EGMN 352 – Nuclear Reactor Theory

Course Description

This course will introduce the fundamentals of nuclear reactors, which are much more interesting than the toys other engineering majors get to play with. Topics include the interaction of neutrons with matter, nuclear fission, controlled self-sustaining chain reactions, neutron balance equation, neutron diffusion and slowing down theory, reactor kinetics and dynamics.

By the end of the course you should be able to:

- **Explain** chain reactions and criticality in terms that a 10-year-old can understand,
- **Compute** reaction rates and leakage rates use cross sections, fluxes, and currents
- **Estimate** the multiplication factor of a homogeneous reactor,
- **Estimate** the neutron distribution in a steady-state homogeneous reactor,
- **Explain** how the neutron population varies with time during a transient in a reactor,
- **Design** homogeneous reactors with specified characteristics.

Details:

Prerequisite: EGMN 351 and MATH 301 with a minimum grade of C, or permission of instructor.

Textbook: *Fundamentals of Nuclear Reactor Physics*, Elmer E. Lewis, Academic Press, 2008.

References: *Nuclear Reactor Analysis*, J.J. Duderstadt & L. J. Hamilton, Wiley & Sons, 1976.
Introductory Nuclear Reactor Statics, K.O. Ott & W.A. Bezella, Am. Nul. Soc., 1989.
Introductory Nuclear Reactor Dynamics, K.O. Ott & R. J. Neuhold, Am. Nul. Soc., 1985.
Nuclear Reactor Physics, 2nd ed., W.M. Stacey, Wiley-VCH, 2007.
Applied Reactor Physics, 2nd ed., A. Hebert, Presses Internationals Poly-technique, 2016.

Instructor: Dr. Zeyun Wu; Phone: 804-827-0237; email: zwu@vcu.edu

Office hours: Upon appointment (send email to schedule)

Schedule: 12:30 PM – 1:45 PM, Tuesdays & Thursdays, Spring Semesters

Classroom; Room E2221, East Engineering Hall

Attendance: Since class discussion is a major course ingredient, regular attendance is mandatory. Students with more than **4** unjustified absences (justified absence requires notification in writing with proof documentations) will automatically receive an **F** in the course.

Class manner: Note this class manner is special for the in case virtual lecturing mode. Students must be muted during the lecture time. Unless class discussion is invoked, students cannot speak individually. However, if you have questions, you can raise up your hands through the 'hand-raise' button in the Zoom chat dialogue. You can also ask questions directly through the Zoom chat dialogue, but please do not make class irrelevant chatting in the chat dialogue. It is acceptable that you turn off your video during the lecture time, but it is encouraged to turn on your video when you speak through the Zoom.

Homework: Homework sets will be assigned at least one week in advance and will be due at the end of the due date except otherwise notified. All homework need to be assigned and requested submission electronically through the Canvas. **No credit will be given if homework is received after the due time.** However, the due time may be extended at certain circumstances. You are encouraged to work in small groups but you must hand in your own work to receive credit. The homework will be graded on the method of the problems as well as the answers.

Exam: There will be two mid-exams and one final exam. All exams will be assigned and requested submission through the Canvas. You cannot discuss with anybody else for the exam and have to work on the problems independently. However, if you have questions on the exam sheet, you can contact the instructor through the emails. All exams will be turned in electronically through Canvas. **No credit will be given if the exam solution is received after the due time.** However, the due time may be extended at certain circumstances.

Grade:

Homework and Attendance	40%,
Mid-Exam I	15%,
Mid-Exam II	15%,
Final Exam	30%.

Final grade: **A**=90-100: **B**=80-89; **C**=65-79; **D**=55-64: **F**<55

Others: This syllabus is subject to change. Please visit **Canvas** to get the latest updates to the syllabus and other class information. Materials provided in class and in **Canvas** are for your personal use only. So please do not distribute them to any public domain.

Homework & Exam submission guidance: scan and combine your solutions into one SINGLE PDF before submitting it to the Canvas. If you scan the solution into JPG files, copy and paste the JPG into a single WORD file, and then convert it into a PDF file before your submission. Make sure the resolution of the PDF file is manageable in a normal view of the screen.

Additional important note from VCU: students should visit http://go.vcu.edu/syllabus and review all syllabus statement information. The full university syllabus statement includes information on safety, registration, the VCU Honor Code, student conduct, withdrawal and more.

Course Outline and Schedule (subject to change)

Class	Day	Date	Topics	HW and Due date	Textbook Reading
1	Tuesday	1/18/202x	Course introduction		1.1
2	Thursday	1/20/202x	Nuclear reactions (1/2)	#1, 1/27/2x	1.2 – 1.4, 1.7
3	Tuesday	1/25/202x	Nuclear reactions (2/2)		
4	Thursday	1/27/202x	Neutron-nucleus interaction (1/2)	#2, 2/03/2x	2.2 – 2.5, 3.3
5	Tuesday	2/01/202x	Neutron-nucleus interaction (2/2)		
6	Thursday	2/03/202x	Chain reactions and criticality	#3, 2/10/2x	1.5 – 1.6
7	Tuesday	2/08/202x	Nuclear reactors		4.1 – 4.2
8	Thursday	2/10/202x	Flux, current, partial current (1/2)	#4, 2/24/2x	3.4
9	Tuesday	2/15/202x	Flux, current, partial current (2/2)		Appendix C
10	Thursday	2/17/202x	**Mid-Exam 1**		
11	Tuesday	2/22/202x	Exam and Homework Review		
12	Thursday	2/24/202x	Neutron conservation (1/3)	#5, 3/03/2x	5.2
13	Tuesday	3/01/202x	Neutron conservation (2/3)		5.4
14	Thursday	3/03/202x	Neutron conservation (3/3)	#6, 3/17/2x	
	Tuesday	3/08/202x	No class (Spring break)		10.1 – 10.5
	Thursday	3/10/202x	No class (Spring break)		5.1-5.2
15	Tuesday	3/15/202x	Long term core behavior		
16	Thursday	3/17/202x	Reactor kinetics (1/3)	#7, 3/24/2x	
17	Tuesday	3/22/202x	Reactor kinetics (2/3)		5.3
18	Thursday	3/24/202x	Reactor kinetics (3/3)	#8, 3/31/2x	5.4
19	Tuesday	3/29/202x	One-group diffusion theory (1/5)		6.1 – 6.2, 6.6
20	Thursday	3/31/202x	One-group diffusion theory (2/5)	#9, 4/07/2x	6.3
21	Tuesday	4/05/202x	One-group diffusion theory (3/5)		6.4 – 6.5
22	Thursday	4/07/202x	One-group diffusion theory (4/5)	#10, 4/21/2x	6.7, 7.3
23	Tuesday	4/12/202x	One-group diffusion theory (5/5)		7.2
24	Thursday	4/14/202x	**Mid-Exam 2**		
25	Tuesday	4/19/202x	Exam and Homework review		
26	Thursday	4/21/202x	Neutron moderation (1/3)	#11, 4/28/2x	3.1 – 3.3
27	Tuesday	4/26/202x	Neutron moderation (2/3)		3.4 – 3.5
28	Thursday	4/28/202x	Neutron moderation (3/3)		4.3 – 4.4
29	Tuesday	5/03/2022	Course Summary	Last Class	
30	Tuesday	5/10/202x	**Final Exam 12:30 - 3:20 PM**		