ENU 4104 Reactor Anal. & Computat. 2 - Dynamics (3 cr), Required Course, Fall, 2006

Description: Continuation of ENU 4103. Neutron thermalization and thermal scattering kernels. Treatment of resonances and Doppler broadening. Dynamic analysis of reactors including point model and space-time models. Feedback and reactor dynamics and control. Short-term transient analysis and long-term time-dependence.

Pre-requisite: ENU 4103

Course Objectives: Development of understanding of dynamic behavior of reactors including feedback arising from thermal neutron spectrum effects and resonance effects; methods of analysis; reactor control; analysis of both short-term and long-term transients.

ABET Program Educational Objectives / Professional Components Supported by Course:

1. Graduates will have successful careers in Nuclear Engineering and related disciplines.
2. Graduates will pursue advanced degrees or continuing education.
4. Graduates will use the knowledge and skills obtained in their undergraduate education to practice high ethical and professional standards in Nuclear Engineering and related disciplines.

ABET Program Outcomes Supported by Course:

Outcome a: an ability to apply knowledge of mathematics, science and engineering for problem solving in engineering.
Outcome e: an ability to identify, formulate and solve engineering problems.
Outcome k: an ability to use the techniques, skills and modern engineering tools, including modern computational skills and tools, necessary for nuclear and radiological engineering practice.
Outcome l: an ability to apply advanced mathematics, science, atomic and nuclear physics and engineering to nuclear and radiological systems and processes.
Outcome n: an ability to work professionally in on or more of the areas of: nuclear power reactors, nuclear instrumentation and measurement, radiation protection and shielding and radiation sources and applications

Text: *Nuclear Reactor Analysis*, Duderstadt and Hamilton, John Wiley & Sons, 1976
[Referred to as **D&H** in the Syllabus]

References: *Nuclear Reactor Physics,* Chapters 1 and 2, Weston M. Stacey, John Wiley & Sons, 2001.
Nuclear Reactor Engineering, 4th Edition, Glasstone and Sesonske, Chapman and Hall Inc., 1994. [Referred to as **G&S** in the Syllabus]
Nuclear Reactor Theory, Chapter 9, Bell and Glasstone, VanNostrand Reinhold Company, New York, 1970.
"Introduction to Nuclear Engineering," 2nd Ed, J.R. Lamarsh, Addison-Wesley Publishing Company, Inc., 1983. [Referred to as **L** in the Syllabus]

Grading: Homework and code reports: 30%, 1st Exam: 35%, Final Exam: 35%

ENU 4104 Reactor Analysis and Computations 2 - Dynamics (Course Outline)

1. Special Considerations for Fast and Thermal Group Constants (11 classes)
   Thermal spectrum effects; resonance energy and spatial shielding effects
   Thermal and fast spectra and generation of fast and thermal group constants using COMBINE (Sections 3.114-3.116 and 4.13-4.45 of **G&S;** Ch 9 pp 375-394, Ch 8 pp 315-332 & pp 358-369, Ch 10 pp 398- 439 of **D&H**; class handouts; and sections from code manuals)
   Use of COMBINE constants in VENTURE multi-group diffusion theory calculations (Sections 4.46-4.69 in **G&S**; Class handouts; Ch 7 pp 285-311 and Ch 13 pp 515-525 of **D&H**; and sections from code manuals)

2. Time Dependent Reactor/Reactor Kinetics – Short Term Time Dependence (6 classes)
   Time dependent diffusion equation, prompt neutron lifetime, delayed neutrons, units of reactivity, point reactor kinetics (PRK) equations/calculations using AIREK (Section 7.1 and 7.2 of **L**; Sections 5.1-5.55 of **G&S**; Ch 6, pp 233-246 & pp 255-268 of **D&H**; class handouts and sections from code manual)

3. Reactivity Control and Feedback Effects (6 classes)
   Reactivity control; fuel temperature (Doppler), moderator temperature and void reactivity feedback; xenon and samarium poisoning.
   (Sections 7.3-7.5 of **L**; Sections 5.56-5.124 of **G&S**; Ch 15 pp 567-577 of **D&H**; and class handouts)

4. Introduction to Fuel Depletion Calculations – Long Term Time Dependence (6 classes)
   Core properties during burnup; fuel depletion calculations with CASMO.
   (Section 7.6 of **L**; Sections 4.70-4.85 and 8.172-8.192 and Sections 4.73-4.93 and 10.13-10.62 in **G&S**; Ch 15 pp 580-600 of **D&H**; and class handouts)

5. Introduction to Control Theory and Review of Laplace Transforms (6 classes)
   Block diagrams, block diagram algebra and feedback paths.
   Properties of Laplace transforms, common input functions, types of roots and olution of differential equations using Laplace transforms
   (Class handouts)

6. Reactor Dynamics and Control (4 classes)
   PRK equations and source transfer and reactivity transfer functions; effects of delayed versus prompt neutrons; zero power reactors w/o feedback
   (Class handouts)

7. Transfer Function and Transient Response with Simple Feedback (4 classes)
   Characteristic function, stability, power limits for stability, resonance frequencies, power oscillations, and importance of delayed versus prompt neutrons
   (Class handouts)

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