

**Technical Elective: Advanced Physical Metallurgy**  
**Syllabus for 2022 Fall**

**Instructor:** Dr. Yingjie Wu (Office: 4-226; Email: yingjie.wu@scupi.cn)

**Lecture:** Thursday, 1:50 pm - 4:25 pm, Room 4-202

**Office hours:** Thursday, 9:15 am – 11:55 am, Room 4-226

**TA:** Weiyi Zhao (Email: florencezwy@163.com)

**QQ Group:** 686581921

**Course Description:**

This course is an advanced course of physical metallurgy, which focuses on the strengthening mechanisms in crystalline solids and annealing phenomena, including grain boundary strengthening, dislocation strengthening, solid solution strengthening, precipitation strengthening, the cold-worked state, crystal plasticity, production of crystalline defects, annealing phenomena, recovery, recrystallization, grain growth, secondary recrystallization, tertiary recrystallization, genesis of preferred orientation, deformation and recrystallization textures. Also, this course describes such areas of contemporary importance as rapid-solidification technology, metal-matrix composites, high strength low alloy steels, dual-phase steels, transformation induced plasticity steels, quench and partitioning steels, twinning induced plasticity steels, hot stamping steels, mechanical alloying, and the finite-element method. It also introduces important advances made in understanding structure-mechanical property relationships, illustrating fundamental concepts by applications and technological developments, and providing in-depth coverage of mechanical testing of metals. By studying this course, students can master the advanced knowledge of physical metallurgy, lay the foundation for numerous metallic materials related courses, and provide applicable tools for the interdisciplinary application of materials science and other disciplines.

**Applicable ABET Outcomes:**

1. An ability to apply knowledge of mathematics, science, and engineering
2. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
3. An ability to identify, formulate, and solve engineering problems
4. An ability to communicate effectively
5. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

**Required Resources:**

**Dislocation Theory:**

1. Hull, D. and D. J. Bacon, *Introduction to Dislocations*. 5th ed., Amsterdam: Butterworth-Heinemann, 2011. Print.
2. Kelly, A. and R. B. Nicholson, *Strengthening Methods in Crystals*. New York: Halstead Press Division, Wiley, 1972, Print.

**Strengthening Mechanisms:**

3. Meyers, M. A. and K. K. Chawla, *Mechanical Metallurgy: Principles and Application*. Prentice Hall, 1983, Print.
4. Meyers, M.A., and K.K. Chawla. *Mechanical Behavior of Materials*, 2nd ed., Cambridge: Cambridge University Press, 2009. Print.

**Recrystallization and Related Annealing Phenomena:**

5. Humphreys, F. J. and M. Hatherley, *Recrystallization and Related Annealing Phenomena*, 2nd ed., Pergamon Press, 2004, Print.

**Advanced High Strength Steels:**

6. Krauss, G., *Steels: Processing, Structure, and Performance*, 2nd ed., Materials Park, Ohio: ASM International, 2015. Print.
7. Fonstein, N., *Advanced High Strength Sheet Steels: Physical Metallurgy, Design, Processing, and Properties*, 1st ed., Cham: Springer International Publishing AG, 2015. Print.

**Course Content (tentative):**

| Week  | Date     | Topics (Lecture)                                  | Reading assignment      | Assignment    |
|-------|----------|---|-------------------------|---------------|
| 2 Th  | 9/8/22   | Dislocation Theory I                              | Required Resources: 1&2 |               |
| 3 Th  | 9/15/22  | Dislocation Theory II                             |                         |               |
| 4 Th  | 9/22/22  | Dislocation Theory III                            |                         | Assignment #1 |
| 5 Th  | 9/29/22  | Strengthening Mechanisms I                        | Required Resources: 3&4 |               |
| 6 Th  | 10/6/22  | Strengthening Mechanisms II                       |                         | Assignment #2 |
| 7 Th  | 10/13/22 | Recrystallization and Related Annealing Phenomena | Required Resources: 5   | Assignment #3 |
| 8 Th  | 10/20/22 | Midterm Review                                    |                         |               |
| 9 Th  | 10/27/22 | <b>Midterm Exam (2 hrs)</b>                       |                         |               |
| 10 Th | 11/3/22  | High Strength Low Alloy (HSLA) Steels             | Required Resources: 6&7 |               |
| 11 Th | 11/10/22 | Dual Phase (DP) Steels                            |                         |               |
| 12 Th | 11/17/22 | Transformation Induced Plasticity (TRIP) Steels   |                         | Assignment #4 |
| 13 Th | 11/24/22 | Quench and Partitioning (Q&P) Steels              |                         |               |
| 14 Th | 12/1/22  | Twinning Induced Plasticity (TWIP) Steels         |                         |               |
| 15 Th | 12/8/22  | Hot Stamping Steels I                             |                         |               |
| 16 Th | 12/15/22 | Hot Stamping Steels II                            |                         | Assignment #5 |
| 17 Th | 12/22/22 | Final Review                                      |                         |               |
| 18 Th | 12/29/22 | <b>Final Exam (2 hrs)</b>                         |                         |               |

## Grading Policies:

| Requirements    | Corresponding Percentages |
|-----------------|---------------------------|
| Assignments (5) | 15%                       |
| Mid-Term Exam   | 35%                       |
| Final Exam      | 45%                       |
| Participation   | 5%                        |

### Grading Scale:

100% ≥ A ≥ 90%; 90% > A- ≥ 85%; 85% > B+ ≥ 80%; 80% > B ≥ 76%; 76% > B- ≥ 73%; 73% > C+ ≥ 70%; 70% > C ≥ 66%; 66% > C- ≥ 63%; 63% > D ≥ 60%; 60% > F.

### Homework:

There will be about 5 homework assignments that will be submitted on Blackboard either as Word document or as pdf before the start of the class (1:50 pm) on the due day. If you are unable to attend a class, you may attach a note to your homework and submit it in advance. ***If homework is submitted late, you would lose 10% per day. You may receive no credit if homework is not submitted within a week from the due day.***

### Exams:

There are two exams, including mid-term and final exams and the exams are not cumulative. An equation sheet might be permitted (information about this will be given a week before the exam). The students need to be present during the exam. In case of an emergency (doctors notice), a make-up exam might be given. The only allowed things during the exams are pens, ruler, water, potentially calculator. Paper and the equation sheet will be provided.

A student found ***cheating, attempting to cheat***, having an ***unauthorized device/tool*** during the exam ***independent of the reason*** will receive a zero on the exam.

### Participation:

Participation through presence but also answering questions, asking questions, contributing to activities is very important to improve active learning for each student. Therefore, your participation will be graded during each lecture starting with the second week.