silver and the basis of wealth Chapter 4 in Sass
   Mechanisms and Properties of Metals Course notes
   The basics of structure
   The basics of mechanical properties
   The Discovery of Iron Chapter 5 in Sass
   A New Material: Glass Chapters 6 - 8 in Sass
   Steel: The Modern Metal Chapters 9 - 11 in Sass

III. Polymers: A Modern Class of Materials Chapters 12 in Sass and Course notes
   The Discovery of Polymerization
   Mechanisms and Properties:
      What are Polymers?
      The Unique Properties of Polymers
   The Growth of a Science and an Industry
   Modern Lifecycle of Plastics: Synthesis, Use and Recycling

IV. The Electronic Properties Materials Chapter 15 in Sass
   The Age of Electronic Materials
   Mechanisms and Properties
   Basics of Electronic and Magnetic Properties
   The Semiconductor Revolution
   The Information Age

V. Other Modern Materials Chapter 13 and 14 in Sass and Course Notes

Take-Home Materials Projects
There will be 3 project reports for the course, based on take home samples and a demonstration done
in the materials teaching lab (room 1135 Kim Engineering Building) with the data posted on
Blackboard.

Project 1: Shape Memory Alloys Handed out: Tues 9/15 Due: Tues 9/24
Project 2: Superabsorbent Polymer Handed out: Tues 10/6 Due: Thurs 10/15
Project 3: Mechanical Properties Handed out: Tues 11/3; Data collection on Tu/Th 11/10&11 Due: Tues 11/24
Project Reports, Papers and Homework
In general, all assignments turned in for this course need to be prepared on a computer. There are numerous computer labs around campus and you can learn more about access from the campus office of information technology:  [http://www.oit.umd.edu](http://www.oit.umd.edu)

All sources in reports and papers must be referenced. It does not matter whether the source is a book, magazine, journal article or the web.  **All sources must be referenced.**

In addition, any figures used in any papers or reports that are not created by you need to be referenced as to the source.

Reports, papers and homework will be due in class, in hard copy form with all pages stapled together. There will be a penalty for late work. It is not the instructor’s responsibility to keep unstapled pages together.

Collaboration and Working together on Homework and Other Individual Assignments
Working together on homework is encouraged but the document that is turned in must represent your own work in solving the homework problem. If it appears that any homework assignments have been copied directly from each other, all will receive a grade of zero for the assignment.

Additional Information
Since the Canvas website is used extensively for distribution of course materials and announcements, it is important that you check it regularly. If you can’t login, you should follow the help instructions on the website home page. Neither the instructor or the T.A. can give you access to the website.

Email and other written communications
In general all written assignments will be collected as hard copy in class. Emailed documents will be accepted only by permission for special circumstances.

All email correspondence with the instructors and TAs should be written as a formal business communication with a salutation, complete sentences, capitalization and punctuation, no texting abbreviations and a closing with your full name and email address. All attachments should include a description of the nature of the document and your name as part of the file name.  For example: ENMA150_HW3_JohnDoe.doc

Academic Accommodations
If you have a documented disability, you should contact Disability Support Services 0126 Shoemaker Hall. Each semester students with documented disabilities should apply to DSS for accommodation request forms which you can provide to your professors as proof of your eligibility for accommodations. The rules for eligibility and the types of accommodations a student may request can be reviewed on the DSS web site at  [http://www.counseling.umd.edu/DSS/registration.php](http://www.counseling.umd.edu/DSS/registration.php)
**Religious Observances**
The University System of Maryland policy provides that students should not be penalized because of observances of their religious beliefs, students shall be given an opportunity, whenever feasible, to make up within a reasonable time any academic assignment that is missed due to individual participation in religious observances. It is the responsibility of the student to inform the instructor of any intended absences for religious observances in advance. Notice should be provided as soon as possible but no later that the end of the schedule adjustment period. Faculty should further remind students that prior notification is especially important in connection with final exams, since failure to reschedule a final exam before the conclusion of the final examination period may result in loss of credits during the semester. The problem is especially likely to arise when final exams are scheduled on Saturdays.

**Academic Integrity**
The University of Maryland has a nationally recognized Code of Academic Integrity, administered by the Student Honor Council. This code sets standards for academic integrity at Maryland for all undergraduate and graduate students. As a student you are responsible for upholding these standards for this course. It is very important for you to be aware of the consequences of cheating, fabrication, facilitation, and plagiarism. For more information on the Code of Academic Integrity or the Student Honor Council, please visit [http://shc.umd.edu/SHC/Default.aspx](http://shc.umd.edu/SHC/Default.aspx)

The University of Maryland is one of a small number of universities with a student-administered Honors Code and an Honors Pledge, available on the web at [http://shc.umd.edu/SHC/HonorPledgeInformation.aspx](http://shc.umd.edu/SHC/HonorPledgeInformation.aspx). The code prohibits students from cheating on exams, plagiarizing papers, submitting the same paper for credit in two courses without authorization, buying papers, submitting fraudulent documents, and forging signatures. The University Senate encourages instructors to ask students to write the following signed statement on each examination or assignment: “I pledge on my honor that I have not given or received any unauthorized assistance on this assignment/examination.”

**Attendance**
Regular attendance and participation in this class is the best way to grasp the concepts and principles being discussed. However, in the event that a class must be missed due to an illness, the policy in this class is as follows:

For every medically necessary absence from class (lecture, recitation, or lab), a reasonable effort should be made to notify the instructor in advance of the class. When returning to class, students must bring a note identifying the date of and reason for the absence, and acknowledging that the information in the note is accurate. If a student is absent on days when tests are scheduled he or she is required to notify the instructor in advance, and upon returning to class, bring documentation of the illness, signed by a health care professional.

The campus policy is available here: [http://www.president.umd.edu/policies/v100g.html](http://www.president.umd.edu/policies/v100g.html)
Applied science and engineering concepts necessary to understand technological advances, breakthroughs and world-leading achievements that have shaped our present lives and will impact our future will be covered. The political, economic, and personal driving forces behind selected technological transformations, societal contexts, and conflicts that are inherent in unsustainable technology will also be covered.

**Preliminary Course Schedule**

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-Jan</td>
<td>Technology and Our World</td>
</tr>
<tr>
<td>25-Jan</td>
<td>Need For Innovation And Inventions</td>
</tr>
<tr>
<td>31-Jan</td>
<td>Problem- and Necessity-Driven Technology: Food Production</td>
</tr>
<tr>
<td></td>
<td><strong>Assignment</strong>: important questions relative to our current use of technology … Nye, chapters 1, 4</td>
</tr>
<tr>
<td>1-Feb</td>
<td>Discussion</td>
</tr>
<tr>
<td>5-Feb</td>
<td>Buildings</td>
</tr>
<tr>
<td>7-Feb</td>
<td>Electrical Technology</td>
</tr>
<tr>
<td></td>
<td><strong>Assignment</strong>: ammonia synthesis, Erisman paper …</td>
</tr>
<tr>
<td>8-Feb</td>
<td>Discussion</td>
</tr>
<tr>
<td>12-Feb</td>
<td>Transportation, Location, Time keeping</td>
</tr>
<tr>
<td>14-Feb</td>
<td>guest lecture: Liangbing Hu, Introduction to Energy Uses and Challenges</td>
</tr>
<tr>
<td></td>
<td><strong>Assignment</strong>: conservation vs. curtailment, energy-saving strategies … Nye, chapter 2</td>
</tr>
<tr>
<td>15-Feb</td>
<td>Discussion</td>
</tr>
<tr>
<td>19-Feb</td>
<td>Making Things Smaller: Transistors …</td>
</tr>
<tr>
<td>21-Feb</td>
<td>Communication</td>
</tr>
<tr>
<td></td>
<td><strong>Assignment</strong>: energy use, future prospects, Hoffert paper …</td>
</tr>
<tr>
<td>22-Feb</td>
<td>Review for Exam</td>
</tr>
<tr>
<td>26-Feb</td>
<td>First Exam</td>
</tr>
<tr>
<td>28-Feb</td>
<td>Medical Technology</td>
</tr>
<tr>
<td></td>
<td><strong>Assignment</strong>: Moore's Law … Nye, chapter 3</td>
</tr>
<tr>
<td>1-Mar</td>
<td>Discussion</td>
</tr>
<tr>
<td>5-Mar</td>
<td>Warfare</td>
</tr>
<tr>
<td>7-Mar</td>
<td>guest lecture: Sumio Kogure, Intellectual Property and International Intellectual Property Coordination</td>
</tr>
<tr>
<td></td>
<td><strong>Assignment</strong>: Unmanned aerial vehicles; Nye, chapter 9</td>
</tr>
<tr>
<td>8-Mar</td>
<td>Discussion</td>
</tr>
<tr>
<td>12-Mar</td>
<td>Artificial Intelligence</td>
</tr>
<tr>
<td>14-Mar</td>
<td>Research, Development and Production: Required Contexts for Technological Evolution</td>
</tr>
<tr>
<td></td>
<td><strong>Assignment</strong>: Watson Is Far From Elementary; Nye, chapters 5, 10</td>
</tr>
<tr>
<td>15-Mar</td>
<td>Discussion</td>
</tr>
<tr>
<td></td>
<td><strong>Spring Break - 3/18 to 3/22</strong></td>
</tr>
<tr>
<td>26-Mar</td>
<td>How Is Technological Change Produced?</td>
</tr>
<tr>
<td>28-Mar</td>
<td>Societal, Environmental and Other Impacts - Technology Choices and Limits, Unintended Consequences</td>
</tr>
<tr>
<td></td>
<td><strong>Assignment</strong>: Nye, chapter 8; How does our society select technologies? J. Diamond</td>
</tr>
<tr>
<td>29-Mar</td>
<td>Discussion</td>
</tr>
<tr>
<td>2-Apr</td>
<td>Sustainable vs. Unsustainable Technology</td>
</tr>
<tr>
<td>4-Apr</td>
<td>Project discussion</td>
</tr>
<tr>
<td></td>
<td><strong>Assignment</strong>: Nye, chapter 6</td>
</tr>
<tr>
<td>5-Apr</td>
<td>Discussion</td>
</tr>
<tr>
<td>9-Apr</td>
<td>Impact on Work</td>
</tr>
<tr>
<td>11-Apr</td>
<td>Resistance to technological change; Amish Dutch – a look at how they control technology</td>
</tr>
<tr>
<td></td>
<td><strong>Assignment</strong>: Nye, chapter 7; Work - better or worse?</td>
</tr>
<tr>
<td>12-Apr</td>
<td>Discussion</td>
</tr>
<tr>
<td>Date</td>
<td>Event</td>
</tr>
<tr>
<td>--------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>16-Apr</td>
<td>Group project update</td>
</tr>
<tr>
<td>18-Apr</td>
<td>Review</td>
</tr>
<tr>
<td>19-Apr</td>
<td>Discussion, Review</td>
</tr>
<tr>
<td>23-Apr</td>
<td><strong>Second Exam</strong></td>
</tr>
<tr>
<td>25-Apr</td>
<td>Technological Society – the Future: Grand Engineering Challenges</td>
</tr>
<tr>
<td></td>
<td>Assignment: Nye, chapter 11; water constraints</td>
</tr>
<tr>
<td>26-Apr</td>
<td>Discussion</td>
</tr>
<tr>
<td>30-Apr</td>
<td>guest lecture: Vincent Brannigan - Ethics and Technology</td>
</tr>
<tr>
<td>2-May</td>
<td>Presentations to class</td>
</tr>
<tr>
<td>3-May</td>
<td>Discussion</td>
</tr>
<tr>
<td>7-May</td>
<td>Presentations to class</td>
</tr>
<tr>
<td>9-May</td>
<td>Outlook</td>
</tr>
<tr>
<td>9-May</td>
<td><strong>Final Papers due</strong></td>
</tr>
</tbody>
</table>

**Textbooks**

Other required reading material will be distributed.

**Grading**: There will be two exams and an independent research project. The latter will be presented to the class and described in a research report. Your grade will be determined approximately by the following:
- Hour Exams: 25% each
- Final Project - Presentation + Report: 25%
- Homework: 15%
- Quizzes: 10%
- Class Participation, Stimulating Questions: up to 10% Bonus

Attendance is mandatory. For every three classes missed, your final grade will be penalized.
ENME 242: Building Products that Last – Failure is NOT an Option!

Description:
Product design in the last half of the twentieth century focused on “planned obsolescence,” the theory of forcing customers to continually buy new products to replace ones that are intended to be used only once, fail after a few years, or just “go out of style.” This “throw-away” society of the last fifty years is now giving way to a new paradigm. With today’s concerns about peak oil, collapsing infrastructure, limited natural resources, and minimizing waste and pollution, people are beginning to see the value in opting for products that are built to last. This is seen in longer warranties on automobiles, and an emphasis on recycling, reuse, and repurposing. These products are now joining large structures, such as space stations, jet aircraft, buildings, and bridges which were always designed for long life.

This course will give students the tools and information needed to understand the causes of product failures; the political, societal, economic, environmental, and ethical impacts of these failures, and the strategies to avoid, postpone, or mitigate them. Students will be encouraged to combine concepts from engineering, natural sciences, social sciences, and the humanities to address these complex issues. Students will be introduced to the basics of failure analysis and reliability engineering, and they will learn the scientific fundamentals underlying the most common types of failure (e.g. fatigue and corrosion). In addition, the cost of failure and the steps taken to prevent failure will be highlighted. Issues of legal liability, and the associated effects of failure on the environment, safety, public policy and regulations will also be addressed. Finally, methods for monitoring the existing condition of a structure will be discussed. This will be accomplished through a combination of readings, lectures, guest speakers, videos, studios, site visits, projects, and class discussion of case-study examples drawn from a wide range of products and systems ranging from automobiles and airplanes to bridges and wind turbines.

Prerequisites: None

Reading:
Readings will be assigned from sources such as the sample texts, handbooks, and journals below which are representative of those used as resources by experts in the field.


Additional Readings:


Journals:
IEEE Transactions on Device and Materials Reliability
IEEE Transactions on Reliability
Microelectronics Reliability
International Journal of Fatigue
Fatigue and Fracture of Engineering Materials and Structures
Corrosion
Additional Course Resources: Videos and articles on famous failures including air disasters, bridge collapses, wind turbine explosions, and actual electronic equipment failures will be included. Guest speakers including university faculty and practicing failure and risk analysts will provide lectures on design for reliability, human factors, risk and cost analysis, legal implications, ethics, and condition monitoring.

Course Objectives: The main objective of this course is for students to understand the causes and political, societal, economic, and ethical impacts of engineered product failures and how to avoid, postpone, or mitigate them. Students completing this course will be able to:

1. Explain the characteristics and fundamental physics behind the most common types of failure
2. Give examples of failures and their root causes
3. Address human factors as a contributor to failure
4. Conduct a failure analysis to determine the root cause of failure
5. Describe different approaches to develop and utilize predictive failure models
6. Make design choices that minimize and mitigate the susceptibility to failure
7. Select and locate monitors to collect data on the environment and system condition
8. Discuss the safety and financial risks associated with failure
9. Discuss the environmental impact of failure
10. Discuss the political and societal impacts and responses to failure
11. Address basic concepts of engineering ethics

Topics Covered:

0. Ethics: will be covered throughout the course

I. WEEK 1: Introduction – What is Failure?
   1. Introduction to a Typical Failure Scenario
   2. Common causes of failure of engineered structures and products
   3. Ways to mitigate the chances of failure and the associated tradeoffs
   4. Planned Obsolescence vs. Sustainable Design

II. WEEKS 2 and 3: Basics of Reliability Engineering
   1. Overstress vs. Wearout
   2. Overstress and Stress Concentration Factors
   3. Design Margins and Their Application
   4. Safety Factors and The Manufacturing Cost of Overdesign
   5. The Effect of Manufacturing Defects (Quality v. Reliability)
   6. Tools and Techniques for Predicting Lifetimes and Failures (Durability v. Reliability)
   7. Physics of Failure Approach vs. Other Approaches
   8. Developing a Failure Model

III. WEEK 4: Human Factors
   1. How Human Interaction Can Contribute to Product Failure
   2. How Products Can Be Designed to Avoid Human Error
   3. How Organizational Factors Can Contribute to Product Failure
IV. WEEK 5: Failure Type #1 - Fatigue Fracture
1. The Fatigue Process
2. Approaches to Modeling Fatigue
3. Observable Characteristics Identifying a Fatigue Failure
4. CASE STUDY: Structure Failing by Fatigue
5. Ways to Mitigate Fatigue Failures

V. WEEK 6: Failure Type #2 - Corrosion
1. The Corrosion Process
2. Approaches to Modeling Corrosion
3. Observable Characteristics Identifying a Corrosion Failure
4. CASE STUDY: Structure Failing by Corrosion
5. Ways to Mitigate Corrosion Degradation

VI. WEEK 7: Failure Type #3 – Creep and Stress Relaxation
1. The Creep Process
2. Approaches to Modeling Creep
3. Observable Characteristics Identifying a Creep Failure
4. CASE STUDY: Structure Failing by Creep
5. Ways to Mitigate Creep Failures

VII. WEEK 8: Failure Type #4 – Polymer Degradation
1. Basics of Polymer Structure
2. Observable Characteristics Identifying Polymer Degradation
3. Good Uses of Polymer Degradation – Recycling, Repurposing
4. Ways to Mitigate Polymer Degradation

VIII. WEEK 9: Failure Analysis
1. Tools and Techniques for Analyzing Failures
2. Clues to Identifying the Root Cause of Failure
3. Clues for Determining the Point of Initiation of Failure
4. Evaluating Failure Analysis Information – What to Trust? How to Validate?

IX. WEEK 10: Condition Monitoring
1. Leading Indicators of Failure
2. Diagnostics and Performance Based Monitors
3. Locating Monitors
4. Environmental Monitors and Incorporation in Failure Modeling
5. Analysis of Condition Monitoring Data
6. Remaining Life Analysis

X. WEEK 11: Economic Effects
1. Costs Associated with Replacement of Product
2. Costs Associated with Loss of Use
3. Costs Associated with Loss of Reputation
4. Costs Associated with Individual Safety
5. Costs of Avoidance
6. How to do a Cost Analysis

XI. WEEK 12: Legal Issues
1. Strict Liability and Negligence – Is there grounds for a suit?
2. Privity of Contract - Who can be sued?
3. Consumer Protection
4. Ethical Concerns
XII. WEEK 13: Political and Societal Effects
1. Effect of Product Failure on Sustainability (Scarce Resources, Energy Efficiency)
2. Effect of Product Failure on the Environment
3. Effect of Product Failure on Individual Safety
4. Effect of Product Failure in Mission Critical Applications
5. Effect of Product Failure on Public Policy and Regulation

XIII. WEEKS 14 and 15 Student Term Paper Presentations (2 weeks)

Grading:
- Final Exam 25%
- Midterm Exam 20% (Anticipated to be Tuesday, March 31, 2015)
- Term Paper 25% See Below
- Weekly Assignments 25% (11 assignments, lowest one is dropped)
- Class Participation 5%

Term Paper: The Class will be broken into teams of 5 students. Each team will choose a famous engineering failure from history, and then determine the root cause; discuss the consequences and impact; suggest potential remedies and discuss how design practices and government policies changed as a result. Each team will provide a term paper and presentation at the end of the semester.

Weekly Assignment: Each Tuesday, a homework assignment will be posted based on the previous week’s topic. Each student will prepare a short (1-2 page) summary of the classroom discussion and studio and answer a series of key questions. The assignments will be due the following Tuesday.

Academic integrity: The University of Maryland has a nationally recognized Code of Academic Integrity, administered by the Student Honor Council. This Code sets standards for academic integrity at Maryland for all undergraduate and graduate students. As a student you are responsible for upholding these standards for this course. It is very important for you to be aware of the consequences of cheating, fabrication, facilitation, and plagiarism. For more information on the Code of Academic Integrity or the Student Honor Council, please visit http://www.studenthonorcouncil.umd.edu/whatis.html. The University of Maryland is one of a small number of universities with a student-administered Honors Code and an Honors Pledge, available on the web at http://www.jpo.umd.edu/aca/honorpledge.html. The code prohibits students from cheating on exams, plagiarizing papers, submitting the same paper for credit in two courses without authorization, buying papers, submitting fraudulent documents, and forging signatures. The University Senate encourages instructors to ask students to write the following signed statement on each examination or assignment: “I pledge on my honor that I have not given or received any unauthorized assistance on this examination (or assignment).”
GEOL 124: Evolution of Life and Environment on Planet Earth

Ever dream of travelling to Mars? Join the scientific mission of the Mars Science Laboratory “Curiosity” rover in real time this fall to search for signs of ancient life on the red planet, while we explore evidence for the origin and evolution of life on Earth in this I-Series course. Weekly discoveries by the MSL rover on the Martian surface will be discussed and compared with those from Earth’s distant past, from the origin of the solar system to the sequential origin of prokaryotic, eukaryotic, and animal life over our planet’s first four billion years.

In this I-Series course titled *Evolution of Life and Environment on Planet Earth* we explore how life has shaped physical environments (and vice versa) over the long run of Earth history, by examining the building blocks of life, the evidence for life’s origin and diversification, and the geological settings in which life arose. Using these deep-time perspectives and methodologies, we explore future interactions between life and the environment on Earth and beyond.

The current MSL rover mission is the culmination of decades of Martian speculation and exploration by NASA’s Astrobiology Program, which has even deeper roots, with important discoveries by now famous scientists that span nearly 200 years. While the rate of 18th and early 19th century insights were slow and poorly coordinated, technological advances in chemical, biological, and space sciences after WWII have served to hasten the pace of astrobiological research into the origin and evolution of life on our home planet, and the search for life elsewhere in the universe, in part through detailed studies of meteorites and rover explorations of the Martian surface.

This course is taught by Professor Alan J. Kaufman of the Geology Department. Over the past 25 years, he has travelled to the four corners of the ancient Earth to study its environmental and biological evolution. In this course he will take you on a journey to deep time and space, putting discoveries on the Martian surface this fall in context of what we know about the evolution of our own planet through a long geological lens.
Syllabus

CORE Physical Science (PS) Course (non Lab CORE) (3 credits)

Class Meetings:  TTh   11:00-12:15   SHM 2102  
Lab sections:  W   3:00-3:50   PLS 1164  
               4:00-4:50   PLS 1164

Professor Alan J. Kaufman  
Phone: 405-0395 (office)  
Office: CHEM 0217A  
Office Hours: By appointment  
<kaufman@umd.edu>

Course Description: This course will examine how the Earth formed, how its place in the solar system allowed for life to take hold, and how, once evolved, life shaped or was shaped by Earth's physical environments. Topics range from the Big Bang to the search for life on other planets, especially Mars, with emphasis on evidence for the co-evolution of life and environment. We will also explore the methods and techniques scientists use to explore origin of life questions, and issues of modern global change and human threats to biodiversity.

Topics: In this course we will explore questions from the perspective of geological, biological, chemical, and physical scientists about:

I. Interconnections between biology, climate, and geology in the Earth System: How did Earth’s environment change in the past, and how are its components linked today? To address this, we explore the way that things work on our planet. We use simulations and scientific methods to get to the nuts and bolts of issues like the greenhouse effect, the role of ozone in the present as well as in deep time, and how biodiversity can respond to and maybe compensate for some types of changes that would upset the equilibrium state of a planet.

II. How life remolds its environment (our planet): How have the processes of life shaped and how do they continue to shape Earth’s environments? Here we examine the consequences of life for the geologic realm. We survey the geologic and geochemical tools used to describe ancient environments, review what the evidence that these tools reveal tells us about how Earth's environments have changed through time, and evaluate hypotheses of the role of living things in these changes. We then apply these insights to investigations of changing present-day environments, use them to propose methods for finding life on other worlds, and consider the potential significance of such discoveries.

III. What life is and what life does: How do we distinguish life from non-life? We examine the basic processes of metabolism - the energy pathways of life, and replication - the transfer of genetic information. Shifting from process to pattern, we ask what the basic subdivisions - the domains of life - are, and how scientists have identified them.

IV. How has Earth changed over time and how is it changing now: We wrap up by examining how we human beings act as biological agents to change our Earth. We frame this in the context of long and short term climate change, and examine how a systems perspective is essential in understanding the issues we face as one of life’s species and that other species faced in more ancient worlds.

A note on Marquee and I-Series Courses: The I Series and Marquee series courses are designed to investigate significant issues and inspire innovative ideas, and to explore how science, technology, engineering, and mathematics can provide solutions to present and future world challenges. They are intended to fulfill university general education requirements in a creative and contemporary way and to challenge students to apply diverse intellectual traditions to today’s big issues. GEOL 124 accomplishes these goals by bridging traditional divisions between the scientific disciplines of geology, biology,
chemistry and physics. It also emphasizes how a perspective of deep time provided by geology principles can be valuable for informing big-picture questions relevant to us in the world today.

Readings and other materials:

We will draw on the book by A.H. Knoll titled Life on a Young Planet (Princeton University Press ISBN 0-691-00978-3). This book provides context that will be relevant for the course, but it is not a textbook in the typical sense. The Knoll book will be read in conjunction with the Discussion sections.

Course goals:
Participants in this course should:

1) To be aware of and able to address common misunderstandings about the nature, language, and limits of science, and to enable students to identify the deeper issues in and critically scrutinize scientific information in popular media, and reliably distinguish real from pseudo-science.

2) To be able to read and evaluate geologic findings reported in the popular science literature (the news, magazines, and books).

3) To use observations and reasoning from geology, biology, and chemistry to reconstruct the conditions for some or Earth’s earliest environments and to compare these with prevailing hypotheses.

4) To foster and enhance group work and activities in support of presentations, scientific investigations, and end of term reports required for the course.

Learning Goals for I-Series Courses: At the completion of an I-Series Course students will be able to:

- Look at complex questions and identify the science in the question and how it impacts and is impacted by political, social, economic, and ethical dimensions
- Understand the limits of scientific knowledge
- Critically evaluate science arguments
- Ask good questions
- Find information using various sources and evaluate the veracity of the information
- Communicate scientific ideas effectively
- Relate science to a personal situation

Grading: Given the emphasis on participation, group work, field activities, and the Curiosity Panels in this freshman course, the grading scheme is balanced in order to accurately reflect your time and efforts.

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midterm I</td>
<td>10%</td>
</tr>
<tr>
<td>Midterm II</td>
<td>10%</td>
</tr>
<tr>
<td>Final Examination</td>
<td>15%</td>
</tr>
</tbody>
</table>

Thus testing only represents 35% of the grade in the course. The remaining 65% is related to your general engagement in the course, including: 1) Participation (20%), 2) Field Reports (10%), 3) Curiosity Panels (25%), and Community Research Project (10%).

The Participation portion of the grade reflects:

1) Meeting course deadlines, including posting of your photo and bio on ELMS
2) Engagement with lecturers and colleagues on-line, in-class, and in the field,
3) Ten Discussion section quizzes, worksheets, or exercises, and
4) Preparation as a Discussion section leader or co-leader for a book chapter.

The Field Reports are well written 1-2 page documents using a prescribed format, including:

1) Name, date, and title
2) Objective
3) Observations, including photographs, sketches, descriptions, and/or tables
4) Conclusions, including activity relevance to the course

The grades for the four Curiosity Panels are based on both group and individual efforts. For the
group, each of the panels is worth 5%. This reflects:

1) Ten separate meetings in Easton Hall,
2) Assessment of the material needed for each presentation,
3) Preparation, practice, and revision of each presentation based on group assessment,
4) Substance and organization of in-class presentation of the Curiosity Panel material.

The remaining 5% is a grade for individual efforts related to the Curiosity Panels. These reflect:

1) Attendance and engagement in the Easton Hall meetings,
2) Submission of one or two scribe reports during the semester,
3) Style your individual Curiosity Panel presentation,
4) On-line evaluation of all Curiosity Panel presentations

The Community Research Project will include:

1) Two week diet survey
2) Collection and preparation of hair samples from two individuals
3) Formulating a hypothesis regarding your hair and that of the community
4) Analysis, graphing, and interpretation of community data
5) Ten page term paper with illustrations, tables, and references cited

Final grades will be assigned based on:

A  90-100%
B  80-89.9%
C  70-79.9%
D  60-69.9%
F  <60%

Assignments:  Assignments will be the focus of Discussion sections and related to the sequence of topics
and concepts, including work on the Curiosity Panel. Each Panel will include teams of students focused on
some aspect of Martian exploration by current and past rovers and probes. Assignments will take the form
of written and oral presentations given by members of each team. The end-term paper will be a maximum
of 10 pages in length (double spaced 12 point Times New Roman text) with illustrations (no larger than ¼
of a page each) and references.

Group Work: Students will organize into groups in order to prepare each of the four Curiosity Panel
presentations during the semester. Each panel will focus on some aspect of Martian exploration by current
and past rovers and probes. All students in each group are expected to participate in the development of the
panel talk (background research, construction of the PowerPoint or Prezi presentation, and review)
although only one or two of the students will present the material during the panel. Group work will require
ten scheduled meetings held in an Easton Hall lounge or study room where groups will self-organize.
Chair(s) (generally the individual(s) who will give the presentation) and scribe will be assigned for each
panel, and tasks for participants related to each of the presentation will be discussed. The role of the scribe
is to take attendance and notes of the meeting and complete a report submitted to the course faculty within
two days of the meeting. Groups may also work together in course-related research projects in the
laboratory or the field or studying for exams.

Academic Accommodations: If you have a documented disability, you should contact Disability Support
Services 0126 Shoemaker Hall. Each semester students with documented disabilities should apply to DSS
for accommodation request forms which you can provide to your professors as proof of your eligibility for
accommodations. The rules for eligibility and the types of accommodations a student may request can be reviewed on the DSS web site at http://www.counseling.umd.edu/DSS/receiving_serv.html.

**Religious Observances:** The University System of Maryland policy provides that students should not be penalized because of observances of their religious beliefs, students shall be given an opportunity, whenever feasible, to make up within a reasonable time any academic assignment that is missed due to individual participation in religious observances. It is the responsibility of the student to inform the instructor of any intended absences for religious observances in advance. Notice should be provided as soon as possible but no later than the end of the schedule adjustment period.

**Academic Integrity:** The University of Maryland has a nationally recognized Code of Academic Integrity, administered by the Student Honor Council. This Code sets standards for academic integrity at Maryland for all undergraduate and graduate students. As a student you are responsible for upholding these standards for this course. It is very important for you to be aware of the consequences of cheating, fabrication, facilitation, and plagiarism. For more information on the Code of Academic Integrity or the Student Honor Council, please visit http://www.shc.umd.edu.

To further exhibit your commitment to academic integrity, remember to sign the Honor Pledge on all examinations and assignments: "I pledge on my honor that I have not given or received any unauthorized assistance on this examination (or assignment)."

**Course Evaluation:** CourseEvalUM Fall 2015: Your participation in the evaluation of courses through CourseEvalUM is a responsibility you hold as a student member of our academic community. Your feedback is confidential and important to the improvement of teaching and learning at the University as well as to the tenure and promotion process. CourseEvalUM will be open for you to complete your evaluations for fall semester courses in early December. Please go directly to the website (www.courseevalum.umd.edu) to complete your evaluations. By completing all of your evaluations each semester, you will have the privilege of accessing online, at Testudo, the evaluation reports for the thousands of courses for which 70% or more students submitted their evaluations.

**Calendar for EVOLUTION OF LIFE AND ENVIRONMENT ON PLANET EARTH**
**Fall semester 2015**

<table>
<thead>
<tr>
<th>Date</th>
<th>Lecture (Activity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept. 1</td>
<td>Landing on Mars: An Introduction to the Solar System <em>(Solar System Model)</em></td>
</tr>
<tr>
<td>2</td>
<td>Discussion (Research Port and UMD Resources)</td>
</tr>
<tr>
<td>3</td>
<td>Back to the Future: Understanding Deep Time <em>(Community Research Project)</em></td>
</tr>
<tr>
<td>8</td>
<td>Electromagnetic Radiation and the Big Bang</td>
</tr>
<tr>
<td>9</td>
<td>Discussion (Chapter 1: In the Beginning?)</td>
</tr>
<tr>
<td>10</td>
<td>Synthesis of the Elements and the Solar System <em>(Meteorite Collection)</em></td>
</tr>
<tr>
<td>15</td>
<td>Life’s Signature in Ancient Rocks</td>
</tr>
<tr>
<td>16</td>
<td>Discussion (Chapter 3: Life’s Signature in Ancient Rocks)</td>
</tr>
<tr>
<td>17</td>
<td>Formation and Circulation of the Solid Earth <em>(Campus Field Trip)</em></td>
</tr>
<tr>
<td>22</td>
<td>Discussion (Chapter 4: The Earliest Glimmers of Life)</td>
</tr>
<tr>
<td>24</td>
<td>The Mobile Earth: Continental Drift and Plate Tectonics</td>
</tr>
<tr>
<td>29</td>
<td><em>(Midterm Exam I)</em></td>
</tr>
<tr>
<td>30</td>
<td>Discussion (Chapter 2: The Tree of Life)</td>
</tr>
<tr>
<td>Oct. 1</td>
<td>Environments of the Primordial Earth <em>(Bobcat Hill)</em> <em>(Curiosity Panel I)</em></td>
</tr>
<tr>
<td>7</td>
<td>Discussion (Chapter 5: The Emergence of Life)</td>
</tr>
<tr>
<td>8</td>
<td>Hypotheses on the Origin of Life</td>
</tr>
<tr>
<td>13</td>
<td>Life without Oxygen: The Microbial World of the Archean</td>
</tr>
<tr>
<td>14</td>
<td>Discussion (Chapter 6: The Oxygen Revolution)</td>
</tr>
<tr>
<td>15</td>
<td>The Base of the Food Chain: Photosynthesis Writ Large</td>
</tr>
</tbody>
</table>
20 Take a Deep Breath: Respiration and the Origin of Eukaryotes
21 Discussion (Chapter 7: The Cyanobacteria, Life’s Microbial Heroes)
22 The Great Oxidation Event
27 (Curiosity Panel II)
28 Discussion (Chapter 8: The Origins of Eukaryotic Cells)
29 Snowball Earth Hypothesis: Global Glaciation

Nov.
3 Midterm Exam II
4 Discussion (Chapter 9: Fossils of Early Eukaryotes)
5 The Origin of Animals
10 The Cambrian Explosion
11 Discussion (Chapter 10: Animals Take the Stage)
12 (Curiosity Panel III)
14 (Saturday) Field Trip to the Smithsonian Museum
17 Mass Extinctions of Animal Life
18 Discussion (Chapter 11: Cambrian Redux)
19 The Community Research Project
24 Geochemical Laboratory Tour: Chemistry Building
25 Discussion (Chapter 12: Dynamic Earth, Permissive Ecology)
26 Thanksgiving (no lecture)

Dec.
1 Modern Problems: Ozone Depletion and Global Warming
2 Discussion (The Community Research Project: Data compilation, graphing, and analysis)
3 (Curiosity Panel IV)
8 The Search for Life beyond Mars
9 Discussion (Chapter 13: Paleontology ad Astra)
10 Course Review

Final Exam: Monday, December 14th, 8-10 a.m.
Term Paper: due by midnight on Monday, December 14th
Course Information and Assignments
Assigned readings, problem sets and exam dates will be made available on the courses Canvas page.

Office Hours
Office hours are from 3:00-4:00 Mondays. I am also generally available in my office and happy to see students; just drop by—or, better yet, give me a call and then drop by.

Course Description

"How did the world come to develop nuclear weapons?"

This course seeks to answer this question. As such it is both a course about history and about science.
The history deals with one of the critical events in the world’s history--- one whose ramifications are of central importance today. However, it is impossible to understand this history without understanding the science behind it.

The course will begin with some essential background: an introduction to some of the critical ideas of nuclear physics and a review of some key historical developments beginning at the end of the 19th century (such as the first World War, the Great Depression and the collapse of Weimar Germany with the rise of the Nazi movement). Nuclear Physics will be developed in a chronological manner starting with the discovery of radioactivity by Becquerel in 1896, and going through to the discovery of fission in Germany in 1938. One advantage of this chronological approach is that students will gain a sense of how scientific knowledge builds. A key question in this part of the course is, "What were the political and social forces which enabled this science to develop?"

The course then turns to the Manhattan Project, the massive US effort to develop the" atomic bomb" (as it was then called). The politics surrounding the project’s inception will be studied extensively. A key question here is "What were the political forces which led the United States to devote massive resources during war time for a project which could have seemed to be science fiction?" The history of the Manhattan Project will be studied in some detail including the political, scientific, military, social and economic issues. The scientific community’s rapid, and secret, development of an understanding of fission is a critical part of this history. The course will focus on some of the key aspects of this science, including the distinct roles played by slow and fast neutrons, the concept of critical mass, the qualitative differences between uranium 235 versus uranium 238, the discovery of plutonium and the possibility of chain-reactions based on either uranium or plutonium. The engineering challenges associated with the development of the bomb are also a central focus of the course. These included the need to develop massive facilities to enrich uranium and to breed plutonium. The challenges associated with the design of the bombs themselves will also be discussed with an emphasis on why a simple design was possible for a uranium weapon but a much more complicated implosion design was needed for plutonium weapons. In considering the Manhattan Project, it is useful to compare it to the unsuccessful effort in Germany to develop nuclear weapons and to consider what led to the success of one effort and the failure of the other.

A final theme in this course is the set of ethical issues associated with the Manhattan Project. A central question is whether the scientists involved had a special ethical obligation to consider the ends to which their work would be used.

Mathematical Preparation

This course has no prerequisites. However, the course will use mathematics extensively. While the mathematics required does not go beyond the level of a standard high school algebra 2 course class, students will need to be comfortable applying mathematics at this level. Students are not required to have taken a class at the precalculus level; however, students might find it helpful to have taken a class at that level.

Reading

The primary reading for the course is *The Making of the Atomic Bomb* by Richard Rhodes (Simon and Shuster, 2012); ISBN978-14516777614. This book is often considered a masterpiece and won
numerous awards including the Pulitzer Prize and the National Book Award. It has been praised by historians and by former Los Alamos weapon scientists. It describes the development of the nuclear physics in the first half of the 20th century as well as the development of the first nuclear weapons during the Manhattan Project. There will also be supplementary readings.

The course also has assigns Michael Frayn’s brilliant play *Copenhagen* (Anchor Publisher, 2000) ISBN 978-0385720793. This Tony Award winning play deals with a meeting between Warner Heisenberg and Niels Bohr in Nazi occupied Denmark in 1941. The play raises many of the issue raised by the course.

You will also be assigned “Los Alamos from Below”, a lecture by Richard Feynman which is available online. You may either read the lecture or listen to it on YouTube.

**Pedagogical Approach**

The course will have both a lectures and discussion sections. Each of these will address both the scientific and the historical aspects of the course.

**Lectures:**

The lectures are intended to be as interactive as possible given the size of the class and the instructor will encourage students to ask questions.

**Sections:**

Many activities will take place in the discussion sections.

One standard activity, which will occur most weeks, will be to work through problems similar to those on the problem sets in an informal and highly interactive manner.

Most other activities will be done in small groups of 4 or 5 students. One of these is aimed at working through more complex scientific problems than a typical student could handle easily on their own, but through discussion a group of students should be able to work through. At the end of the activity, one member of the group can describe the solution to the full class. Another small group activity will be the discussion of questions with historical or ethical implications. These questions will be ones, which are open in the sense that reasonable people might come to different conclusions, but for which interesting and insightful analysis is possible.

**Assignments and Grading Policies**

- Problem sets: problem sets will be assigned during the semester on the scientific aspects of the course. It is impossible to learn the science without working through examples. The problem sets will make up approximately 15% of the course grade. Note, only a representative sample of the
problems will be graded. Students are allowed to collaborate on problem sets; indeed I strongly encourage students to work in groups on these. However, as always, copying somebody else’s solution and submitting it as your own is strictly forbidden; this is not “collaboration”. Solutions for the problem sets will be posted on the course web site.

- Papers. There will be two written assignments during the semester. The first of these will be a short paper (3-4 pages) analyzing how the play *Copenhagen* deals critical historical, ethical and scientific issues raised in the course. The second paper will be somewhat longer (5-8 pages). In it students will focus on one of the central figures in the Manhattan Project and analyze his or her role in some key event or some particular aspect of the program. Collectively, these papers will account for approximately 30% of the final grade with 10% for the first paper and 20% for the second.

- Quizzes: There will be quizzes on the reading given during the lectures. Collectively these will account for approximately 5% of the grade.

- Class Participation in section will be worth approximately 5% of the grade.

- There will be a midterm exam and a final exam in this course. Together these will account for approximately 45% of the total grade.

- Grading policies
  - Grades will NOT in general be given according to the scheme in which numerical scores greater than 90 corresponds to an A, between 80 and 90 a B etc. Rather, the correspondence between letter grades and numerical scores will depend on many factors including the difficulty of the assignment.
  - If a student miss a quiz or a problem set for a legitimate reason, he or she will be awarded the average score obtained for other quizzes or problem sets during the semester.
  - Late problem sets will not be accepted.
  - Late papers will be accepted. However, scores will be reduced by 10% for each day late. Papers more than 10 days late will not be accepted.

### Course Outline

#### A. Background

This unit will develop the scientific and historical background needed to understand the remainder of the course. Background scientific information ranging from the concept of energy to some basic ideas about relativity and quantum mechanics will be introduced. Key developments in nuclear physics from the discovery of radioactivity through the discovery of the nucleus by Rutherford and the discovery of the neutron by Chadwick will be at the core of this unit. The unit ends with the discovery of nuclear through the discovery of fission in 1938.

Historical background will also be developed. Major historical events in the first part of the Twentieth will be reviewed. The circumstances of the late 1930s will be discussed in detail with an emphasis
on both the military and political situation and on the particular issues affecting science and scientists including the large number of Jewish scientists who fled the Nazis.

**Reading:** Chapters 1-9 in Rhodes

**Problem sets:** There will be several problem sets on the material in this section covering:
- Basic problems concerning the nature of energy; Exponentials;
- Relativistic Mass-Energy relations; radioactive decay chains
- Quantum Physics and the statistical nature of nuclear decays; the concept of half-lives; Atomic and nuclear models; Nuclear energetics and fission.

**B. From the discovery of fission to the establishment of Los Alamos**

This unit covers the period from 1938 through 1942. During this period World War II erupted with the United States entering the war following the Japanese attack on Pearl Harbor on December 7, 1941. The unit focuses largely on the how the Manhattan Project emerged and in particular how the US Government became committed to such a massive and secret undertaking. Scientifically the unit focuses on fission. The remarkable scientific advances during the years following 1938 are introduced with an emphasis on the very different behavior of $^{235}\text{U}$ and $^{238}\text{U}$ regarding their responses to fast and slow neutrons and the implications of this for both weapons and reactors. Another critical scientific issue on which the unit focuses is the discovery of the transuranic element plutonium with a fissile isotope, $^{239}\text{Pu}$.

**Reading:** Chapters 10-13 in Rhodes; *Copenhagen*;

**Paper:** A short paper (3-4 pages) analyzing how the play *Copenhagen* deals critical historical, ethical and scientific issues raised in the course will be due at the end of this section.

**Problem sets:** Problems sets on the material in this section will cover:
- Elastic and absorption cross-sections
- Properties of chain reactions; the nature of exponential growth
- The physics of nuclear reactors

**C. The development of the atomic bomb**

This unit covers the period from the establishment of Los Alamos in October 1942 through the Trinity test in July 1945. During this period many of the scientific challenges were of an engineering nature. There was need for operations to separate $^{235}\text{U}$ and $^{238}\text{U}$ on an industrial scale for the uranium bomb program. There was also a need to both breed $^{239}\text{Pu}$ in reactors and to chemically separate it from uranium. Finally the design of the weapons was technically quite challenging particularly for the case of the plutonium weapons. The science behind these issues will be covered. On the historical side, the many issues associated with running three secret city-sized facilities will be stressed including the problem of problem of security and espionage.

**Reading:** Chapters 14-18 in Rhodes; Richard Feynman’s

**Problem sets:** Problem sets on the material in this section will cover:
- Enrichment of uranium
- Mean-free path and critical mass

**D. Aftermath**
This unit deals what followed the Trinity test. The decision to use the atomic bomb on Japanese cities is central in this as are some of the stark moral issues raised by this decision. The scale of the destruction due to the bombing of Hiroshima and Nagasaki will be central to the unit. Finally the unit deals with attempts of the world in the immediate post war era to come to grips with living with nuclear weapons will be discussed.

**Reading:** Pages 678-788 in Rhodes; supplementary readings

**Paper:** A paper of from 5 to 8 pages focusing on one of the central figures in the Manhattan Project and analyze his or her role in some key event will be due at the end of this unit.