NRE 4214 Reactor Engineering (Required)

Catalog Description: NRE 4214 Reactor Engineering (3-0-3)
Prerequisite: ME 3322, ME3345, ME 3340
Nuclear heat generation; fuel elements' thermal analysis; single and two phase flow and heat transfer in reactor systems; core thermal design and treatment of uncertainties.

Textbook: Todreas, N. E. and M. S. Kazimi, Nuclear Systems I: Thermal Hydraulic Fundamentals, Taylor and Francis (1990).

Topics Covered:

1. Power Plant Descriptions/Thermal Design Principles**
2. Reactor Heat Generation
3. Thermal Analysis of Fuel Elements
4. Single Phase Fluid Mechanics/Pressure drop in rod bundles
5. Single Phase Heat Transfer
6. Two-Phase Flow
7. Boiling Heat Transfer
8. Reactor Thermal Hydraulic Design/ Uncertainty Analysis

Course Outcomes:

Outcome 1: To familiarize the students with various reactor types and their main design and operational characteristics.
- 1.1 Students will demonstrate an understanding of the main design features and operational characteristics of various reactor types.
- 1.2 Students will demonstrate an understanding of the basic thermal design principles of nuclear fission reactors.

Outcome 2: To teach the students how to estimate the volumetric heat generation rate in fission reactor cores under normal operation and shutdown conditions.
- 2.1 Students will be able to calculate the volumetric heat generation rate and its distribution within the core under normal and shutdown conditions.

Outcome 3: To teach the students how to analyze the thermal performance of nuclear fuel elements.
- 3.1 Students will be able to calculate the temperature distribution within fuel elements including the effects of temperature-dependent conductivity, non-uniform heat generation, gap conductance, and fuel element restructuring.
- 3.2 Students will be able to estimate the maximum linear heat rate, surface heat flux and volumetric heat generation rate to assure compliance with thermal design limits.

Outcome 4: To teach the students the basic fluid mechanics of single phase reactor cooling systems.
- 4.1 Students will be able to setup and apply shell momentum balances for single phase systems.
- 4.2 Students will be able to determine the velocity distributions in steady incompressible, Newtonian flow systems.

Outcome 5: To teach the students how to calculate pressure drop in reactor systems, including tube bundles, and spacer grids.
- 5.1. Students will demonstrate the ability to calculate single phase pressure drop in channels including entrance effects.
- 5.2 Students will demonstrate the ability to calculate the pressure drop in tube bundles including spacer grids and minor losses.

Outcome 6: To teach the students how to analyze the heat transfer characteristics of single phase reactor cooling systems.
- 6.1 Students will be able to setup and apply shell energy balances to determine the temperature distributions in single phase systems.
- 6.2 Students will be able to estimate the heat transfer coefficients for non-metallic and metallic coolants in channels and rod bundles.

Outcome 7: To teach the students the basic fluid mechanics of two-phase systems, including flow regime maps, void-quality-slip relations, pressure drop, and critical flow.
- 7.1 Students will differentiate between various two-phase flow regimes.

7.2 Students will understand the relationship between quality, void fraction and slip ratio.
7.3 Students will be able to use two-phase friction multiplier models to estimate the frictional pressure drop in two-phase systems.
7.4 Students will be able to calculate the acceleration and gravitational pressure drop in two-phase systems.

Outcome 8: To teach the students the fundamentals of Boiling heat transfer, and its implications for reactor design.
8.1. Students will understand the various physical processes taking place in boiling heat transfer.
8.2 Students will understand the differences between the various boiling regimes.
8.3 Students will be able to estimate the critical heat flux and understand its implications in core thermal design.

Outcome 9: To teach the students the fundamentals of core thermal design, with attention to design uncertainty analysis and hot channel factors.
9.1. Students will be able to understand how uncertainties in various design parameters and correlations are accounted for in the design process.
9.2 Students will be able to estimate hot spot subfactors and overall hot spot factors.
9.3 Students will understand and apply the basic principles of statistical design.

Correlation between Course Outcomes and Program Educational Outcomes:

NRE 4214 Reactor Engineering	Outcome a			Outcome b	Outcome c	Outcome d	Outcome e	Outcome f	Outcome g	Outcome h	Outcome i	Outcome j	Outcome k
Course Outcomes	i	ii	iii										
Course Outcome 1.1												X	
Course Outcome 1.2					X							X	
Course Outcome 2.1							X						
Course Outcome 3.1			X				X						
Course Outcome 3.2					X		X						
Course Outcome 4.1			X				X						
Course Outcome 4.2			X				X						
Course Outcome 5.1							X						
Course Outcome 5.2							X						
Course Outcome 6.1			X				X						
Course Outcome 6.2							X						
Course Outcome 7.1							X						
Course Outcome 7.2							X						
Course Outcome 7.3							X						
Course Outcome 7.4							X						
Course Outcome 8.1							X						
Course Outcome 8.2							X						
Course Outcome 8.3							X						
Course Outcome 9.1					X		X						
Course Outcome 9.2					X		X						
Course Outcome 9.3					X		X						

Prepared by: Said Abdel-Khalik
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