MechEng 714: SOLIDIFICATION PROCESSING
COURSE GOALS AND OBJECTIVES

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SCHEDULE Wednesday 09:00 to 11:30 am

LOCATION JHE/144

TEXT Course notes will be provided in the duration of the course.
The following textbooks were used in developing the course material

(1) W. Kurz and D.J Fischer, Fundamentals of Solidification 4th Revised Edition, Trans Tech Publications, Switzerland, 1984.
(2) M. Flemings, Solidification Processing, McGraw-Hill Inc., USA 1974
(3) D. M. Stefanescu, Science and Engineering of Casting Solidification, Second Edition, Springer, USA, 2009.
(4) Solidification and Casting, Eds. B. Cantor and K. O'Reilly, Institute of Physics Publishing, UK, 2003.
(5) M.E. Glicksman, Principles of Solidification; An Introduction to Modern Casting and Crystal Growth Concepts, Springer, USA, 2011.

and several others; **use the library**

GOALS To gain a new appreciation for the art of solidification processing (casting) through the rigours of a fundamental understanding of the science.

OBJECTIVES Upon completion of this course the student should be able to:

- Know various solidification processes (casting).
- Understand the structure of liquid metals and alloys, broadly.
- Analyze heat transport in solidification.
- Understand pure metal solidification.
- Understand alloy solidification through heat and mass transport.
- Relate solidification microstructure to process conditions.
- Evaluate solidification parameters from experiment results.
- Gain insight in numerical models for solidification
- Knowledge about defects formed during solidification.
- Appreciate recent advances in the field of near net shaped casting.

GRADING ***Tentative***

Group Assignments	60%
Midterm Examination	20%
Final Exam	20%

ALL DIGITAL SUBMISSIONS FOR GRADING MUST ADHERE TO HIGH STANDARDS AKIN TO THAT IN NOTABLE JOURNAL PUBLICATIONS.

Each week will have a set of specific learning outcome, which shall be the focus of the weekly lectures and practice problems given to students to work on their own time. The students' efforts on the practice problems will not be graded but will certainly enhance knowledge on the topic and prove beneficial during exams.

COURSE OUTLINE

Week Number	Topics	Details
	Solidification Processes (Casting in today's Commerce)	Historical Perspective of Casting Length Scales DC and Continuous Casting Processes Net Shaped Casting Processes Necessity of the Variety of Processes Casting Materials and Applications Future Prospects
	Liquid to Solid	Atomic Structure of Liquid Metals and Alloys Atomic Boding and Flow of Metallic Liquids Theory of Metallic Liquid State Transformation of Liquid to Solid Latent Heat of Fusion Pure and Binary Systems Introduction to Eutectics and Peritectics
	Thermodynamics of Solidification	Free Energy Entropy and Reversibility Energy Balances Source Term Generation Sharp Interface Energetics (Stefan's Problem) Shrinkage and Chvorinov's Rule
	Energy Transport	Heat Flow Rate of Solidification Analyze a laboratory experiment of Unidirectional solidification.
	Solute Redistribution	Solid-Liquid Interface Fluid Feedability (Capillarity) Diffusion and Convection/Advection Solid/Liquid Interface Characteristics Constitutional Undercooling Stability of solidifying interface Mullins-Sekerka Stability Criterion Interface gradient and velocity relationships
	Solute Redistribution	Perturbation Analyses of S/L Interface Analytical Models of Solute Redistribution
	Solidification Microstructure	Growth of Perturbed Interface Ivantsov's Proposition The Mushy Zone Planar/Cellular/Dendritic Growth *Macro*segregation Solute *Micro*segregation Atomically Rough and Smooth Interface Growth Directionality and Morphology (Interface Surface Stiffness)
	Solidification Microstructure	S/L Interface Undercooling Polyphase solidification Eutectic Solidification Peritectic Solidification Solute Trapping Rapid Solidification
	Nucleation	Homogeneous Nucleation Heterogeneous Nucleation Grain Refinement

		In-Situ Crystallization in Melt
	Solidification Defects	Dissolved Gas Pin Holes Porosity Shrinkage Hot Tear Inclusions
	Fluid Dynamics	Fluid Flow during Mould Filling (Macro) Ten rules for Good Casting Micro Scale Fluid Flow Effect of Forced Convection on Microstructure Non-Dendritic Castings