MSE 8803P – Special Topics *(Fundamentals of Corrosion)*

Time: Tuesdays and Thursdays – 9:30 am – 10:45 pm,
Classroom**:** MoSE 1201A

Instructor: Prof. Preet M. Singh
Office: 246, Paper Tricentennial Bldg. (PTB) (Renewable Bio-products Institute)
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Course Objective: To introduce graduate students to the basic principles of interaction between materials and environments, and degradation in properties of engineering materials due to corrosive environment. To provide an understanding of the fundamentals of corrosion processes so that students can recognize different corrosion mechanisms and methods to mitigate corrosion.

Textbook: D. A. Jones: *Principles and Prevention of Corrosion*, Macmillan Publ. Co., 1996.

Other recommended references:

- D. Landolt: Corrosion and Surface Chemistry of Metals, EPFL Press, Distributed by CRC Press, ISBN 978-0-8493-8233-8, 1st edition, 2007.
- J. C. Scully: The Fundamental of Corrosion, 2nd ed., Pergamon Press.
- E. E. Stansbury and R. A. Buchanan, Fundamentals of Electrochemical Corrosion, ASM International, 2000.
- M. G. Fontana: Corrosion Engineering, 3rd. Ed., McGraw Hill.
- J. M. West: Electrodeposition and Corrosion Control, J. Wiley
- W. Revie (ed.): Corrosion Handbook, Electrochemical Society Series, John Wiley and Sons, 2000.
- Metals Handbook, Vol. 13: Corrosion, ASM International

Course Mode: All lectures and exams will be in-person in the allocated classroom. Quizzes will be online (through Canvas).

Learning Objectives: Upon completion of this course, students will be able to:

(1) Understand thermodynamics and kinetics of aqueous and high temperature gaseous corrosion phenomenon
(2) Understand basic electrochemical principles and apply them to aqueous corrosion
(3) Understand mechanisms of different forms of corrosion
(4) Apply understanding of corrosion to their research projects or to mitigate corrosion in their professional career.

Course Website: Canvas site for this course will be used to post the course syllabus, lecture notes, homework, homework-solutions, as well as for all quizzes and exams. Important announcements will also be sent to your Canvas account (Canvas e-mail) so please check it regularly.

Exams and Project: All exams will be in-person and closed book. No formula sheets other than the ones provided with the exam paper will be allowed. The first two mid-term exams will be given at the same time as scheduled lectures. The 3rd exam will be held during the Finals week, during the exam time-slot allocated by the registrar's office

1. Exam #1
2. Exam #2
3. Exam #3 (during finals week)

4. Research Papers (two papers) *(To be submitted into the Canvas folder)*

5. Quizzes *(Students will take these on canvas after each major topic is finished)*

6. Presentations (Recorded group presentation) *(To be recorded by the group and posted into the Canvas drop box folder)*

Office Hours: My "Microsoft Teams" office hours and link will be posted on Canvas (TAs will also hold Teams Office hours), but students can also request an in-person session if needed.

Grades: Final grade in the course will be determined by sudent's performance on quizzes, three written examinations, homework, and the group project. All exams will be in-person, closed book tests (i.e., no supplementary materials of any kind are to be used). The three examinations will be held on the dates indicated on the syllabus. The following is the grading scale:

A: 85-100
B: 70-85
C: 55-70
D: 40-55
F: <40

Grading: Note that this distribution is subject to change.

	MSE 8803P
Exam-1	15 %
Exam-II	15 %
Quizzes/Homework	15 %
Research Papers (two papers)	40% (20% + 20%)
Exam-III ***(during finals week)***	15%

Homework Assignments: After each topic is completed, homework problems will be assigned. Only the homework assignments for the first 4 topics and the High Temperature Corrosion will be graded. DO NOT underestimate the importance of completing ALL the homework assignments, since they will require understanding similar to that expected for exams and quizzes and will be representative of similar problems and questions given on exams and quizzes. Solutions of some of the homework will be posted on the course Web Site (Canvas).

Class Quizzes: A 10 to 15-minute online quizzes will be given after finishing a major topic/chapter *(unless otherwise specified)*. Students will take this quiz online on Canvas. ***Announcement of the upcoming quiz date will be made in the classroom upon the completion of each major topic/chapter.***

If you are unable to take a quiz or exam for some reason, you are required to inform me in advance.

Make-up tests or quizzes will only be allowed if the students had any medical emergency or had informed me in advance in writing (e-mail is fine).

For any questions involving any Academic Honor Code issues, please consult teaching assistants, www.honor.gatech.edu, or me.

Extenuating Circumstances: Please be sure to inform the office of the Dean of Students if you encounter extenuating circumstances that interfere with your ability to attend class and/or prepare for exams. The Dean's office is your best resource when you would prefer to not discuss the details of your personal situation.

Grade Accuracy: Errors in grading and/or recording of scores for quizzes and exams must be addressed within 7 days of posting on Canvas by contacting the instructor in writing via email. Disputes after this one-week period will not be considered.

Research Paper Topics and Presentations: Groups of two graduate students each will work on **<u>two research papers</u>**

- ***1st paper on electrochemistry fundamentals***
- ***2nd paper on a selected corrosion problem and its solution***

Topics research paper can be proposed by the students but have to be approved by the instructor. The research-paper topics for the first paper should be finalized by 2nd week of instructions and the second topic in 1st week of March. The papers should be <u>based on published research in that particular area</u>. The final papers should have 1.5 line spacing and be 15 pages (max.) in length (not including references, figures and tables). It should start with an abstract and have introduction, body and summary. The papers will have at-least ten (15) references (maximum 25). The term papers must contain figures or data to support your conclusions or explanations.

Email Policy: You must use your Georgia Tech issued email address or the messaging option in Canvas when contacting the instructor. Email originating from outside the Georgia Tech network may be ignored to protect your personal information and comply with Federal and Georgia Tech policies.

Academic Integrity: All students in this class are expected to respect the *Georgia Tech honor code* and behave in a professional manner when it comes to academic integrity. Any students violating the honor code or suspected of academic misconduct will be turned over to the office of Academic Integrity, Dean of Students to investigate the incident(s). Cheating off of another person's test is unethical and unacceptable. Cheating off of anyone else's work is a direct violation of the GT Academic Honor Code, and will be dealt with accordingly. *For any questions involving any Academic Honor Code issues, consult me, my teaching assistants, or* www.honor.gatech.edu.

Electronic Devices (in classroom): All electronic devices (cell phones, smart watches, etc.) should be turned off and put away when in the classroom. Email, texting, and other forms of electronic communication are prohibited in the classroom. Please talk to the instructor if you plan to use an electronic device for note taking during lecture.

The only electronic device that you may use during a quiz or exams is a commercially available calculator that cannot communicate with other devices without a direct physical connection (i.e., no wireless, IR or other communication capabilities). Programmable and graphing calculators are allowed, but their memories should be appropriately cleared. Your use of a calculator should be consistent with the class policy that reference materials of any kind are *not permitted* on quizzes or exams. The use of any mobile/wireless communication device (smart watch, cell phone, smart phone, etc.) in any way, shape, or form during a quiz or exam is strictly forbidden. If you have any electronic device in your possession during a quiz or exam, you will be considered in violation of the academic integrity policy and referred to the office of Academic Integrity. All electronic devices must be placed inside of and remain in a closed bag, purse, or backpack during quizzes and exams. Sharing or passing of calculators is also strictly forbidden: all persons involved in the sharing or passing will be in violation of the academic integrity policy and referred to the office of Academic Integrity.

Special Needs: The Georgia Institute of Technology encourages qualified persons with disabilities to participate in its programs and activities. If you anticipate needing any type of accommodation in this course or have questions about physical access, please tell the instructor as soon as possible.

Make up policy: Make-up exams or quizzes will only be permitted when absences are due to legitimate reasons such as illness, religious observance, or other events recognized by the Institute as a valid excuse. In any case, you must contact the instructor in advance of the test in writing (email is fine) to schedule a make-up exam or a makeup quiz. If you do not contact the instructor in advance, it may not be possible to schedule a make-up test. When possible, make-ups will be administered during the week following the originally scheduled date. Make-up exams may be different from those administered during the regular examination period.

Accommodations for Students: If you have been approved by ODS for an accommodation, I will work closely with you to understand your needs and make a good faith effort to investigate whether or not requested accommodations are possible for this course. If the accommodation request results in a fundamental alteration of the stated learning outcome of this course, ODS, academic advisors, and the school offering the course will work with you to find a suitable alternative that as far as possible preserves your progress toward graduation.

Final Exam Conflicts: The Institute has established the policies for final exam scheduling conflicts that are summarized in the list below. If you request an accommodation, please contact the instructor via email and include a list of all of your courses (course numbers and sections) and their exam periods on the day in question. If you have additional questions about the Institute's policies, please refer to the Office of the Registrar's website which is located at http://www.registrar.gatech.edu/students/examguide.php . Please note the following Institute policies:

- "All students should check the Final Exam Schedule against their own class schedule and report any conflicts to the instructor(s) as soon as possible. It is the responsibility of each student to see that all possible conflicts are resolved by the instructor and the proper authorization received no later than 2 weeks before the Monday of exam week. A special period is provided as a conflict period in which to reschedule conflicting examinations. Refer to the Final Exam Schedule for the conflict date. Other periods within the exam week may also be used for conflicting examinations provided no student is forced to take more than two examinations in one day."
- "Any course that is offered outside the normal scheduling format must make arrangements to give way to courses offered in the normal time slot. If a conflict arises between two courses that offer finals outside the normal scheduling format, the conflict will be resolved by the instructor rescheduling the examination for the course with the lower number. The common final for any course may not take up more than one exam period."
- "In the event a student has two examinations scheduled for the same period, the conflict will be resolved by the course having the lower course level number being considered in conflict. The final examination in that course shall be given during the conflict examination period or, by agreement of the instructor and the student, at a mutually satisfactory time."
- "In the event a student is scheduled for three examinations in one day, the examination scheduled for the middle period will be considered in conflict. The conflict will be resolved by giving the examination during the conflict period at another time mutually agreed upon by the instructor and the student."

Word: Use of any previous semester course materials is allowed for this course; however, we remind you that while they may serve as examples for you, they are not guidelines for any tests, quizzes, homework, projects, or any other coursework that may be assigned during the semester

Special Needs: The Georgia Institute of Technology encourages qualified persons with disabilities to participate in its programs and activities. If you anticipate needing any type of accommodation in this course or have questions about physical access, please tell the instructor as soon as possible.

Class Schedule: Synchronous, Three hours per week (Tuesday, Thursday) at 9:30 pm to 10:45 am

Instructor's Office Hours: Tuesday (1:00 pm – 2:00 pm). (Teams sessions upon request)

Teaching Assistants: You are encouraged to contact your TA(s) for questions/problems. TA contact and office hour information will also be posted on Canvas

TAs will hold Teams Office hours. You are encouraged to contact your TA for questions/problems. Following is the name and e-mail address of your TA. Additional contact and office hour information will be posted on Canvas website

Name: **TBD**

Tentative Course Schedule: ***Exam or quiz dates can be changed. Any changes in the syllabus or schedule will be announced in the class.***

Week	Date	Topics Covered *(Tentative)*
1	**9-Jan**	***Introduction to Corrosion:*** Basics of Corrosion, , Different forms of Corrosion, Corrosion Rate, Electrochemical nature of corrosion, Electrochemical cell
	11-Jan	***Introduction to Corrosion:*** Electrochemical nature of corrosion, Electrochemical cell; ***Thermodynamics:*** Electrode Potential, Measurements
2	***16-Jan***	***Thermodynamics:*** Electromotive Force Series, Using Electromotive Force Series, Pourbaix Diagrams
	18-Jan	***Thermodynamics:*** Pourbaix Diagrams
3	***23-Jan***	***Quiz 1 (15 Min, Online)*** ***Thermodynamics:*** Pourbaix Diagrams **(1st Term Paper Topics Due)**
	25-Jan	***Kinetics:*** Faraday's Laws of Electrolysis, Double Layer, ***Kinetics:*** Exchange Current, Corrosion Current, Polarization
4	***30-Jan***	***Kinetics:*** Polarization, Evans Diagrams, Tafel Equation, Mixed Potential Theory
	1-Feb	***Quiz 2 (15 Min)*** ***Kinetics:*** Mixed Potential Theory, Applications
5	***6-Feb***	***Kinetics:*** Mixed Potential Theory, Passivity
	8-Feb	**Passivity, *Electrochemical methods:*** DC Polarization

6	***13-Feb***	***Quiz 3 (15 Min)*** **Passivity,** ***Electrochemical methods:*** DC Polarization
	15-Feb	***Exam 1 – During Regular Class Time***
7	***20-Feb***	***Forms of Corrosion:*** General Corrosion, ***Galvanic Corrosion, Dealloying***
	22-Feb	***Quiz 4 (15 min)*** ***Forms of Corrosion:*** **Intergranular corrosion, Weld Decay,** ***Concentration Cells, Differential Aeration Cells***
8	***27-Feb***	***Forms of Corrosion: Pitting and Crevice Corrosion*** **(2nd Term Paper Topics Due)**
	29-Feb	***Pitting and Crevice Corrosion*** – *Test Methods for localized Corrosion,* filiform corrosion
9	***5-Mar***	***Quiz 5 (15 min)*** ***Forms of Corrosion:*** **Erosion Corrosion, Cavitation corrosion,** **(1st Term Paper Due)**
	7-Mar	***Forms of Corrosion:*** **Erosion Corrosion, Fretting corrosion,**
10	***12-Mar***	***Forms of Corrosion: Erosion corrosion***
	14-Mar	***Quiz 6 (15 min)***
11	***18-Mar***	**Spring Break (March 18th to 22st)**
	22-Mar	
12	***26-Mar***	***Exam 2 (Topics Covered between 1st Exam and April 7th) Online exam – No regular synchronous class today. Environmentally Induced Cracking***: SCC, Corrosion Fatigue, Hydrogen Induced Cracking
	28-Mar	***Environmentally Induced Cracking***: SCC mechanisms
13	***2-Apr***	***Environmentally Induced Cracking***: SCC, Corrosion Fatigue,
	4-Apr	***Quiz 7 (15 min)*** ***Environmentally Induced Cracking***: Corrosion Fatigue, Hydrogen Induced Cracking
14	***9-Apr***	***Environmentally Induced Cracking***: Hydrogen Induced Cracking
	11-Apr	***High Temperature Corrosion:*** Oxidation in Gaseous Environments, Ellingham Diagrams, Scale formation
15	***16-Apr***	***High Temperature Corrosion:*** Oxidation in Gaseous Environments, Ellingham Diagrams, Scale formation. **(2nd Term Paper Due)**
	18-Apr	***Quiz 8 (15 min)*** ***High Temperature Corrosion:*** Oxidation in Gaseous Environments, Ellingham Diagrams, Scale formation
16	***23-Apr***	***Last Day of Instructions (Remaining Topics)***
	25-Apr	***Reading Period***

17	*25-Apr to 2-May*	***Exam 3 (during finals week)*** ***https://registrar.gatech.edu/students/exams.php for final exam schedule;***