MIE408/1130: Nuclear Engineering II
Course Syllabus

General Information

Instructor	Professor Hisham Hasanein
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Lectures	Thursday, 9-12 In-Person/BA 2159
Tutorials	Friday, 15-17 In-Person/MY 490

Course Description

This course covers the basic principles of the thermo-mechanical design and analysis of nuclear power reactors. Topics include reactor heat generation and removal, nuclear materials, diffusion of heat in fuel elements, thermal and mechanical stresses in fuel and reactor components, single-phase and two-phase fluid mechanics and heat transport in nuclear reactors, and core thermo-mechanical design.

Textbooks

Thermalhydraulics:

1. Todreas, Neil E., and Mujid S. Kazimi. *Nuclear Systems Volume 1: Thermal Hydraulic Fundamentals*. ©2012 Taylor & Francis group, LLC, August 16, 2011, Second Edition. ISBN: 9781439808870.

Structural Mechanics (Optional):

2. Harvey, J. F. *Theory and Design of Pressure Vessels*. New York, NY: Van Nostrand Reinhold, 1997. ISBN: 9780442232481.
3. The American Society of Mechanical Engineers. *Fiber-Reinforced Plastic Pressure Vessels: Asme Boiler and Pressure Vessel Code and International Code*. Section II and Section III (Subsections NB and NH). Fairfield, NJ: ASME Press, 1998. ISBN: 9780791825181.

Schedule of Lectures/ Topics/Reading & Homework Assignments (The Plan)

Note 1: For MIE 408 Students: Problems with bolded numbers and placed between parenthesis (e.g. **{6-5}**) are not required.

Note 2: No lectures or tutorials during Reading Week (February 17-21).

Note 3: Tutorials follow lectures and cover same topics.

LEC #	TOPIC	READING ASSIGNMENTS TEXTBOOK (1)	HOMEWORK ASSIGNMENTS	LECTURE DATES
1	Course introduction and reactor types	Chapter 1,	Assignment#1 2-1, 3-4	Jan 9
2	Reactor Fuel Assemblies	Chapter 1,		
3	Reactor heat generation	Chapter 2 (2.3) Chapter 3 (3.1, 3.2, 3.5, 3.6, 3.9)		
4	Thermal design principles	Chapter 2 (2.4, 2.5, 2.6)	Assignment#2 6-3,**{6-5}**	Jan 16
5	Conservation equations	Chapter 4 (4.3.2, 4.5.1, 4.5.2, 4.5.3)		
6	Rankine power cycles	Chapter 6 (6.4.1, 6.5)		
7	Brayton power cycles	Chapter 6 (6.6, 6.7, 6.8)	Assignment#3 7-2, **{7-7}**	Jan 23
8	Containment analysis	Chapter 7 (7.2.1)		
9	Containment analysis (cont.)	Chapter 7 (7.2.2)		
10	Thermal analysis of fuel elements (introduction)	Chapter 8 (8.1, 8.2, 8.3)	Assignment#4 **{8-4}**, 8-5	Jan 30
11	Thermal analysis of fuel elements (temperature distributions)	Chapter 8 (8.4, 8.5)		
12	Thermal analysis of fuel elements (Gap conductance)	Chapter 8 (8.6)		

LEC #	TOPIC	READING ASSIGNMENTS TEXTBOOK (1)	HOMEWORK ASSIGNMENTS	LECTURE DATES
13	Thermal analysis of fuel elements (Gap conductance)	Chapter 8 (8.7.1)		
14	Thermal analysis of fuel elements (overall heat resistance)	Chapter 8 (8.7.3)	Assignment#5 14-1	Feb 6
15	Thermal analysis of fuel elements (maximum temperature in the core)	Chapter 14 (14.5.1)		
16a,b,c	Single phase thermal-hydraulics -1	Chapter 9 (9.1,9.2.2, 9.3.1-9.3.4, 9.4.1) Chapter 10 (10.1, 10.2.1)	Assignment#6 9-1, 9-6, 10-5	Feb 13
17	Single phase thermal-hydraulics (fluid dynamics and heat transfer) – 2	Chapter 9 (9.4.2, 9.4.3, 9.5.3-9.5.7, 9.6.4) Chapter 10 (10.2.2, 10.2.3, 10.5)		
18	Single phase thermal-hydraulics (turbulence analysis) -3	Chapter 9 (9.5.1, 9.5.2) Chapter 10 (10.3.1, 10.3.2)		
		Reading Week Feb 17-21		
	Quiz 1 (open book) All material through Lec #15			Feb 27 (9-12)

LEC #	TOPIC	READING ASSIGNMENTS TEXTBOOK (1)	HOMEWORK ASSIGNMENTS	LECTURE DATES
19	Two phase flow (basic parameters and models)	Chapter 5 (5.3, 5.4)	Assignment#7 **{5-1}**,5-3,11-3	Mar 6
20	Two phase flow (basic parameters and models) (cont.)	Chapter 5 (5.5)		
21	Two phase flow (basic parameters and models)	Chapter 11 (11.1, 11.2.1, 11.2.2)		
22	Two phase flow (models and void-quality-slip relations)	Chapter 5 (5.1) Chapter 11 (11.3, 11.4, 11.5.1, 11.5.2, 11.5.3)	Assignment#8 **{11-5},**11-8**,** 11-11	Mar 13
23	Two phase flow (pressure drop and instabilities) (cont.)	Chapter 11 (11.6.1, 11.6.2, 11.6.3)		
24	Two phase flow (critical flow)	Chapter 11 (11.7.1, 11.7.2, 11.7.3.1)		
25	Two phase heat transfer (pool boiling)	Chapter 12 (12.1, 12.2, 12.3, 12.4*, 12.5, 12.6)	Assignment#9 12-3,**{13-1}**	Mar 20
26	Two phase heat transfer (flow boiling)	Chapter 13 (13.1, 13.2)		
27	Two phase heat transfer (flow boiling) (cont.)	Chapter 13 (13.3.1, 13.3.2)		
28	Two phase heat transfer (flow boiling) (cont.)	Chapter 13 (13.3.3)	Assignment#10 13-3,**{14-3},** 14-4	Mar 27
29	Two phase heat transfer (dryout and post-dryout heat transfer)	Chapter 13 (13.4)		
30	Single Heated Channel	Chapter 14 (14.5.3, 14.6.1)		
	Quiz 2 Open book will cover entire course			April 3 (9-12)

Learning Objectives

By the end of this course the student should be able to:

- identify nuclear reactor key systems, structures and components and their design objectives
- demonstrate a comprehensive understanding of principles of the thermo-mechanical design and analysis of nuclear power reactors, covering the following topics:
  - Reactor heat generation and removal (heat sources and heat sinks),
  - Nuclear materials,
  - Diffusion of heat in fuel elements,
  - Thermal and mechanical stresses in fuel and reactor components,
  - Single-phase and two-phase fluid mechanics and heat transport in nuclear reactors,
  - Plant, core and single channel thermal performance characteristics of water cooled reactors.
- demonstrate a basic understanding of principles and concepts of nuclear reactor safety (control, cool, and contain; multiple barriers; defence-in-depth) and key thermal parameters impacting reactor safety and operation.
- logically think through a problem and solve it using the right modelling approach for the transport conservation equations.

Grading and Discussions of Plans

Grading	Homework	25%
	Exam#1	35%
	Exam#2	40%

1. Readings:
   - ❖ Readings are from Todreas and Kazimi text (Textbook).
2. Homework Practices:
   - ❖ It is acceptable for the student to:
     - Work completely independently;
     - Consult Professor or TA; and
     - Work with other students.
   - ❖ However, the student should not adopt a solution directly for any outside source without being sure that you understand both concepts and calculations. Points will be deducted if it appears that you do not understand.
3. Homework assignments are due at the start of tutorial the week following the lectures. **Late homework will receive up to half full credit.**