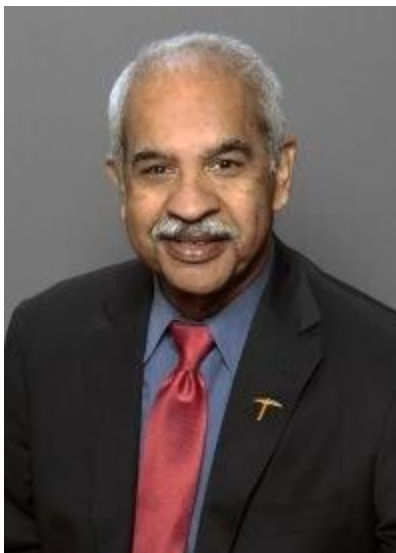


MME 3406 - Nanofunctional Physical Metallurgy

Instructor



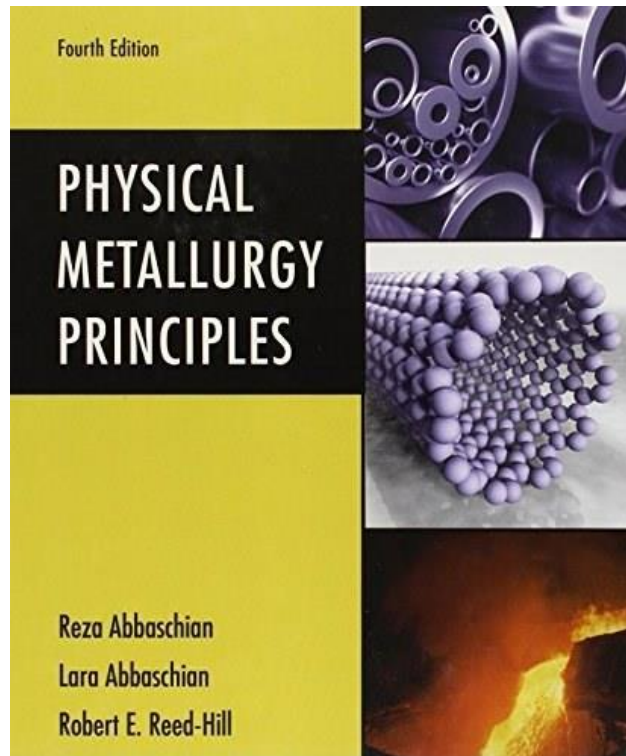
Dr. S. K. Varma

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Textbook

"Physical Metallurgy Principles" by Reza Abbaschian, Lara Abbaschian, and Robert E. Reed-Hill, Fourth Edition, Cengage Learning, 2009.



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Lecture and Lab Hours

Lecture TR 10:30 - 11:50 MT

Lab T 1:30 - 4:20 MT

Lab R 1:30 - 4:20 MT

Course Outline

NO.	CHAPTER	DATE	TOPIC
1	1	Aug 25	Crystal Structures
X	1	25	Crystal Structures (LAB)
2	1	27	Crystal Structures
3	11	Sept 1	Phase Diagrams
X	11	1	Phase Diagrams (LAB)
4	11	3	Phase Diagrams
5	X	8	Examination No. 1
X	11	8	Phase Diagrams (LAB)
6	11	10	Phase Diagrams
7	18	15	Fe-C System
X	18	15	Fe-C System (LAB)
8	18	17	Fe-C System
9	19	22	Fe-C System
X	X	X	LAB WEEK
10	19	24	Fe-C System
11	19	29	Fe-C System
X	X	X	LAB WEEK
12	X	Oct 1	Examination No. 2
13	5/6	3	Dislocations/Grain Boundaries
X	X	X	LAB WEEK
14	5/6	6	Dislocations/Grain Boundaries
15	5/6	8	Dislocations/Grain Boundaries
X	X	X	LAB WEEK
16	5/6	13	Dislocations/Grain Boundaries
17	8	15	Annealing
X	X	X	LAB WEEK
18	8	20	Annealing
19	8	22	Annealing
X	X	X	LAB WEEK
20	X	27	Examination No. 3
21	9	29	Solid Solutions
X	X	X	LAB WEEK
22	9	Nov 3	Solid Solutions
23	16	5	Precipitation Hardening
X	X	X	LAB WEEK
24	12	10	Diffusion in Substitutional Solid Solutions
25	12	12	Diffusion in Substitutional Solid Solutions
X	X	X	LAB WEEK
26	13	17	Diffusion in Interstitial Solid Solutions
27	13	19	Diffusion in Interstitial Solid Solutions
X	X	X	LAB WEEK
X	13	24	Diffusion in Interstitial Solid Solutions
28	14	26	Solidification THANKSGIVING HOLIDAY
29	14	Dec 1	Solidification
30	X	3	Examination No. 4
X	X	12	FINAL EXAM (Thursday 10:00AM - 12:45PM)

Homework

10%

Laboratory

20%

Four Examinations

60%

Final Examination

10%

Details of Course Outline

CHAPTER 1 (The Structure of Metals)

- 1.1 The Structure of Metals
- 1.2 Unit Cells
- 1.3 The Body-Centered Cubic Structure (BCC)
- 1.4 Coordination Number of the Body-Centered Cubic Lattice
- 1.5 The Face-Centered Cubic Lattice (FCC)
- 1.6 The Unit Cell of the Hexagonal Closed-Packed (HCP) Lattice
- 1.7 Comparison of the Face-Centered Cubic and Closed-Packed Hexagonal Structures
- 1.8 Coordination Number of the Systems of Closest Packing
- 1.9 Anisotropy
- 1.10 Textures or Preferred Orientations

- 1.11 Miller Indices
 - Direction Indices in the Cubic Lattice
 - Cubic Indices for Planes
 - Miller Indices for Hexagonal Crystals
- 1.12 Crystal Structures of the Metallic Elements

CHAPTER 4 (Introduction to Dislocations)

- 4.1 Discrepancy Between the Theoretical and Observed Stresses of Crystals
- 4.2 Dislocations
- 4.3 The Burgers Vector
- 4.4 Vector Notation for Dislocations
- 4.5 Dislocations in the Face-Centered Cubic Lattice
- 4.6 Intrinsic and Extrinsic Stacking Faults in Face-Centered Cubic Metals
- 4.7 Extended Dislocations in Hexagonal Metals
- 4.8 Climb of Edge Dislocations

CHAPTER 5 (Dislocations and Plastic Deformation)

- 5.1 The Frank-Read Source
- 5.2 Nucleation of Dislocations
- 5.3 Bend Gliding
- 5.5 Slip Planes and Slip Directions
- 5.6 Slip Systems
- 5.7 Critical Resolved Shear Stress
- 5.8 Slip on Equivalent Slip Systems
- 5.9 The dislocation Density
- 5.10 Slip Systems in Different Crystal Forms
 - Face-Centered Cubic Metals
 - Hexagonal Metals
 - Easy Glide in Hexagonal Metals
 - Body-Centered Cubic Crystals
- 5.11 Cross-Slip

5.12 Slip Bands

5.13 Double Cross-Slip

CHAPTER 6 (Elements of Grain Boundaries)

6.10 The Grain Size

6.11 The Effect of Grain Boundaries on Mechanical Properties: Hall -Petch Relation

6.12 Grain Size Effects in Nanocrystalline Materials

CHAPTER 7 (Vacancies)

7.7 Vacancies

7.8 Vacancies Motion

7.9 Interstitial Atoms and Vacancies

CHAPTER 8 (Annealing)

8.1 Stored Energy of Cold Work

8.2 Relationship of Free Energy to Stored Energy

8.3 The Release of Stored Energy

8.4 Recovery

8.5 Recovery in Single Crystals

8.6 Polygonization

8.7 Dislocation Movements in Polygonization

8.8 Recovery Processes at High and Low Temperatures

8.9 Recrystallization

8.10 The Effect of Time and Temperature on Recrystallization

8.11 Recrystallization Temperature

8.12 The Effect of Strain on Recrystallization

8.13 The Rate of Nucleation and the Rate of Nucleus Growth

8.14 Formation of Nuclei

8.15 Driving Force for Recrystallization

8.16 The Recrystallized Grain Size

8.17 Other Variables in Recrystallization

8.18 Purity of the Metal

- 8.19 Initial Grain Size
- 8.20 Grain Growth
- 8.21 Geometrical Coalescence
- 8.23 The Grain Growth Law
- 8.24 Impurity Atoms in Solid Solution
- 8.28 Preferred Orientation
- 8.29 Secondary Recrystallization
- 8.30 Strain Induced Boundary Migration

CHAPTER 9 (Solid Solutions)

- 9.1 Solid Solutions
- 9.2 Intermediate Phases
- 9.3 Interstitial Solid Solutions
- 9.5 Substitutional Solid Solutions and the Hume-Rothery Rules
- 9.6 Interaction of Dislocations and Solute Atoms
- 9.7 Dislocation Atmospheres
- 9.8 The Formation of a Dislocation Atmosphere
- 9.10 The Drag of Atmosphere on Moving Dislocations
- 9.11 The Sharp Yield Point and Luders Bands
- 9.12 The Theory of Sharp Yield Point
- 9.13 Strain Aging
- 9.15 Dynamic Strain Aging

CHAPTER 11 (Binary Phase Diagram)

- 11.1 Phase Diagrams
- 11.2 Isomorphous Alloy Systems
- 11.4 Equilibrium Heating and Cooling of an Isomorphous Alloy
- 11.5 The Isomorphous Alloy System from the Point of View of Free Energy
- 11.6 Maxima and Minima
- 11.7 Superlattices
- 11.8 Miscibility Gaps

- 11.9 Eutectic Systems
- 11.10 The Microstructures of Eutectic Systems
- 11.11 The Peritectic Transformation
- 11.12 Monotectics
- 11.13 Other Three-Phase Reactions
- 11.14 Intermediate Phases
- 11.16 Ternary Phase Diagrams

CHAPTER 12 (Diffusion in Substitutional Solid Solutions)

- 12.1 Diffusion in Ideal Solution
- 12.2 The Kirkendall Effect
- 12.3 Pore Formation
- 12.4 Darken's Equations
- 12.5 Fick's Second Law
- 12.6 The Matano Method
- 12.7 Determination of the Intrinsic Diffusivities
- 12.8 Self-Diffusion in Pure Metals
- 12.9 Temperature Dependence of the Diffusion Coefficient

CHAPTER 13 (Interstitial Diffusion)

- 13.1 Measurement of Interstitial Diffusivities
- 13.2 The Snoek Effect
- 13.3 Experimental Determination of the Relaxation Time
- 13.4 Experimental Data
- 13.5 Anelastic Measurements at Constant Strain

CHAPTER 14 (Solidification of Metals)

- 14.1 The Liquid Phase
- 14.2 Nucleation
- 14.4 Crystal Growth from the Liquid Phase
- 14.6 The Nature of the Liquid-Solid Interface
- 14.9 Stable Interface Freezing

- 14.10 Dendritic Growth in Pure Metals
- 14.11 Freezing in Alloys with Planar Interface
- 14.13 Dendritic Freezing in Alloys
- 14.14 Freezing of Ingots
- 14.15 The grain Size of Castings

CHAPTER 16 (Precipitation Hardening)

- 16.1 Significance of the Solvus Curve
- 16.2 The Solution Treatment
- 16.5 Aging of Al-Cu Alloys at Temperatures Above 100 oC (373K)
- 16.6 Precipitation Sequences in Other Aluminum Alloys
- 16.7 Homogeneous Versus Heterogeneous Nucleation of Precipitates
- 16.8 Interphase Precipitation
- 16.9 Theories of Hardening
- 16.10 Additional Factors in Precipitation Hardening

CHAPTER 18 (The Iron-Carbon System)

- 18.1 The Iron-Carbon Diagram
- 18.2 The Eutectoid Transformations of Austenite
- 18.3 Transformation of Austenite to Pearlite
- 18.4 The Growth of Pearlite
- 18.5 The Effect of Temperature on the Pearlite Transformation
- 18.8 The Rate of Nucleation of Pearlite
- 18.9 Time-Temperature-Transformation Curves
- 18.10 The Bainite Reaction
- 18.11 The Complete T-T-T Diagram of an Eutectoid Steel
- 18.12 Slowly Cooled Hypoeutectoid Steels
- 18.13 Slowly Cooled Hypereutectoid Steels
- 18.14 Isothermal Transformation Diagrams for Non-eutectoid Steels

CHAPTER 19 (The Hardening of Steel)

- 19.1 Continuous Cooling Transformation (CCT)

- 19.2 Hardenability
- 19.3 The Variables that Determine the Hardenability of a Steel
- 19.4 The Austenite Grain Size
- 19.5 The Effect of Austenitic Grain Size on Hardenability
- 19.6 The Influence of Carbon Content on Hardenability
- 19.7 The Influence of Alloying Elements on Hardenability
- 19.8 The Significance of Hardenability
- 19.9 The Martensite Transformation in Steel
- 19.10 The Hardness of Iron-Carbon Martensite
- 19.11 Dimensional Changes Associated with Transformation of Martensite
- 19.12 Quench Cracks
- 19.13 Tempering
- 19.15 Spheroidized Cementite

Important Notes

1. Homework is always to be done on a standard letter size paper and only one side of the paper is to be used. The complete homework is to be stapled and not clipped or corners folded.
2. Please do not copy home work from others and if caught, both (or more) sets of home work will be given a grade of zero.
3. Questions will be asked from the students at random from the material already covered in the lectures. You must come prepared to the class for this type of discussion.
4. Absence from the class must be explained in writing (signed) otherwise it will be considered as unexcused absence. Students will be dropped from the class after 4 unexcused absences.
5. The grades on homework, weekly quizzes, lab reports and exams can only be discussed within one week after returning them in the class. It is your responsibility for collecting these immediately after my handing it out to in the class. The days of absence are included in this one-week period.

6. Homework grades can only be discussed with the TA who is responsible for grading.
7. Instructions on laboratory details will be provided to you later.
8. Again, do not copy the lab reports and make copies of the data sheets. Penalties similar to homework described above will be assessed.
9. Lectures are all online using Blackboard (BB). The nature exam format is yet to be decided. It will be explained in the lecture period. Handouts will always be posted on BB.
10. Online office hours will be announced later once the classes begin. TA will also assist you in the class.

Technology Requirements

The course content is delivered via the Internet through the Blackboard learning management system (LMS). Ensure your UTEP e-mail account is working and that you have access to the Web and a stable web browser. Mozilla Firefox and Google Chrome are the most supported browsers for Blackboard; other browsers may cause complications with the LMS. When having technical difficulties, update your browser, clear your cache, or try switching to another browser.

You will need to have or have access to a computer/laptop, scanner, a webcam, and a microphone. You will need to download or update the following basic software: Microsoft Office, Adobe, Flashplayer, Windows Media Player, QuickTime, and Java. Check that your computer hardware and software are up-to-date and able to access all parts of the course.

If you encounter technical difficulties beyond your scope of troubleshooting, please contact the Help Desk as they are trained specifically in assisting with technological needs of students.

Netiquette

- Always consider audience. Remember that members of the class and the instructor will be reading any postings.
- Respect and courtesy must be provided to classmates and to instructor at all times. No harassment or inappropriate postings will be tolerated.
- When reacting to someone else's message, address the ideas, not the person. Post only what anyone would comfortably state in a F2F situation.

- Blackboard is not a public internet venue; all postings to it should be considered private and confidential. Whatever is posted on in these online spaces is intended for classmates and professor only. Please do not copy documents and paste them to a publicly accessible website, blog, or other space. If students wish to do so, they have the ethical obligation to first request the permission of the writer(s).

Accommodations Policy

The University is committed to providing reasonable accommodations and auxiliary services to students, staff, faculty, job applicants, applicants for admissions, and other beneficiaries of University programs, services and activities with documented disabilities in order to provide them with equal opportunities to participate in programs, services, and activities in compliance with sections 503 and 504 of the Rehabilitation Act of 1973, as amended, and the Americans with Disabilities Act (ADA) of 1990 and the Americans with Disabilities Act Amendments Act (ADAAA) of 2008. Reasonable accommodations will be made unless it is determined that doing so would cause undue hardship on the University. Students requesting an accommodation based on a disability must register with the UTEP Center for Accommodations and Support Services².

Scholastic Integrity

Academic dishonesty is prohibited and is considered a violation of the UTEP Handbook of Operating Procedures. It includes, but is not limited to, cheating, plagiarism, and collusion. Cheating may involve copying from or providing information to another student, possessing unauthorized materials during a test, or falsifying research data on laboratory reports. Plagiarism occurs when someone intentionally or knowingly represents the words or ideas of another as ones' own. Collusion involves collaborating with another person to commit any academically dishonest act. Any act of academic dishonesty attempted by a UTEP student is unacceptable and will not be tolerated. All suspected violations of academic integrity at The University of Texas at El Paso must be reported to the Office of Student Conduct and Conflict Resolution (OSCCR)³ for possible disciplinary action. To learn more HOOP: Student Conduct and Discipline⁴.

²<https://www.utep.edu/student-affairs/cass/ada-policies/accommodations-for-individuals-with-disabilities.html>

³<https://www.utep.edu/student-affairs/osccr/>

⁴<https://www.utep.edu/hoop/section-2/student-conduct-and-discipline.html>