

## Engy-4340: Nuclear Reactor Theory

**Instructor:** Prof. Valmor F. de Almeida

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**Web:** <https://www.uml.edu/Engineering/Chemical/faculty/de-Almeida-Valmor.aspx>

**Lectures:**

- Mon/Wed 5:00 – 6:15 pm, **Ball Hall 206 North Campus.**

**Days meetings total :** 27.

**Week meetings total:** 15/16.

Website: On-line course [repository](#) and UMass Lowell Blackboard System.

**Office hours and location:** meet after lecture in classroom.

**Additional office hours:** email prof. de Almeida for appointment.

**Additional help:** UML Linux Club meetings, Fridays 5 to 6 pm, email prof. de Almeida

**Teaching assistant:** Mr. Ankit Mishra (email: [Ankit\\_Mishra@student.uml.edu](mailto:Ankit_Mishra@student.uml.edu)).

**Office hours and location:** meet at 1:45 – 2:45 pm, Mon/Wed; **Pinanski Hall 300.**

**Catalog description:** Emphasis is placed on neutron interactions in various nuclear core and shield configurations along with the development, solution, and analysis of the neutron balance equation for various situations. Several aspects of nuclear reactor core physics including neutron diffusion, criticality, power production, reactor kinetics, reactivity feedback and control, fuel depletion, fission product poisoning, and some energy removal considerations are treated. General reactor core design and safety considerations are also discussed.

**Pre-requisites:** Engy-3310 Fund. of Nuclear Science & Engineering, and Math-2360 Eng. Differential Equations.

**Course designation:** Core undergraduate.

**Helpful:** [ChEn-3170 Computational Methods in Chemical Engineering](#).

**Textbooks and Notes:**

Course notes are provided; in addition two textbooks are required (one textbook is used in the pre-req Engy-3310).

1. *Classroom course notes and repository (updated during the semester)*
2. [LB] [Introduction to Nuclear Engineering](#), John R. Lamarsh and Anthony J. Baratta, Pearson, 2018 Fourth Edition (or Third Edition), 802 pp.
3. [SF] [Fundamentals of Nuclear Science and Engineering](#), J. Kenneth Shultis and Richard E. Faw, CRC Press, 2017 Third Edition (or a recent previous edition), 638 pp.

Software used in this course and homework: Jupyter notebook access options for this course

1. Preferred way: [Anaconda](#) free download (use the Python 3 version) for Mac OS X or Windows (Linux too in case you are a rare die-hard programmer; if this is your case come talk to me). After install, use [Anaconda-Navigator](#) to start a Jupyter Notebook server.
2. Use the [UMass Lowell vLabs](#) Learning Commons machine. Download the VMWare Horizon Client and install on your computer. Login with your academic credentials. Anaconda is pre-installed, use the Anaconda-Navigator to start the Jupyter Notebook application.
3. Use Binder at the course [repository](#)

Instructive background **on programming environment, review of undergraduate computational methods:** [ChEn-3170](#)

**Supplement materials:** On-line course [repository](#): <https://github.com/dpploy/engy-4340>.

**Course topics (Fission Reactors):**

- Nuclear reactions and neutron interactions
- Power reactor core (multiplication factor formulae)
- Reactor kinetics
- Spatial diffusion of neutrons
- Neutron distributions in reactors
- Thermal energy coupling
- Reactivity feedback
- Long-term reactor core behavior

**Grading:** for grading purposes the requirements for this course include

- Two midterm exams and a final exam (all closed book, closed notes)
- Homework every other week (total of 7).

Course Grading	Value
Midterm 1	20/100
Midterm 2	20/100
Final	15/100
Homework (7)	45/100

Letter Grade Scale	Value
A	92+
A-	87–91.9
B+	82–86.9
B	77–81.9
B-	72–76.9
C+	67–71.9
C	62–66.9
C-	58–61.9
D+	54–57.9
D	50–53.9
F	<50

**Learning outcomes:** Upon completion of this course, a student should be able to

1. Understand nuclear reactions and their energetics.
2. Calculate radioactive decay of nuclides.
3. Know how neutrons interact with matter through scattering and absorption.
4. Quantitatively assess neutron slow down.
5. Apply basic neutron balance law.
6. Understand the kinetics of neutron in single point reactors.

**Schedule (updated weekly):**

Week	Day	Date	Notebook	Assessment	Note
-	-	September	-	-	-
2	W	07Sep22	00/class notes	-	Syllabus/Thermal Neutron LB 2/SF 2
3	M	12Sep22	class notes	Homework 01 (due 26Sep22)	Thermal Neutron/Fission Reaction LB 3/SF 4, 6
3	W	14Sep22	class notes	-	Fission Reaction/Products LB 3/SF 4, 6

Week	Day	Date	Notebook	Assessment	Note
4	M	19Sep22	class notes	-	Fission Products/Decay LB 3/SF 5, 6
4	W	21Sep22	class notes	-	Radioactive Decay LB 3/SF 6, 7
5	M	26Sep22	class notes	Homework 02 (due 11Oct22)	Decay/Neutron Scattering LB 3/SF 6, 7
5	W	28Sep22	class notes	-	Microscopic Cross Section LB 3/SF 6, 7

Week	Day	Date	Notebook	Assessment	Note
-	-	October	-	-	-
6	M	03Oct22	class notes	-	Microscopic/Macroscopic Cross Section LB 3/SF 6, 7
6	W	05Oct22	class notes	-	Macroscopic Cross Section LB 3/SF 6, 7
7	M	10Oct22	No class	No class	Columbus day holiday
7	T	11Oct22	-	Midterm 1, Homework 03 (due 24Oct22)	(Monday schedule)
7	W	12Oct22	class notes	-	Macroscopic Cross Section LB 3/SF 6, 7
8	M	17Oct22	class notes	-	Classroom problem solving HW2 P.2
8	W	19Oct22	class notes	-	Classroom problem solving HW2 P.3
9	M	24Oct22	class notes	Homework 04 (due 07Nov22)	Cross Section Energy Dependency LB 3/SF 6, 7
9	W	26Oct22	class notes	-	Cross Section Energy Dependency LB 3/SF 6, 7
10	M	31Oct22	class notes	-	Classroom problem solving HW3/Midterm 1 P.4

Week	Day	Date	Notebook	Assessment	Note
-	-	November	-	-	-

Week	Day	Date	Notebook	Assessment	Note
10	W	02Nov22	class notes	Resubmission of Homework 2	Neutron Excitation Energy / Head-on Elastic Scattering Collision / Collision Probability Collision
11	M	07Nov22	class notes	Homework 05 (due 21Nov22), Resubmission of HW3/Midterm 1 P.4	Probability / Neutron Slowdown Decrement Neutron Distribution in Energy / Fuel and Moderators / Generation Factor $\eta$ AICHe/ANS meetings
11	W	09Nov22	class notes	-	AICHe/ANS meetings
12	M	14Nov22	no class	HW05	-
12	W	16Nov22	no class	HW05	Thanksgiving holiday
13	M	21Nov22	-	Midterm 2, Homework 06 (due 05Dec22)	Classroom problem solving: midterm 2
13	W	23Nov22	no class	-	Neutron Energy Spec- tra/Neutron Flux
14	M	28Nov22	class notes	-	
14	W	30Nov22	class notes	-	
Week	Day	Date	Notebook	Assessment	Note
-	-	December	-	-	-
15	M	05Dec22	class notes	-	Homework 04 classroom solution
15	W	07Dec22	class notes	-	Homework 05 classroom solution
16	M	12Dec22	class notes	-	Neutron Flux/Nuclear Heat Source/last day of classes
16/17	Th	15Dec22	-	Final Exam 6:30pm to 9:30pm Ball Hall 206	Comprehensive

## General Information

**Attendance:** Students are expected to attend all classes.

**Credit hour policy:** A credit hour requires a minimum of 2 hours of out-of-class student **deep work** per 1 hour of instructor-led course activity.

**Classroom/Online Conduct:** Students are expected to exhibit professional and respectful behavior that is conducive to a mutually beneficial learning environment in the classroom. Examples of inappropriate behavior include: text messaging, listening to music, cell phone use (other than the campus alert system), late arrivals, early departures, use of laptops for other than class purposes, disrespectful comments or behavior, intentional disruptions, failure to follow faculty directives, etc. Students in violation of these standards may be asked to leave class and/or be referred to the Dean of Students for disciplinary action.

**Academic Integrity:** Cheating and plagiarism will not be tolerated. A first offense will result in a failing grade for the assignment/exam in question and a formal filing with the Office of Provost according to the Academic Integrity Policy. A second offense could lead to a failing grade in the course, suspension or expulsion, as detailed in the policy, defined [here](#).

**Instructional Resources:** The Centers for Learning and Academic Support Services provide many tutoring resources; more details are available [here](#) Technology Resources: For a listing of available computing and software resources available to students, [visit here](#).

**Accommodations:** In accordance with University policy and the ADA, accommodations are provided for students with documented disabilities. If you have a disability, please contact the Office of Disability Services as soon as possible. Their office is in UC 220 (978-934-4574, Disability@uml.edu). Documentation of disability is confidential. Requests for accommodation for religious reasons should be directed to Equal Opportunity and Outreach at 978-934-3565, Wannalancit Mills, Suite 301.

**Counseling Services:** As part of the Wellness Center, Counseling Services at UMass Lowell provide mental health counseling, consultation and referrals to help students achieve personal and academic success. They also assist students in better understanding and coping with their feelings, relationships, and choices surrounding their academic success. [Visit](#) Veterans' Services: UMass Lowell is committed to helping our military students take full advantage of all the educational benefits available through the federal and state governments. For complete information on the services and resources available please visit our [website](#). University Cancellation Information: If campus is closed (most likely for weather), visit the website for announcements relevant to the class.