جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

Course Syllabus: Multi-Phase Flows - ME 302

Division	Physical Science and Engineering Division
Course Number	ME 302
Course Title	Multi-Phase Flows
Academic Semester	Fall
Academic Year	2019/2020
Semester Start Date	08/25/2019
Semester End Date	12/10/2019
Class Schedule (Days & Time)	02:30 PM - 04:00 PM | Mon Thu

Instructor(s)

Name	Email	Phone	Office Location	Office Hours
Sigurdur T Thoroddsen	Sigurdur.Thoroddsen@kaust.edu.sa	+966128082160		To Be Determined when course starts.

Teaching Assistant(s)

Name	Email
N/A	N/A

Course Information

Comprehensive Course Description	Selected topics in engineering two-phase flows with emphasis on practical problems in modern hydrosystems. Fundamental fluid mechanics, heat, mass and energy transport in multiphase flows. Surface tension, Young-Laplace equation. Foam, Plateau borders. Basic free-surface flows, capillary waves. Non-dimensional numbers. Wetting of solids. Contact lines and triple lines, Super-hydrophobicity. Marangoni-driven flows. Bubble and drop dynamics, Coalescence, Pinch-off self-similarity. Splashing and air entrapment. Liquid/vapor/gas (LVG) flows, nucleation, cavitating and boiling flows. Leidenfrost dynamics. Flow in porous media. Paticle-laden flows. Models of LVG flows; instabilities, dynamics and wave propagation. fluid/structure interactions. Discussion of two-phase flow problems in conventional, nuclear and geothermal power plants and other hydraulic systems. Separation vessels in petrochemical industry.
Course Description from Program Guide	Selected topics in engineering two-phase flows with emphasis on practical problems in modern hydrosystems. Fundamental fluid mechanics and heat, mass and energy transport in multiphase flows. Liquid/ vapor/gas (LVG) flows, nucleation, bubble dynamics, cavitating and boiling flows, models of LVG flows; instabilities, dynamics and wave propagation; fluid/structure interactions. Discussion of two-phase flow problems in conventional, nuclear and geothermal power plants, marine hydrofoils, and other hydraulic systems.
Goals and Objectives	Make the student familiar with the effects of bubbles, droplets or solid particles on the flow of a liquid in nature and industrial processes. By the end of the course the student should know how to classify the various different multiphase flows and know how to determine which mechanisms are at play for various different conditions which occur in natural processes and industry. Typical topics: How does surface tension effect the flow of foamy materials, or bubbly flow, or the motion of emulsions. Production of monodisperse and compound emulsions; How does Leidenfrost affect spray cooling, etc.
Required Knowledge	Basic knowledge of the Navier-Stokes equations, surface tension. Basics of Thermodynamics. Vector Calculus.

Reference Texts	Lecture Notes will be loaded online before lectures. Students will be directed to classical scientific papers on the topics at hand. Useful texts on the various topics: o Foams: Structure and Dynamics, by Isabel Cantat et al., Oxford University Press (2013). o Physics of Wetting, by E. Y. Bormashenko. De Gruyter (2017). o Capillarity and Wetting Phenomena: Drops, Bubbles, Pearls, Waves, by de Gennes, Brochard-Wyart and Quere. Springer (2004). o Multiphase flow metering, by Gioia Falcone , Geoffrey F Hewitt. Elsevier Science (2009). o Fundamentals of Multiphase Flow, by Christopher Brennen (2005) o Computational Methods for Multiphase Flow: by Prosperetti and Tryggvason, Cambridge
Method of evaluation	**40.00**% - Midterm exam **20.00**% - Homework /Assignments **40.00**% - Group Project(s)
Nature of the assignments	Four bi-weekly homework will test knowledge of the topics. These should be individually solved. Group projects will include significant lab experiments, data reduction, writing of a lab report and final presentation in class. Midterm exam will be given after 2/3 of lectures and will be closed book, closed notes. It will test basic conceptual knowledge.
Course Policies	Students should attend all lectures, unless getting approval from the instructor. Bi-weekly homework should be turned in on-time, but extra time can be given for legitimate reasons.
Additional Information	The laboratory experiments will include use of high-speed cameras and intense lighting, possibly low-power LEDs. The students should have taken basic laboratory safety courses online, as will be specified in the lectures.

Tentative Course Schedule *(Time, topic/emphasis & resources)*		
Week	**Lectures**	**Topic**
1	Mon 08/26/2019	Surface tension, Young-Laplace equation
1	Thu 08/29/2019	Foam, Plateau borders
2	Mon 09/02/2019	Basic free-surface flows, non-dimensional numbers
2	Thu 09/05/2019	Capillary waves
3	Mon 09/09/2019	Marangoni flows
3	Thu 09/12/2019	Wetting of solids. Contact lines and triple lines
4	Mon 09/16/2019	Superhydrophobicity and Superhydrophilicity
4	Thu 09/19/2019	Bubbles and Drops, natural oscillations
5	Mon 09/23/2019	Saudi National Day
5	Thu 09/26/2019	Laboratory experiments
6	Mon 09/30/2019	Basic thermodynamics review
6	Thu 10/03/2019	Leidenfrost dynamics
7	Mon 10/07/2019	Boiling
7	Thu 10/10/2019	Cavitation
8	Mon 10/14/2019	Flow of Liquid/vapor/gas (LVG)
8	Thu 10/17/2019	Flow of emulsions. Coarsening
9	Mon 10/21/2019	Bubbly Flow
9	Thu 10/24/2019	Metering of multiphase flow in pipes.
10	Mon 10/28/2019	Mid-semester break
10	Thu 10/31/2019	Drop impacts and splashing
11	Mon 11/04/2019	Spray formation in jets
11	Thu 11/07/2019	General equations of disperse multiphase flow
12	Mon 11/11/2019	Coalescence Probabilities
12	Thu 11/14/2019	Underwater Sounds Generation in drop impact
13	Mon 11/18/2019	Singular Jets during drop-impact crater collapse
13	Thu 11/21/2019	Interface stability and van der Waals forces
14	Mon 11/25/2019	Interferometric methods and thin films
14	Thu 11/28/2019	Mid-semester break
15	Mon 12/02/2019	Laser cavitation
15	Thu 12/05/2019	Final Presentation
16	Mon 12/09/2019	Exams

Note

The instructor reserves the right to make changes to this syllabus as necessary.