MEC7109: Two Phase Flow and Heat Transfer

Hours per Semester				Weighted Total Mark	Weighted Exam Mark	Weighted Continuous Assessment Mark	Credit Units
LH	PH	TH	CH	WTM	WEM	WCM	CU
35	10	10	45	100	60	40	3

Course Description:

This course is directed toward teaching the student about physical phenomena and specific models that can be used as an aid in understanding two phase flow and heat transfer. These physical processes can occur during plant operation and therefore are needed for the design and analysis of the combustion systems, nuclear and other reactors, and heat transfer industrial processes commonly found in plants.

Course Objectives:

The objectives of this course are to:

- Introduce and describe the processes in internal two-phase flows as well as spray formation and the interaction of sprays with solid surfaces.
- Understand and model the behavior of two-phase thermal-hydraulic system components.

Learning Outcomes

At the end of this course, the student should be able to:

- Demonstrate the ability to model multiphase flows
- Perform fundamental analysis of multiphase flow system
- Demonstrate linkage between mass transfer and heat flow

Detailed Course Content:

1. Introduction (3 Hours)

- Fundamentals of heat and mass transfer
- Generating phase diagrams in Engineering Equation Solver (EES) software
- Introduction to mass transport
- Gas-Liquid interfacial phenomena
- Interfacial waves on thin films, jets, jet breakup and bubble growth

2. Two-phase mixtures (5 Hours)

- Particles and films, Homogeneous vs. separated flow model
- Two-phase flow regimes
- Two-phase modeling – one-dimensional
- Flow regime-based pressure drop prediction
- Two-phase modeling – multi-dimensional

3. **Drift Flux Model** **(5 Hours)**
   - Drift Flux model and void fraction prediction
   - Flow regimes and interfacial area
   - Pressure drop comparison of macro- and micro-scale heat exchangers
   - Two-phase flow in small passages

4. **Nucleate boiling** **(5 Hours)**
   - Electronics cooling via immersion
   - Film boiling
   - Flow boiling
   - Flow regime-based heat transfer model
   - Flow regimes and impact on flow boiling

5. **CHF and post-CHF heat transfer** **(6 Hours)**
   - Analysis of the physical basis for CHF hypotheses
   - Flow boiling in small passages
   - CHF in small passages
   - Two-phase microchannel cold plate for electronics thermal management

6. **Fundamentals of condensation** **(3 Hours)**
   - Internal flow condensation
   - The original Carrier Air Conditioner
   - Condensation on jets and droplets
   - Choking in two-phase flow

7. **Efervescent atomizer** **(8 Hours)**
   - Critical two-phase flow models
   - Spray formation and Spray evaporation rate
   - Single droplet behavior
   - Instabilities - droplet breakup Atomization of the jet in cross-flow
   - Instabilities - droplet breakup
   - Spray/Wall impingement Spray cooling thermal management of high heat flux sources
   - Spray/wall impingement

Mode of delivery
This course will be delivered through lectures, tutorials, exercises, field visits and group projects aimed at solving real life problems.

Laboratory
Boilers and Heat Exchangers **(10 Hours)**

Method of Assessment
Students will be assessed through assignments, tests, practical work and projects which make up the course work and a final exam at the end of the course as follows:

Course work	40%
Final Exam	60%
Total Mark	100%

Reference Textbooks

[1] Mostafa Ghiaasiaan S. (2008), Two-Phase Flow, Boiling, and Condensation 1st Edition, Cambridge University Press, Cambridge. **ISBN-10:** 0521882761

[2] Nellis G. F. and Klein S. A. (2008). *Heat Transfer 1st Edition*, Cambridge University Press, Cambridge, **ISBN-13:** 978-0521881074

[3] P B Whalley (2008). *Two-Phase flow and heat transfer***,** Atlantic **ISBN:** 0198564449

[4] John G Collier (1999). *Two- Phase Flow and Heat Transfer in the Power and Process Industries* McGraw-Hill Companies ISBN: 0070049025 EAN: 9780070049024