**NPRE 247, Section C**

**Modeling Nuclear Energy System**

Fall 2024

**Course Website:** <https://canvas.illinois.edu/courses/51523>

**Meeting time:** MWF, 10:00 pm – 10:50 am

(might use Zoom or Teams in case of sickness or emergency)

**Meeting Location:** 3117 Everitt Laboratory

**Credit Hours:** 3 (undergraduate)

**Prerequisites:** PHYS 211; some programming (CS 101), some differential equations (MATH 285), some linear algebra.

**Course Description**

Applications of elementary nuclear physics in nuclear engineering; nuclear reactor materials and components; steady-state and transient operation of nuclear reactors; nuclear energy removal and conversion; radiation shielding.

**Course Format**

In-class lectures, discussions, exams; take-home homework, quizzes, computer projects, reading assignment; anticipated time commitment of 6-9h per week outside of class.

**Instructor: Tomasz Kozlowski**

[txk@illinois.edu](mailto:txk@illinois.edu) (send message through MS Teams, avoid email)

111D Talbot Laboratory

**Teaching Assistant**

Samar Abdelkawy, [selsafy2@illinois.edu](mailto:selsafy2@illinois.edu) (message with MS Teams)

TBD Talbot Laboratory

**Office hours: Instructor** – 11am - 1pm after class, sometimes I have another meeting, send message on MS Teams to confirm if I’m available

**Samar** – Tu and Th 1 - 3pm, 131 Talbot Lab

**Course communication**

* Course announcements – sent through Canvas course group
* Discussion board – Canvas course group, Q&A on lectures, HW, CP, Exams, policy, and anything else course related
* Grade corrections – submit through Gradescope
* Direct message – use MS Teams, avoid email unless necessary
  + TAs and Instructors do not offer immediate round-the-clock support, you have to plan ahead
  + Past experience shows most of the questions could have been posted to discussion board or asked in class
  + **Lifehack**: Phrase questions such that they can be answered “Yes” or “No;” questions which require substantial response should be asked during lecture or office hours

**Required Text, Readings, and Materials**

1. *Fundamentals of Nuclear Science and Engineering*, 3rd ed., Shultis and Faw
2. *Chart of the Nuclides*, any ed., Knolls Atomic Power Laboratory (required)
   * <http://www.nuclidechart.com/xcart/home.php>
   * Any “peer reviewed” source of nuclear data is OK, e.g., textbooks, CoN, CRC Handbook, nuclear data centers, NIST, NEA, IAEA, …
   * <https://www.nndc.bnl.gov/> – USA nuclear data center, not user-friendly

**Course Assessment and Grading**

Grading will be based on an absolute scale (no curve, extra credit built-in) with the following criteria:

*3 Credit Hours (undergraduate):*

|  |  |
| --- | --- |
| Home assignments (HW + Quiz) | 10% |
| Computer projects (code, results, report) | 30% |
| Exams (2 in-class, 1 final) | 60% |
| **Total** | **100%** |

*Home assignments (HW, Quiz, CP)*

* All take-home assignments are individual, but you can work in small groups, each person has to submit individually
* HW (problem sets) typically due Monday (watch for exceptions!)
* Quiz (short problems) typically due Friday (watch for exceptions!)
* Submit pdf through Gradescope on the day assignment is due (by 11:59pm)
* Make sure the photo/scan quality is sharp, high contrast, straight, flat paper, cropped to page, uniform lighting, no shadows, no extra objects; imagine you had to submit it to your client at a nuclear company, would you submit it?
* Quality reduction: Q% reduction for poor quality (Q = 2 x semester week #)
* Late reduction: Dt%, where Dt = hours late (rounded up to the nearest integer)

*Exams*

* 2 in-class exams scheduled during class time, the final is scheduled by the University, it cannot be rescheduled unless it satisfies Student Code:

<http://studentcode.illinois.edu/article3/part2/3-201>

* All exams are cumulative; individual work; lowest exam grade is weighted 10%, middle grade is weighted 20%, the best grade is weighted 30%; if you don’t take the final, it will be assigned 0, lowest, so 10% of the grade
* You can bring one single-sided letter-size handwritten page with any formulas and notes you wish

Letter grades will be assigned as follows (lowest cut-off):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| A | 93.0% | B- | 80.0% | D+ | 67.0% |
| A- | 90.0% | C+ | 77.0% | D | 63.0% |
| B+ | 87.0% | C | 73.0% | D- | 60.0% |
| B | 83.0% | C- | 70.0% | F | 00.0% |

It is important that you understand and agree with the grade you receive on assignments and exams. If you would like to dispute your score, submit a regrade request through Gradescope. Check grade entries in Gradescope and report any corrections as soon as possible. You have 2 weeks to correct grades from the date the assignment was returned.

**Learning Objectives**

Upon completion of the course students will be able to:

* Principles of elementary nuclear physics used in nuclear engineering
* Knowledge of binary nuclear reactions behavior and energies
* Knowledge of radioactive decay behavior and energies
* Knowledge of reactor physics principles and constraints related to reactor design

**Required Software and Programming**

Basic programming skills are required, such as CS 101 or similar. Use of interpreted language, such as Julia, Python, Octave/MATLAB is recommended, but not required. If you stay in science and engineering, I [almost] guarantee it will pay off in your career.

**Web tools**

* Canvas – Course material, Announcements, Discussion board
* Gradescope – All home assignments (HW, Quiz, CP)
* <https://www.uiuc.chat/NPRE247-Fall-2024/chat> – AI chatbot (based on course material via LLM + RAG), it is very good but not perfect, use at your own risk!

**Learning Resources (and Googling)**

* Relevant course material is posted on Canvas, use of other “peer-reviewed” material encouraged; please share with the class what you found useful
* You can use web for general information about a topic, but confirm it by a real (“peer-reviewed”) reference, e.g., textbook, journal publication, lab/government report (DOE, NRC, …), international organization report (IAEA, NEA, …)

*Sidenote*: There are DOE, NRC, and international reports that are not peer-reviewed, but for the purpose of this class I’ll accept all of them as peer reviewed.

* Non-peer-reviewed sources (e.g., Wikipedia, ChatGPT, …) have to be backed up by a peer reviewed reference; Wikipedia is not considered a reference because it is not “peer reviewed”, it has wrong (misleading) info on reactor physics; ChatGPT (and similar) makes up info and data to satisfy your question
* Efforts are made to make sure UIUC.chat is correct, but its output is not peer-reviewed, it is your responsibility to confirm all information, if you use it directly, and it is wrong, it will be treated as if it was your own word/work
* If you are not sure if a source is considered “peer reviewed,” ask
* I found this to be a high-quality source of info, it is not “peer reviewed”, but it often provides peer-reviewed references <https://www.nuclear-power.com/>

**It is a joint effort to make this an enjoyable learning experience**

I will - hold in-person meetings

- encourage group work for all assignments (except Exams)

- hold open-door office hours (confirm “soft appointment” on MS Teams)

I ask you to - come to class

- read the textbook

- pay attention, ask questions, think critically

- challenge me if I say something wrong, we are not immune to mistakes!

***Course Schedule – Tentative***

**NPRE 247, Modeling Nuclear Energy System**

**Fall 2024**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Week** | **Day** | **Topic** | **Reading** | **Due date** |
| Aug 26  Aug 28  Aug 30 | M | Course info, Fundamental concepts (Ch. 1) | 1.1, 1.2, 1.3 |  |
| W | Modern physics concepts (Ch. 2) | 2.1, 2.2, 2.3, (2.4, 2.5) |  |
| F | Atomic and nuclear models (Ch. 3) | 3.1, 3.2 | Q |
| Sep 2  Sep 4  Sep 6 | M | --- (Labor Day) |  | Ch. 1, 2, 3 |
| W | Nuclear energetics (Ch. 4) | 4.1, 4.2 |  |
| F | Nuclear energetics (Ch. 4) | 4.3, 4.4 | Q |
| Sep 9  Sep 11  Sep 13 | M | Nuclear energetics (Ch. 4) | 4.5, 4.6 | Q |
| W | Nuclear energetics (Ch. 4) | 4.7, 4.8 |  |
| F | Radioactivity (Ch. 5) / ppt | 5.1, 5.2, (5.3), ppt | Q |
| Sep 16  Sep 18  Sep 20 | M | Radioactivity (Ch. 5) | 5.4, 5.5, 5.6 | Ch. 4 |
| W | Radioactivity (Ch. 5) | 5.7, 5.8, 5.9 |  |
| F | Radioactivity (Ch. 5) | lecture | Q |
| Sep 23  Sep 25  Sep 27 | M | CP1 / finite difference method | lecture | Ch. 5 |
| W | Open/Review |  |  |
| F | **In-class Exam 1** |  |  |
| Sep 30  Oct 2  Oct 4 | M | Binary nuclear reactions (Ch. 6) | 6.1, 6.2, 6.3, (6.4) | Q |
| W | Binary nuclear reactions (Ch. 6) | 6.1, 6.2, 6.3, (6.4) |  |
| F | Binary nuclear reactions (Ch. 6) | 6.5, 6.6 | Q |
| Oct 7  Oct 9  Oct 11 | M | Binary nuclear reactions (Ch. 6) | 6.5, 6.6 | CP1 (decay) |
| W | Binary nuclear reactions (Ch. 6) | 6.7 |  |
| F | Binary nuclear reactions (Ch. 6) | 6.7 | Q |
| Oct 14  Oct 16  Oct 18 | M | Exam 1 review |  | Ch. 6 |
| W | Radiation interaction with matter (Ch. 7) | 7.1, 7.2 |  |
| F | Radiation interaction with matter (Ch. 7) | 7.3 | Q |
| Oct 21  Oct 23  Oct 25 | M | Radiation interaction with matter (Ch. 7) | 7.4 | Q |
| W | Radiation interaction with matter (Ch. 7) |  |  |
| F | Reactor materials, fuel, mod. prop. (Ch. 10) | 10.1, ~~10.2~~, 10.3 | Q |
| Oct 28  Oct 30  Nov 1 | M | Reactor materials, fuel, mod. prop. (Ch. 10) | 10.1, ~~10.2~~, 10.3 | Ch. 7 |
| W | Open/Review |  |  |
| F | **In-class Exam 2** |  |  |
| Nov 4  Nov 6  Nov 8 | M | Neutron balance and criticality / CP2 | lecture | Q |
| W | Neutron balance and criticality / CP2 | lecture |  |
| F | Neutron life cycle, 6-factor formula (Ch. 10) | 10. 4, 10.5, 10.6 | Q |
| Nov 11  Nov 13  Nov 15 | M | Neutron life cycle, 6-factor formula (Ch. 10) | 10. 4, 10.5, 10.6 | Ch. 10a |
| W | Exam 2 review |  |  |
| F | Reactivity feedback (Ch. 10) | 10.8 | Q |
| Nov 18  Nov 20  Nov 22 | M | Reactivity feedback (Ch. 10) | 10.8 | CP2 (eigenval.) |
| W | Fission product poison (Ch. 10) | 10.9 |  |
| F | Fission product poison (Ch. 10) | 10.9 | Q |
| Nov 25  Nov 27  Nov 29 | M | --- (Fall beak) |  |  |
| W | --- (Fall break) |  |  |
| F | --- (Fall break) |  |  |
| Dec 2  Nov 4  Dec 6 | M | Simulator lab | lecture | Q |
| W | Neutron Diffusion and Moderation (Ch. 10) | 10.10, lecture |  |
| F | Neutron Diffusion and Moderation (Ch. 10) | 10.10, lecture | Q |
| Dec 9  Dec 11  Dec 13 | M | Ethics and nuclear accidents / ppt | ppt | Ch. 10b |
| W | Open/Review |  | CP3 (simulator) |
| F | --- (Finals begin) |  |  |

CP1 – Radioactive decay

CP2 – Eigenvalue/eigenvector

CP3 – simulator, moderator feedback