**DEPARTMENT OF MECHANICAL & INDUSTRIAL ENGINEERING**

**PROPERTIES AND FAILURE OF MATERIALS - MECH 321/4 - 2019**

**Instructor (Section X):** Dr. M. Medraj, **Office:** EV 12.185 **Email:** mmedraj@encs.concordia.ca

**Class:** Wednesday - Friday: 10:15 – 11:30am H-531 **Office Hours**: Wed. 14:30 – 16:00

**Tutorials:** Friday: 4:15 – 5:35pm (XA in MB-S2.401 and XB in MB-S1.430)

**COURSE HOMEPAGE:** [**www.me.concordia.ca/~mmedraj/mech321.html**](http://www.me.concordia.ca/~mmedraj/mech321.html)

**Lab:** H-1058. See Lab Manual for Mech 321, available at Digital store and the course website.

**Calendar Description**

*(Prerequisite: MECH 221). The service capabilities of alloys and their relationship to microstructure as produced by thermal and mechanical treatments; tensile and torsion tests; elements of dislocation theory; strengthening mechanisms; composite materials. Modes of failure of materials; fracture, fatigue, wear, creep, corrosion, radiation damage. Failure analysis. Material codes; material selection for design. Lectures: three hours per week. Tutorial: one hour per week. Laboratory: two hours per week, alternate weeks.*

**Required Texts:**

1. Textbook for MECH 221: Materials Science and Engineering, W.D. Callister, Wiley 8th or 9th Edition (7th, 6th or 5th edition will suffice although some Section numbers and Figure numbers etc. will be different).

2. MECH 321 Coursepack from Bookstore. This contains material from the supplementary reference books including: Mechanical Metallurgy, G.E. Dieter, 3rd edition, McGraw-Hill, 1987. Deformation and Fracture Mechanics of Engineering Materials, RW. Hertzberg, Wiley, 4th Edition, 1995. Engineering Materials1, Ashby and Jones. Materials selection in engineering design.

3. MECH 321 Lab Manual from Digital store or the course website.

Copies of Overhead Transparencies are available in pdf format on the 321 course webpage.

**COURSE LEARNING OUTCOMES & GRADUATE ATTRIBUTES**

By the end of this course you should have an understanding of the mechanical behavior of materials (and metals in particular). This will include the deformation behavior of metals and the ways that metals can fail. We will be studying the effects of mechanical loading on real materials beyond the elastic limit and by the end of the course you should have answers to the following questions:

* What happens to a metal when the yield stress is exceeded?
* Why does this happen?
* Can we control it and how?
* Why and how do materials fail?
* Can we prevent failure?
* How do we make metals stronger?
* How do we soften metals?
* Why do materials behave differently under dynamic loads compared to static loads?
* Why do materials behave differently at elevated temperatures?
* Is this good or bad?
* How do we select the right material for the job?

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| **Attribute** | **Indicator** | **Level of knowledge** |
| **A knowledge base for engineering:** | Knowledge base in natural science and specific domain | INTERMEDIATE |
| **Investigation:** | Conducting experiments and collection of data.  Analysis and interpretation of data | INTERMEDIATE |
| **Use of engineering tools:** | Ability to use appropriate engineering tools, techniques and resources | INTERMEDIATE |

**COURSE LEARNING Outcomes (CLOs)**

Upon successful completion of MECH231, the students will be able to:

|  |  |
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| **Course Learning Outcome** | **Graduate Attribute** |
| Describe what is happening as the yield strength of a metal is exceeded | **A knowledge base for natural science and engineering** |
| Use tensile, flexural and impact testing to measure mechanical properties of metals, ceramics and polymers. | **Use of engineering tools, and Investigation** |
| Demonstrate a knowledge and understanding of the different strengthening methods for metals and composites | **A knowledge base for natural science and engineering** |
| Demonstrate a knowledge and understanding of the different failure processes for metals | **A knowledge base for natural science and engineering** |
| Determine Plane strain fracture toughness by experiment. | **Use of engineering tools, and Investigation** |
| Use engineering diagrams and data to predict fatigue and creep failure | **Design** |
| Demonstrate a knowledge and understanding of the different corrosion processes for metals and how to mitigate them | **A knowledge base for natural science and engineering** |
| Use materials information and design criteria to do materials selection | **Design** |

**COURSE CONTENTS**

**1: MATERIALS TESTING**

1.1 Review of the Tensile Behaviour (Callister, 6.1-6.6)

1.2 True stress, true strain, hardness and Safety factors (Callister, 6.7-6.12)

1.3 The Torsion Test (Dieter, 10.1-10.4)

**2: ELEMENTS OF DISLOCATION THEORY**

2.1 Strength of a Perfect Crystal (Hertzberg, 2.1)

2.2 The Need for Lattice Imperfections: Dislocations (Hertzberg, 2.2)

2.3 Observation of Dislocations (Hertzberg, 2.5)

2.4 Dislocation Multiplication (Hertzberg, 2.10)

2.5 Slip Systems (Callister, 7.4)

2.6 Slip in Single Crystals (Callister, 7.5)

2.7 Plastic Deformation of Polycrystalline Materials (Callister, 7.6)

2.8 Deformation by Twinning (Callister, 7.7)

**3: STRENGTHENING MECHANISMS**

3.1 Grain Boundary Strengthening (Callister, 7.8)

3.2 Solid Solution Strengthening (Callister, 7.9)

3.3 Strain Hardening & Recrystallization (Callister, 7.10-7.13)

3.4 Two Phase Strengthening

3.4.1 Precipitation Hardening (Callister, 11.9)

3.4.2 Dispersion Strengthening (Callister, 16.2-16.3)

3.5 Martensite Strengthening (Callister, 10.5-10.9)

3.6 Fiber Strengthening (Callister, 16.4 - 16.5)

3.7 Composite Materials (Callister, 16.6-16.13)

**4: FRACTURE**

4.1 Fundamentals of Fracture (Callister, 8.1-8.2)

4.2 Ductile Fracture (Callister, 8.3)

4.3 Brittle Fracture (Callister, 8.4)

4.4 Principles of Fracture Mechanics (Callister, 8.5)

4.5 Impact Fracture Testing (Callister, 8.6)

**5: FATIGUE**

5.1 Cyclic Stresses (Callister, 8.7)

5.2 The S-N Curve (Callister, 8.8)

5.3 Low Cycle Fatigue (Dieter, 12.6-12.8)

5.4 Crack Initiation and Propagation (Callister, 8.9)

5.5 Crack Propagation Rate (Callister, website)

5.6 Factors That Affect Fatigue Life (Callister, 8.10-8.11)

**6: CREEP**

6.1 Generalized Creep Behavior (Callister, 8.12)

6.2 Stress and Temperature Effects (Callister, 8.13)

6.3 Activation Energy for Steady State Creep (Dieter, 13.8)

6.4 Presentation of Eng. Creep Data (Dieter 13.12-13, Callister 8.14)

6.6 Alloys for High Temperature use (Callister, 8.15, 11.3)

**7: CORROSION**

7.1 Corrosion & Electrochemical Considerations (Callister, 17.1-17.2)

7.2 Corrosion Rate (Callister, 17.3)

7.3 Prediction of Corrosion rate (Callister, 17.4)

7.4 Passivity (Callister, 17.5)

7.5 Environmental Effects (Callister, 17.6)

7.6 Form of Corrosion (Callister, 17.7)

7.7 Corrosion Environment (Callister, 17.8)

7.8 Corrosion Prevention (Callister, 17.9)

7.9 Oxidation & Degradation (Callister, 17.10-17.13)

**8: FRICTION & WEAR**

8.1 Mechanisms of Wear (Ashby & Jones)

8.2 Factors Influencing Wear (Ashby & Jones)

8.3 Wear Measurement (Ashby & Jones)

**9: MATERIAL CODES**

9.1 Ferrous Alloys (Callister, 11.1 - 11.2)

9.2 Nonferrous Alloys (Callister, 11.3)

**10: MATERIAL SELECTION**

10.1 Strength (Callister, 6.12)

10.2 Case Studies: (Callister, Ashby)

**Labs Topics:** Tensile, Fracture toughness, Brittle Fracture, Impact, Heat treatment, Materials Selection.

The timetable and explanation of each laboratory experiment can be found in the Mech 321 lab Manual available in the Copy Centre. A short report is required for every lab. Lab attendance will be taken and is mandatory in order to receive a grade. The reports are to be submitted to the lab instructor. The student may expect at least one lab-related question on the final exam. Good presentation, including legibility, spelling and grammar, is expected for all work. There are lab quizzes, so have the lab manual on hand and read the experiment before coming to the laboratory.

**Evaluation:**

In-Tutorial Assignment Problems 10 %

Lab & Lab Reports (6) 15 %

Midterm (tentative date Feb. 22nd) **In-class** 25 %

Final Exam (**Closed Book – 3hrs**) 50 %

**Midterm Examination:** The date for the midterm is provisionally set for February 22nd at 10.15 am (in-class). The midterm is voluntary: if you do the midterm then it can count towards your final mark if it will improve your mark. If you do not do the midterm or do not do well in it, then it will not be included in your final mark. However you need to pass the midterm and labs in order to be able to get a Medical deferral in the final exam should the need arise.

**Assignments & Tutorial Problems**

Sample questions will be posted on the web page. Solutions will be covered in tutorials. They will NOT be marked but these questions will be used as the basis for the *In-Tutorial Assignment Problems* which will take place every second tutorial and will be marked (10% total).

**Students must obtain a passing mark on the final exam and the labs in order to pass the course.**

This information and other updates relating to the course (notes, lab results, changes, etc.) will be posted on the course Moodle page.

**Coursework – Certificate of Originality**

In keeping with Faculty policy, as part of this course each student must have the appropriate **Certificate of Originality** form filled-in and attached as the cover page for the first Lab report. These forms are available on the following website: [**http://www.encs.concordia.ca/scs/index.htm**](http://www.encs.concordia.ca/scs/index.htm)

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**“What is Plagiarism?**

The most common offense under the Academic Code of Conduct is plagiarism which the Code defines as **"the presentation of the work of another person as one's own or without proper acknowledgement"** (Article 16a).

This could be material copied word for word from books, journals, internet sites, professor's course notes, etc. It could be material that is paraphrased but closely resembles the original source. It could be the work of a fellow student, for example, an answer on a quiz, data for a lab report, a paper or assignment completed by another student. It might be a paper purchased through one of the many available sources. Plagiarism does not refer to words alone - it can also refer to copying images, graphs, tables, and ideas. "Presentation" is not limited to written work. It also includes oral presentations, computer assignments and artistic works. If you translate the work of another person into French or English and do not cite the source, this is also plagiarism. If you cite your own work without the correct citation, this too is plagiarism.

**In Simple Words:**

DO NOT COPY, PARAPHRASE OR TRANSLATE ANYTHING FROM ANYWHERE WITHOUT SAYING FROM WHERE YOU GOT IT! DON'T FORGET TO USE QUOTATION MARKS!”

[Source: <http://provost.concordia.ca/academicintegrity/plagiarism/>]

**OTHER RESOURCES**

**ACADEMIC ADVISING**

Student Academic Services – ENCS – EV 2.125 [http://www.encs.concordia.ca/scs/index.html]

Undergraduate Program Assistant – MIE - EV004.144 <mailto:sabrina@encs.concordia.ca>

***Disclaimer***

*In the event of extraordinary circumstances beyond the University's control, the content and/or evaluation scheme in this course is subject to change.*

**ADDENDUM TO THE COURSE OUTLINE**

**ACADEMIC CONDUCT ISSUES - The basic ten rules that make you a good engineer**

The B. Eng. program is set to satisfy most of the requirements for your education and prepares you for a professional engineering career that requires dedication and knowledge. What you learn, and how you learn, will be used extensively in your engineering profession for the next 30 to 40 years. Therefore, the four years spent in the engineering program are crucial towards your professional formation. The first step is for you to learn to “think like an engineer” which means:

* accept responsibility for your own learning
* follow up on lecture material and homework
* learn *problem-solving skills,* not just how to solve each specific homework problem
* build a body of knowledge integrated throughout your program
* behave responsibly, ethically and professionally

One of the mainstays of being a professional engineer is a professional code of conduct and as an engineering student this starts with the Academic Code of Conduct (Article 16.3.14 of the undergraduate calendar). However, you may encounter situations that fall outside the norm and in such cases, you use your common sense.

Further, the following issues should be given serious consideration:

**1.** Attendance at lectures and tutorials are major learning opportunities and should not be missed. The labs represent a unique opportunity for you to acquire practical knowledge that you will need in your career. Class and tutorial attendance is important for you to comprehend the discipline and make the connections between engineering skills. You are strongly encouraged to participate in the class, ask questions and answer the instructor’s questions. Tutorials are just extensions of the classes in which application of the concepts presented during the lectures are presented and problems are practically solved.

**2.** The decision to write tests that are not mandatory is entirely yours. For example, midterm test are often stated in many courses as optional. However, one the objectives of midterms is to check on your comprehension of the material and allow time for whatever action is necessary (from more study time to discontinuing a course). Plan to attend the class tests even if they are not mandatory. If you pay attention in the lectures, it will take you significantly shorter time to comprehend the material. **Note also** that if you are in the unfortunate position of being unable to write a final exam due to medical reasons and seek a deferral, this may not be possible if the instructor has no information indicating that you have been attending the course and assimilating the material (ie through midterms, quizzes, assignments etc).

**3.** Homework is usually mandatory and it has some weight in the final grade (such information is given in the course outline). Homework may also be conceived as training material for the class tests. Under all circumstances, it is highly recommended to carry out the home work on time and submit it on the prescribed date. Late submissions are not granted to individual cases regardless of the reason. This is part of the training for being in the workforce where deadlines have to be met. Please, plan your work such that you submit all the assignments and lab reports on time and in the correct place (not in the corridor or on the street!).

**4.** Office hours with tutors, lab instructors or class instructors are listed in the course outline/website/office doors. Please respect these office hours and in case you have a serious conflict, contact the instructor asking for a special time arrangement.

**5.** Class tests (midterms, quizzes) are returned to the student. The final exams are not. If you wish to see your exam paper, be aware that most instructors allow only a narrow window of time for that purpose. For the fall term, exams may usually be reviewed in January and May for the spring term.

**6.** When you see your marked work (assignments, midterms, final exam etc), be aware that you are supposed to review your material and see the type of errors you made and if marks have been added incorrectly. This is not an opportunity to try and “negotiate” a higher grade with the instructor. If you believe that your grade is not right, you may apply for a formal Course Reevaluation through the Birks Student Centre.

**7.** Writing tests and exams represents a major component of your course work. These tests and exams have rigorous requirements such as:

* **No cell** **phone or other communication enabling tool** **is allowed on the student** during the examination period.
* Only **specified faculty calculators** are allowed during tests and exams unless otherwise indicated by the instructor.
* Usually, **no materials** are allowed in the exam unless otherwise announced.
* Get used to signing in and out of your exam. Make sure that you leave your exam papers with the invigilator. There are rules concerning general exam issues in the UG Calendar. These requirements are there to eliminate any possible misunderstanding and you are asked to **respect the rules**. Disciplinary measures are taken when the rules are not followed.

**8.** Respect your colleagues and those that you meet during the class: tutors, instructors, lab instructors, technical personnel, assistants, etc. Use appropriate communication means and language. Be considerate for all human beings. This includes small things such as turning off cell-phones before a class begins. Concordia University is a very diverse group of people and a very large multicultural community.

**9.** Communication is part of your future profession. Learn how to communicate effectively and efficiently in the shortest time possible. Write short but meaningful e-mails, make effective phone calls, etc. If your instructor accepts emails make sure that your request is clear with the course number and your name in the *Subject* line. Do not ask for special treatment as instructors have to treat all students equitably.

**10.** Respect all the above and you will get closer to your future profession.