

## **First Course Handout for MSE 639: Interfaces and Materials Properties**

Course Instructor: Dr. Rajdip Mukherjee, Office: FB407, Email: [rajdipm@iitk.ac.in](mailto:rajdipm@iitk.ac.in)

Teaching Assistants: Pooja Rani and Shivansh Gupta

Emails: [rpooja20@iitk.ac.in](mailto:rpooja20@iitk.ac.in) and [shivanshg24@iitk.ac.in](mailto:shivanshg24@iitk.ac.in)

Class Hours and Venue: T (T108) 10:30-11:45 , Th (T108) 12:00-13:15

Office Hours: Any day by appointment through email

### **Course Contents:**

Topics	Number of Lectures*
1. Introduction to the interfaces: basic classification and definitions	1
2. Basics of Energetics <ul style="list-style-type: none"><li>• Definitions and relations to physical properties</li><li>• Broken bond model</li><li>• Gamma plot</li><li>• Wulff plot and construction</li></ul>	4
3. Solid-Vapour interfaces <ul style="list-style-type: none"><li>• Surface structure (Terraces, ledges and kinks) and defects</li><li>• Surface relaxation and reconstruction</li><li>• Phase transformations</li><li>• Crystal growth from vapour (Nucleation and Growth, Vicinal surfaces)</li><li>• Surface films</li></ul>	12
4. Solid-Liquid Interfaces <ul style="list-style-type: none"><li>• Structure and properties of liquids</li><li>• Interfacial structure and energy</li><li>• Crystal growth</li><li>• Solute partitioning and morphological stability</li><li>• Electrical aspects of surfaces</li></ul>	6
5) Solid-Solid Interfaces <ul style="list-style-type: none"><li>a) Types of solid-solid interfaces and basics</li><li>b) Home-phase Interfaces<ul style="list-style-type: none"><li>• Grain boundary structure and energy</li><li>• Types of grain boundaries and dislocation models</li><li>• Stacking Fault and Twin Boundaries</li><li>• Grain Boundary Segregation</li><li>• Grain boundary and twin boundary equilibria</li></ul></li><li>c) Hetero-phase Interfaces<ul style="list-style-type: none"><li>• Interphase boundaries</li><li>• Coherent and semicoherent interphase boundaries and their energetic</li><li>• Phase transformations on interphase boundaries</li><li>• Interfaces between differences materials and structures</li><li>• Terrace-ledge and kink models</li></ul></li></ul>	12

• Growth, morphology and segregation at the heterophase interfaces	
6) Interfaces and Functional Behaviour	2
7) Surface modification and impact on properties	2
<b>Total</b>	<b>39</b>

\*Lecture distribution in the course content is tentative.

#### Evaluation Components & Policies:

- Mid Sem: 30%
- End Sem: 40%
- Two announced quizzes: 30%
- No make-up exams will be held for quizzes and mid-sem examination. Only SUGC approved medical leave will be considered, if you miss any quiz. There will be no discussion in any other scenario.
- The use of mobile phones, tablets and laptops in class is strictly prohibited and may lead to a lower grade or deregistration. Calculators are allowed.
- Attendance is not mandatory but highly recommended. Biometric attendance will be taken.
- Late entry in the class will not be allowed. It may lead to a lower grade.
- Grading will be relative. However, for a passing grade, a minimum of absolute performance would be necessary.
- Any use of unfair means (in exam or quizzes) would lead to automatic 'F' grade or de-registration and will be reported to SSAC. It is your responsibility to ensure that other students do not copy from you. If any use of unfair means is found, then all parties involved will be penalized. During exams, borrowing or sharing of any material (pen/ pencil/ eraser/ calculator etc.) is strictly not allowed. Bring your own stationaries.
- The instructor of this course owns the copyright of all the course materials. This lecture materials will be distributed only to the students attending this course, and should not be distributed in print or through electronic media without the consent of the instructor.

#### Books and References:

- Surface Science: An Introduction, John B. Hudson, Wiley
- Interfaces in Crystalline Materials, A.P. Sutton and R.W. Balluffi, Oxford Classic Texts in the Physical Sciences
- Physics and chemistry of interfaces By Hans-Jurgen Butt, Karlheinz Graf, Michael Kappl, Wiley-VCH
- Physics of surfaces and interfaces, H. Ibach, Springer.
- Solid surfaces, interfaces and thin films, Hans Luth, Springer.
- Physical Chemistry of Surfaces, Arthur W. Adamson, Wiley-Interscience
- Mechanisms of Diffusional Phase Transformations in Metals and Alloys Hubert I. Aaronson, Masato Enomoto, Jong K. Lee, CRC Press
- Interfacial Science An Introductio, G.T. Barnes, I.R. Gentle, Oxford University Press
- Phase Transformations in Metals and Alloys, David A. Porter, Kenneth E. Easterling, Mohamed Sherif, CRC Press, Taylor and Francis Group

# Department of Materials Science and Engineering

**Course Name:** Capstone Project Lab

**Course No.:** MSE360

**Course Credits:** 0-0-6-0 (6 credits)

**Lab Days:** M & Th (EVEN Roll No.); T & Fr (ODD Roll No.)

**Lab Time:** 2:00 PM to 5:00 PM

**Course Instructor:** Prof. Shikhar Mishra (Ph: 2257; email: [shikharm@iitk.ac.in](mailto:shikharm@iitk.ac.in))

Prof. Shashank Shekhar (Ph: 6528; email: [shashank@iitk.ac.in](mailto:shashank@iitk.ac.in))

**Lab Coordinators:** I P Singh ([indraps@iitk.ac.in](mailto:indraps@iitk.ac.in)); Shilankar ([slankar@iitk.ac.in](mailto:slankar@iitk.ac.in))

## Lab Coordinators for related labs:

Staff Member	Lab	Email (@iitk.ac.in.in) / Landline
A. K. Verma	Engineering Metallurgy Lab (Not available on M & W)	akumarv@ // 7978
G. P Bajpai	Physical Metallurgy (Not available on T & Th)	gpbajpai@ // 7933
N. Deka	Process Metallurgy	dnripen@ // 7949
S. Kant	Functional Materials Lab (Not available on Th)	skant@ // 7933
S. K. Agnihotri	Mechanical Behavior Lab and Workshop	skagni@ // 7969

**Lab Venue:** Mechanical Behavior Lab (DJAC101H)  
Engineering Metallurgy Lab (DJAC101H)  
Physical Met. Lab (WL201)  
Process Metallurgy Lab (WL Extension)  
Functional Materials Lab (WL203)  
Workshop (DJAC101H)

**Course Objective:** The capstone project is a design and implementation project Lab, which utilizes the knowledge gained from all previous core courses and labs. The purpose of the lab is to evaluate the overall understanding of the students in the field of Materials Engineering.

**Pre-requisite:** It is expected that students registering for this lab course have completed other labs of the department, viz. Engineering Metallurgy Lab (TA211), Physical Metallurgy and Materials Characterization Lab (MSE251), Mechanical and Electrical Properties of Materials Lab (MSE351) and Process Metallurgy and Manufacturing Lab (MSE352). The overall understanding gained from these labs have to be put in this lab in the form of a project to showcase structure-process-property correlation.

**Group Formation:** The whole batch would be divided into two sections. Even roll no. students would be in Section-1 which will have labs on Monday and Thursday, while Odd roll no. students would be in Section-2 will have labs on Tuesday and Friday. Each section would be further divided in project groups consisting of 5 to 6 students. Thus, each section would have about 8 project groups. Each project group has to come up with a project which should have task that involves 6 students for 6 hours each for 12 weeks (~425 man-hours).

**Project Topics:** The general guideline for selecting the project topics are as follows

- Project should highlight structure-process-property correlation
- Project can be related to concepts and ideas discussed in course whose proof-of-concept can be shown in the project (eg. Using CCT diagram to draw binary phase diagram; Bauschinger effect; etc.)
- Development of equipment/ device with application to materials testing/ characterization. (eg. DTA can be developed to measure phase transformation)
- Project can also involve development of app or software or use of Machine learning to create a tool for characterization/ testing (Eg. Identification of grain size, grain boundaries)

**Equipment and Facilities:**

Processing		Characterization	
Rolling	Swaging	Optical Microscopy	SEM
Forging	Casting (1100 °C)	XRD	Raman
Furnace (1150 °C)	Furnace (1400 °C)	Tensile	Fatigue
3-d Printing polymer	Photo-resist	Creep	Bend Test
Spin coating	Photolithography	Impact Testing	2-pt probe
Masking	Tape Casting	UV-Vis	Contact Angle
Joining	Diffusion Bonding (1100 °C)	Conductivity	Density
Oxidation Chamber	Calorimetry	Hardness	Porosity
Particle Size distribution	Controlled environment furnace	Thermal Conductivity	I-V Measurement
		4-pt probe	Hall Measurement
		DMA	

**Project Timeline:**

Week-1:	Ideation and Finalization of Project (Submission of Project Details)
Week-2 to 5:	First phase of project
Week-5:	Midterm evaluation and Feedback
Week- 6 to 12:	Project progress
Week-12:	Assembly and Wrapping of Project
Week-13:	Poster Presentation and Evaluation

**Evaluation:**

Attendance and Weekly Progress:	30%
Initial Project Report:	10%
Midterm Evaluation:	20%
Poster Presentation:	20%
Final Project Evaluation:	20%

(Minimum 40% required for passing the lab). Also note that individual members of a project group would be evaluated individually and the marks for each student can be different.

**Attendance:**

Attendance in each lab is mandatory. Absence only for medical emergency is acceptable, with approval from SUGC. In such cases, no make-up or compensation for quiz or attendance would be given. Absence in 3 or more labs (including SUGC approved leave) will result in FAIL grade or de-registration.

**TA s for MSE360**

TA	Section Assigned	Domain	Contact
Dr. Ankur Sharma	S-1 (M,Th)	Mechanical Behavior; Process Metallurgy	ankurs@
Dr. Deepak Gorai	S-2 (T, Fr)	Modeling; ML/ AI	dkgorai@
Cheepati Raviteja	S-1 (M, Th)	Physical Metallurgy	cheepatir21@
Vivek Kumar	S-2 (T, Fr)	Material Chemistry	vivek21@
Sandipan Bhattacharyya	S-1 (M, Th)	Ceramics; Physical Metallurgy	sandipan20@
Amit Kumar Yadav	S-2 (T, Fr)	Mechanical Behavior	amitky21@
Alekhyia Kumari Kyama	Instructor		alekhyak24@

## **Laboratory Safety Guidelines:**

1. **Proper Attire:**
  - Always wear appropriate clothing and shoes.
2. **Aprons and Gloves:**
  - Each student will be provided with an apron and either cotton or surgical hand gloves during the project. These must be worn at all times while working in the laboratory. Students who do not comply will be prohibited from working in the lab.
3. **Mobile Phones:**
  - Mobile phones are strictly prohibited in the laboratory during project work.
4. **Think Before Acting:**
  - Always think carefully before proceeding with any task. Avoid acting impulsively.
5. **Clean Workspace:**
  - At the end of each project day, students must clean up and remove or reorganize all tools and materials from the work area.
6. **Lab Timing and Attendance:**
  - Laboratory sessions are from **2:00 pm to 5:00 pm**. There will be two attendance checks.
  - If a student needs to leave the lab before the scheduled time, they must seek permission from the tutor, especially in case of an emergency.
  - Active participation in the group project is a mandatory component of the course.



## MSE360 Lab Schedule

### 2024-2025, Semester-II, Laboratories Schedule

**Time: 02:00 pm to 05:00 pm**

Day \ Project Turns	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	6 <sup>th</sup>	7 <sup>th</sup>	8 <sup>th</sup>	9 <sup>th</sup>	10 <sup>th</sup>	11 <sup>th</sup>	12 <sup>th</sup>	13 <sup>th</sup>
Turn wise	Capstone Project discussion		P3	P4	P5 Midterm Evaluation	P6	P7	P8	P9	P10	P11 & 12 Assembly		Capstone Project Evaluation (CPE)
Monday	6/1	13/1	27/1	3/2	10/2	17/2	3/3	17/3	24/3	31/3	7/4	14/4	21/4
Tuesday	7/1	21/1	28/1	4/2	11/2	18/2	4/3	18/3	25/3	1/4	8/4	15/4	
Thursday	9/1	16/1	23/1	30/1	6/2	13/2	20/2	6/3	20/3	27/3	3/4	10/4	17/4
Friday	10/1	17/1	24/1	31/1	7/2	14/2	7/3	21/3	28/3	4/4	11/4	18/4	

**Holiday/ Mid & End Sem Examination**

**Date**

Mid Semester Examination	Feb 21 – 28, 2025 (Fri-Fri)
Mid Semester Recess (Holi)	Mar 8 – 16, 2025 (Sat – Sun)
End Semester Examination	April 26- 06 May, 2024 (Sat-Tue)

**Re: Internship Acceptance letter**

Dear Arun Kumar Yadav,

We are pleased to accept you as a Student of **IIT KANPUR** for an internship in **Hybrid Electric Vechiles** with our Company Academor. This is an Internship and Training Program. Our goal is for you to learn more about the domain, to get real industrial knowledge & experience.

[However, at the sole discretion of the Company, the duration of the internship may be extended or shortened with or without advance notice. During the Internship no leaves will be provided.]

As an intern, you will work on the internship and training program for the specified period. The first half will be a complete training part, where in you will learn everything and upskill yourself and the second half you will be deployed to industrial projects in the form of problem statement and training program is not an offer of employment, and successful completion of the internship does not entitle you to employment with the Company.

During your internship, you may have access to confidential, proprietary, and/or trade secret information belonging to the Company. You agree that you will keep all this information strictly.

Confidential and refrain from using it for your own purposes or from disclosing it to anyone outside the Company. In addition, you agree that, upon conclusion of the internship, you will immediately return to the Company all its property, equipment, and documents, including electronically stored information.



By accepting this offer, you agree that you will follow all of the Company's policies that apply to non-employee interns, including the Company's anti-harassment policy.

This letter constitutes the complete understanding between you and the Company regarding your internship and supersedes all prior discussions or agreements. This letter may only be modified by a written agreement signed by both of us.

I hope that your internship with the Company will be successful and rewarding. Please indicate your acceptance of this offer by signing below and returning it to our company desk.

If you have any questions, please do not hesitate to contact us.

Very truly yours,  
ACADEMOR

I accept Intern with the Company on the terms and conditions set out in this letter.

Date : **06/01/2025**