

MSE 441 – Metals Processing – Spring 2024

The content presented in this class is brand new as of 2024 and I am excited for you to learn about the processing of metallic materials, which is a fascinating and multi-faceted topic. While it would take many years to cover all aspects of metals processing in detail, I selected the most important topics that are relevant today. The intent of this course is to give you an adequate basis in this field for you to understand its grand challenges so you can continue learning on your own and deepening your knowledge in a specific area in your future job, projects, etc.

I am Marie Charpagne, you can call me Prof Marie. I joined UIUC in Fall of 2021. My research is centered around alloy design for additive manufacturing, which is at the intersection between materials design, processing, mechanical and environmental properties. For me, **processing is the most interesting part in alloy design, because we leverage theoretical concepts inherited from thermodynamics, mechanics, and kinetics to generate and convert the material's microstructure into specific configurations to obtain desirable properties. Processing is literally when the magic happens.**

Hence, the course naturally follows up on core MSE classes such as MSE 401, 402, 405, and 406. MSE 443 is not a pre-requisite at all, but if you're interested in metals, I recommend you to take it next Fall.

There are 4 modules in 441, focused on **Extraction, Solidification, Solid-state processing** (i.e., forging and heat treatment), and **Additive Manufacturing**. They are of different lengths, according to the number of concepts we have to cover in each of them. The schedule looks as follows:

	Lecture schedule	Assignment schedule
W 17 Jan	Intro I: Syllabus & logistics	
F 19 Jan	Recap on the microstructure of metals	
M 22 Jan	Extractive Metallurgy	
W 24 Jan	Extractive Metallurgy	HW1 due R Jan 25
F 26 Jan	Extractive Metallurgy : HW correction & quiz prep	
M 29 Jan	QUIZ 1: extractive metallurgy	
W 31 Jan	Solidification: nucleation	
F 2 Feb	Solidification: single phase solidification	
M 5 Feb	Solidification: undercooling	
W 7 Feb	Solidification: multi-phase solidification	HW2 due Thu R Feb 8
F 9 Feb	Solidification: HW correction & quiz prep	

M 12 Feb QUIZ 2: solidification

W 14 Feb Presentation of individual projects topics + Q/A

F 16 Feb Solid state processing: deformation & texture

M 19 Feb Solid state processing: rolling & forging

W 21 Feb Solid state processing: static recrystallization HW3 due R Feb 22

F 23 Feb Solid state processing: HW3 correction

M 26 Feb QUIZ 3: solid-state processing 1 | grain structure

W 28 Feb Solid state processing: diffusive phase transformations & TTT diagrams

F 1 Mar Solid state processing: diffusion-less transformations & orientation relationships

M 4 Mar TMS - no class - prepare mid-term essay

W 6 Mar TMS - no class - prepare mid-term essay

F 8 Mar TMS - no class - prepare mid-term essay Mid-term essay due F Mar 8

M 11 Mar Spring Break

W 13 Mar Spring Break

F 15 Mar Spring Break

M 18 Mar Solid state processing: precipitation strengthening recap from MSE 406

W 20 Mar Solid state processing: precipitation strengthening HW4 due R Mar 21

F 22 Mar Solid state processing: HW4 correction & quiz prep

M 25 Mar QUIZ 4: solid state processing 2 | multi-phase materials

W 27 Mar Intro + DEMO of laser DED AM

F 29 Mar	Powder metallurgy powder making	
M 1 Apr	Powder metallurgy techniques	
W 3 Apr	Additive manufacturing: laser AM - overview, techniques and challenges	article for comprehensive exam is given
F 5 Apr	Additive manufacturing: laser AM - melt pool dynamics, surface tension	
M 8 Apr	Additive manufacturing: laser AM - processing maps & common defects	
W 10 Apr	Additive manufacturing: laser AM - solidification texture, cracking, residual stresses	
F 12 Apr	Additive manufacturing: laser AM - mechanical properties	
M 15 Apr	Additive manufacturing: laser AM - binder jetting; wire making & WAAM	
W 17 Apr	Additive manufacturing: laser AM - comprehensive quiz preparation	
F 19 Apr	Comprehensive exam: additive manufacturing questions on article	
M 22 Apr	Group projects presentations	Final presentations
W 24 Apr	Group projects presentations	
F 26 Apr	Group projects presentations	
M 29 Apr	Group projects presentations	
W 1 May	Group projects presentations	
F 3 May	Group projects presentations	

Grading is continuous throughout the semester and relies assignments of various types for fairness:

Homework (20%) - 4 HW that are to be prepared at home, submitted individually via Canvas (single PDF). They are to be submitted on Thursdays at 11PM. We will have one in-class session focused on HW correction the Friday after you submit, which is aimed at preparing you for the quizzes. This session is

intended to be interactive and an opportunity for you to ask all the questions you'd like (this is a small class, so that's manageable).

Quizzes (20%) - 4 Quizzes will follow the HW sessions. They will be held on Mondays during lecture time and following the HW correction session, to give you enough time to revisit your HW and study other solved questions. The topics of the Quizzes are: Extraction, Solidification, Solid-state processing 1 (single-phase materials & grain structure), Solid-state processing 2 (multi-phase materials). Each quiz weights 5% of the final grade. These quizzes will have maths-questions in them with partial credit (80% of each math question), as well as some comprehensive questions that relate to the lectures directly.

Comprehensive exam (10%) - This exam will also take place during class and consists of comprehensive questions, asked on a scientific article given 2 weeks prior. This article relates to additive manufacturing and relates to several concepts we have discussed in class. An example article and set of solved questions will also be given ahead of time for you to know what to expect.

Group project (45% of total grade - 2 assignments)

A large component of this course is the completion of a project on a specific topic that you are interested in, and as a group. We are 26 so we will make 6 groups of 4. I will provide a list of topics on Feb 14th, but you may also propose your own topic of interest, which I'm happy to discuss and define with you. There are two assignments in this project.

Mid-term essay (15%) - right before Spring break, you will have to provide a group essay. Each topic relates to a challenge in metals processing, so you'll want to present: some background information about the topic and why it is important to tackle/solve (i.e. societal, economical and/or environmental outcomes), what are the key materials' questions to solve (you want to dive into technical challenges here, and the core concepts behind them, hopefully relating to themes that we treat in class). The essay will be submitted as a PDF file which will be screened for AI-generated content and plagiarism, should have a clear structure, up to 5 figures of your own design, tables and equations as needed, references properly formatted, and a maximum of 10 pages (1" margins, 11pt font Times or Arial or equivalent).

Final group presentation (30%) - as a final assignment in this class, you will present one and up to 3 strategies that have been utilized to overcome the challenge related to your project. The presentation will last 25 mins, followed by 10 to 15 mins of questions from other students and the instructor. Since you are presenting in the classroom, you will need to properly explain the context depicted in your essay, and present the strategies in a comprehensive manner. You will be judged on the clarity and quality of the presentation, including its structure, but also figures, references, tables, units. You will need to blend in contents presented during the lectures directly in your slides, as commentary elements to each solution/processing technique presented. Each person in the group should have an approximately equal time. 75% of the grade goes toward the presentation, while 25% of the grade goes toward your ability to answer questions.

Participation (5%) - Whether you come in class. Does not include excused absences.

Office hours

Dates/times TBD during first class

Marie's office: MSEB 408A | email: mcharp@illinois.edu

Grading policies

You are expected to have read the [Student Code section related to Academic Integrity](#) . All infractions listed in the Student Code, including cheating and plagiarism, will result in penalties in accordance with the Student Code. If you have any question regarding what constitutes an infraction, contact me.

COVID

Following University policy, all students are required to engage in appropriate behavior to protect the health and safety of the community. Students are also required to follow the campus COVID-19 protocols. Students who feel ill must not come to class, email the instructor with a proof of illness (i.e. doctor's note). In addition, students who test positive for COVID-19 or have had an exposure that requires testing and/or quarantine must not attend class (and provide a proof of said positive test). Students with excused absences should contact the instructor via email about making up the work. Students who fail to abide by these rules will first be asked to comply; if they refuse, they will be required to leave the classroom immediately. If a student is asked to leave the classroom, the non-compliant student will be judged to have an unexcused absence and reported to the Office for Student Conflict Resolution for disciplinary action. Accumulation of non-compliance complaints against a student may result in dismissal from the University.

Inclusivity

The intent is to raise student and instructor awareness of the ongoing threat of bias and racism and of the need to take personal responsibility in creating an inclusive learning environment. The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the wellbeing of our students and our university community. The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to the Bias Assessment and Response Team (BART , <https://bart.illinois.edu/>). Based on your report, BART members will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

Sexual Misconduct Reporting Obligation

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX Office. In turn, an individual with the Title IX Office will provide information about rights and options, including accommodations,

support services, the campus disciplinary process, and law enforcement options. A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: wecare.illinois.edu/resources/students/#confidential . Other information about resources and reporting is available here: wecare.illinois.edu. Academic Integrity The University of Illinois at Urbana-Champaign Student Code should also be considered as a part of this syllabus. Students should pay particular attention to Article 1, Part 4: Academic Integrity. Read the Code at the following URL: <http://studentcode.illinois.edu/> . Academic dishonesty may result in a failing grade. Every student is expected to review and abide by the Academic Integrity Policy: <https://studentcode.illinois.edu/article1/part4/1-401/> . Ignorance is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

Religious Observances

Illinois law requires the University to reasonably accommodate its students' religious beliefs, observances, and practices in regard to admissions, class attendance, and the scheduling of examinations and work requirements. You should examine this syllabus at the beginning of the semester for potential conflicts between course deadlines and any of your religious observances. If a conflict exists, you should notify your instructor of the conflict and follow the procedure at <https://odos.illinois.edu/communityofcare/resources/students/religious-observances/> to request appropriate accommodations. This should be done in the first two weeks of classes.

Disability-Related Accommodations

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak St., Champaign, call 333-4603, email disability@illinois.edu or go to <https://www.disability.illinois.edu> . If you are concerned you have a disability related condition that is impacting your academic progress, there are academic screening appointments available that can help diagnosis a previously undiagnosed disability. You may access these by visiting the DRES website and selecting "Request an Academic Screening" at the bottom of the page.

Accommodation letters should be submitted in Canvas under the pre-class questionnaire.

Family Educational Rights and Privacy Act (FERPA)

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See <https://registrar.illinois.edu/academic-records/ferpa/> for more information on FERPA.