

Course: MTL5 3T04
Title: Phase Transformations

Instructor:

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Office Hours:

- Thursday: 11:30 to 1:00 in **JHE 357D**

Teaching Assistants:

- Azin Mehrabi
- Bahareh Mobedpour
- Nizia Mendes

Calendar Description:

Molar Gibbs energy diagrams. Fundamentals of diffusion. Curved interfaces, Gibbs-Thomson effect. Grain growth, Zener pinning. Homogeneous and heterogeneous nucleation. Solidification. Scheil formalism. Constitutional supercooling. Eutectic growth. Coarsening. Recovery, recrystallization. Spinodal decomposition. Eutectoid, massive, order-disorder and martensitic transformations.

Three lectures, one lab (three hours); second term

Prerequisite(s): MATLS 1M03, 2D03 and 2X03.

Course Topics:

Week 1: Significance of phase transformations.

Week 2: Review of solution thermodynamics, regular solution model.

Week 3: Use of the common tangent construction, Gibbs Thomson Effect.

Week 4: Crystal interfaces, grain boundaries, grain-growth and recrystallization

Week 5: Diffusion control vs. interface control.

Week 7: Solidification.

Week 8: Diffusional transformations. Spinodal decomposition, homogenous and heterogeneous nucleation.

Week 9: Growth of precipitates. TTT and CCT diagrams. Age hardening.

Week 10: Pearlite and bainite transformations.

Week 11: Martensitic Transformation. Nucleation, growth. Martensite crystallography.

Week 12: Tempering of martensite.

Week 13: Review.

Course Objectives:

At the conclusion of this course, the student should be able to:

- a. Describe the Gibbs energy of mixing of binary alloys and relate it to the phase diagram.
- b. Describe the key features of diffusional and non-diffusional transformations.
- c. Describe the processes of homogenous and heterogeneous nucleation.
- d. Identify the boundary conditions that operate during a diffusional phase transformation.
- e. Understand the factors that control the kinetics of various phase transformations.
- f. Describe the role of phase transformations in microstructure development.
- g. Apply their knowledge of microstructure development to failure analysis problems.
- h. Work effectively in a team.
- i. Use modern engineering tools to characterize the microstructure of common engineering materials.

Professional Development:

MATLS 3T04 is an important part of your training as an engineer. In particular:

Items (a-f) will contribute to your specialized engineering knowledge (CEAB attribute 1.4). The failure analysis lab, item (g), will also contribute to attribute 2 (Problem Analysis) and attribute 3 (Investigation). This course will also give you exposure to modern engineering tools, item (i), which is linked to attribute 5 (Use of Engineering Tools). Finally, the team work component of this course, item (h), will contribute to developing your ability to work individually and in teams (attribute 6).

Primary Textbook:

D. Porter, K. Easterling and M. Sherif, Phase Transformations in Metals and Alloys, 3th edition, CRC Press.

Other useful Resources:

- Hoyt, Phase Transformations
- Shewmon, Phase Transformations in Metals
- Haasen, Physical Metallurgy
- Veerhoeven, Fundamentals of Physical Metallurgy
- Kingery, Introduction to Ceramics

Lectures:

Monday, Wednesday and Thursday 4:30-5:30, MS Teams.

Laboratories:

Laboratories are scheduled every week. The experiments are listed below and described in detail in the laboratory manual:

- (A) Solidification and Casting
- (B) Phase Transformations in Steel.
- (C) Microstructure Evolution and Age-hardening.
- (D) Failure Analysis

All labs work will be completed online. There will be no in-person labs this year.

Evaluation:

Lab Participation (A,B,C,D):	10%
Failure Analysis Project	15% (10% for the report and 5% for the presentation).
Tests (2):	40% 1 hour each, February 8 th and March 8 th .
Final Exam	35% 2.5 hr exam.

* For labs A, B, C and D the student will receive 2.5% for attending the lab, performing the required tasks and participating in the lab discussion with the TA. All students are expected to keep a hard bound lab book in which all lab observations and discussions are recorded.

* The failure analysis lab requires a formal lab report. The report is due on April 5th. The failure analysis presentations will take during lab time on April 9th. Lab reports and presentations should be submitted into the appropriate drop-off box on Avenue. Late lab reports will be penalized 25% per day.

* A peer evaluation multiplier will be applied to the grade of the failure analysis project (presentation and report).

Important Notices to Students from the University Administration

Academic Integrity

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. The academic credentials you earn are rooted in principles of honesty and academic integrity. **It is your responsibility to understand what constitutes academic dishonesty**

Academic dishonesty is to knowingly acting or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at www.mcmaster.ca/academicintegrity.

The following illustrates only three forms of academic dishonesty:

1. Plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
2. Improper collaboration in group work.
3. Copying or using unauthorized aids in tests and examinations.”

Authenticity/Plagiarist Detection

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. **All submitted work is subject to normal verification that standards of academic integrity have been upheld** (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.

Courses with an On-line Element:

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

Online Proctoring:

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/ software during tests or exams. This software may be required to be installed before the test/exam begins.

Conduct Expectations:

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the [Code of Student Rights & Responsibilities](#) (the “Code”). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online**.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that **interfere** with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students’ access to these platforms.

Academic Accommodation for Students with Disabilities:

Students with disabilities who require academic accommodation must contact [Student Accessibility Services](#) (SAS) at 905-525-9140 ext. 28652 or sas.mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University’s [Academic Accommodation of Students with Disabilities](#) policy.

Requests for Relief for Missed Academic Term Work:

McMaster Student Absence Form (MSAF): In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar “Requests for Relief for Missed Academic Term Work”.

Academic Accommodation for Religious, Indigenous or Spiritual Observances (RISO):

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office **normally within 10 working days** of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

Copyright and Recording:

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law

protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

Extreme Circumstances:

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.

Completed by: Hatem S. Zurob, December 2020