Nuclear Engineering 101/210M
Nuclear Reactions and Radiation
Spring Semester 2021
Version 1.0 (1/20/21)

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Lectures take place **Mondays, Wednesdays, and Fridays, 1:00-2:00 PM via Zoom**. The discussion section takes place on Fridays from **2:00-3:00 PM via Zoom**.

You will need to register in advance for the lectures at the following link:
https://berkeley.zoom.us/meeting/register/tJYuduuprDojHNfrgyhIKnxtsKD8-CC4HAks

After registering, you will receive a confirmation email containing information about joining the meeting.

Text: *Introductory Nuclear Physics*, by K. Krane.

Course prerequisite is Physics 7C or equivalent.

Learning Objectives

The goal of the course is to provide nuclear engineers and scientists with a broad overview of the physics concepts behind nuclear science and technology. Students will be given the fundamental tools needed to understand the nucleus as a quantum mechanical system. Examples from applied nuclear science and engineering will be used to demonstrate nuclear physics topics including:

- Nuclear properties and radioactive dose
- Nuclear structure (liquid drop model, properties of low-lying states, capture resonances)
- Alpha- beta- and gamma-decay
- Actinide fission, including prompt and delayed particle emissions
- Low-energy (< 20 MeV) neutron- and charged-particle-induced nuclear reactions
- Interaction of radiation with matter

- Applications (Radiation detection, astrophysics, fusion energy systems, radioisotope production)

In addition to these technical goals, students in NE101/210M **will gain an understanding of the following in support of the ABET requirements**

- What is needed to design, carry out and analyze successful nuclear science experiments;
- Contemporary issues in nuclear science and engineering, including nuclear medicine, nuclear nonproliferation and novel nuclear energy systems;
- What is needed to work as a part of a multidisciplinary team (particularly for NE210M students);
- The professional and ethical responsibilities of nuclear engineers.

Inclusivity and a Safe Environment

Every student has the right to learn, regardless of race, color, religion, creed, sex, sexual orientation, gender identity, national origin, ancestry, age, veteran status, disability, genetic information, military service, or other protected status. The teaching team will always strive to make every student feel welcome and safe in the learning environment. All students will treat each other with respect and abide by the UC Berkeley Student Code of Conduct (http://sa.berkeley.edu/code-of-conduct). The teaching team will not tolerate behavior that creates a hostile or unsafe learning environment for any of the students.

Homework Policy

- Homework is due one week after it is assigned.
- Late homework decays in value according to an exponential curve with a half-life of 1 day.
- Late homework has no value after solutions are posted, no exceptions.
- Homework extensions will be granted only for documentable illness, emergencies, and academic conflicts.
- Typed homework may be turned in on bCourses or at lecture. Handwritten homework must be turned in by the lecture time, no exceptions. Handwritten homework not turned in at lecture on time will lose value until turned in. Handwritten homework that is digitally written must still be turned in at lecture.
- Students may tutor each other. **Sharing/verifying answers in any way is strictly prohibited.**
- Homework will be graded and returned within two weeks of the due date.
- Each student will be given one and only homework drop. This dropped homework will not factor into the student's grade.

Exam Policy

- We understand that a timed written exam can in some cases provide an inaccurate assessment of a student's knowledge of the topic. Therefore, we will allow students who perform at the D level (approximately 1.5 standard deviations below average) to take a short oral exam with two members of the teaching team. The team will reach out to students who meet these criteria within 1 week after the exam to schedule the oral

exam. The oral could increase the student's grade to a B maximum.
- Exam dates are set in this syllabus and will take place in class during the Friday lecture/discussion.
- Students with DSP testing accommodations should contact the Instructor/GSI as soon as possible to set up these accommodations in advance.
- Students without DSP testing accommodations must take the exam at the designated date and time in the designated location. Exceptions will only be granted for documentable illness, emergencies, and academic conflicts. Those with illness or academic conflicts should contact the Instructor/GSI as soon as possible; last-minute notification may not be able to be accommodated.
- **The final exam date is May 11, 2021, 8-11am. A Zoom link will be provided.**

Grading Policy

The NE101 (undergraduate-level) course grade will be based on:

Homework (25%)
Two in-class exams (20% ***each***, 40% total)
Final exam (35%)

The NE210M (graduate mezzanine level) course grade will be based on:

Homework (20%)
Two in-class exams (20% ***each***, 40% total)
Final exam (20%)
Laboratory practical experiment and report (20%)

- This class will be graded on separate curves for PhD/MS, MEng, and undergraduate students.
- Homework and homework solutions are written by the GSI. Homework is graded by the readers.
- Homework re-grades will be directed to the readers. Homework re-grade disputes will be referred to the GSI/Instructor by the readers.
- Exams will be graded by the Instructor, the GSI, and the readers. Exam re-grades will be directed to the individual that graded the section/problem. Exam re-grade disputes will be referred to the Instructor.

210M Laboratory Practical Experiment

210M students will analyze data from a nuclear physics experiment. A manuscript style lab report will be written and submitted for feedback. After the feedback is returned, the student may re-write their lab report for a better grade. The lab will be conducted sometime after the first exam and will be scheduled, conducted, and graded by the GSI. The purpose of this lab is to given MEng students practical laboratory experience and peer-reviewed writing experience. While students work together on the laboratory experiment, each student must write their own report.

Office Hours

I think that the best learning occurs during office hours. Make sure to use them!

Instructor – Dr. Lee Bernstein – 11:30 AM-12:30 PM Mondays via Zoom and by appointment.
GSI – Austin Mullen –Monday 2:00pm-3:00pm & Wednesday 3:30pm to 4:30pm via Zoom.
Reader – Alex Ungar – 11:00 AM - 12:00 PM Fridays via Zoom.
The reader may choose to host office hours but is not required to do so.

- Instructor office hours are primarily for the discussion of nuclear physics topics. Homework questions should be taken to GSI/reader office hours.
- In order to maintain fairness to all students, the GSI/readers will not offer individual tutoring or office hours. Students may request to meet with the GSI/readers about private matters (DSP status, re-grading, illness, etc.) but homework questions will not be entertained during these individual meetings.
- Office hours may be moved to accommodate as students as possible. Office hours are also subject to change based on Instructor/GSI schedules. Changes to office hours will be announced on bCourses.

Discussion Section and Review Sessions

The discussion section will be led by the GSI. While attendance is not mandatory, it is strongly encouraged. A rough outline of the discussion section content is as follows:

- review of homework with a focus on commonly missed concepts
- supplementary material for the week's lecture material
- questions from students on concepts they want fielded

If a student would like the discussion section to cover a specific topic or concept, they are encouraged to notify the GSI of this via email.

Review sessions will be scheduled before both midterm exams and the final. Session times will be chosen to accommodate as many students as possible. These review sessions will cover brief review of the concepts and example problems. Attendance is optional but recommended.

Teaching Team Evaluations

The teaching team may occasionally ask students for anonymous feedback through online surveys. Please fill out these surveys, the teaching team takes them seriously and listens to your feedback. The tentative plan is to send out an anonymous survey after the first discussion section and after the first midterm. Students are strongly encouraged to fill out the university distributed end-of-semester course evaluations; the teaching team takes these very seriously and uses this feedback to guide future course plans. Students are also encouraged to bring feedback to the teaching team throughout the semester as need be.

Academic Integrity

"The high academic standard at the University of California, Berkeley, is reflected in each degree that is awarded. As a result, every student is expected to maintain this high standard by ensuring that all academic work reflects unique ideas or properly attributes the ideas to the

original sources. Individual departments often have their own ways of citing and attributing work, so it is the responsibility of each student to seek that information out if it is not otherwise provided through a syllabus, course website, or other means."
(http://sa.berkeley.edu/conduct/integrity)

Cheating of any kind will not be tolerated. Infractions will be reported to the UC Berkeley Center for Student Conduct (http://sa.berkeley.edu/conduct).

ADA and DSP Accommodations

"No one, on the basis of their disability, may be excluded from participation in, be denied the benefits of, or otherwise be subjected to discrimination under any UC Berkeley program or activity. The ADA (Americans with Disabilities Act)/504 Compliance Officer is responsible for ensuring that the policies and procedures developed by the campus comply with federal, state, and University requirements. The ADA/504 Compliance Officer serves as a resource to those with disabilities who believe that they are not receiving appropriate accommodations or that they are being treated in a discriminatory manner. In addition, the ADA/504 Compliance Officer may set aside or modify an accommodation that is under dispute."
(https://compliance.berkeley.edu/responsibilities-guide/disability-services)

The teaching team will take all necessary steps to ensure the classroom and course-related activities are ADA accessible. Please contact the teaching team with any concerns with regard to this.

The UC Berkeley Disabled Students' Program (DSP) (http://dsp.berkeley.edu) provides students with disabilities accommodations to ensure equal opportunity in the classroom. The policy of the university is that testing and teaching accommodations may only be provided to students with a DSP certified Letter of Accommodation. Students with DSP accommodations are encouraged to contact the teaching team as soon as possible to arrange their accommodations. Students with disabilities that have not been provided a Letter of Accommodation by DSP and encouraged to contact DSP as soon as possible, the teaching team can only provide interim accommodations if allowed to do so by DSP.

FERPA and Privacy

"Under the Federal Family Educational Rights and Privacy Act of 1974 (FERPA) and provisions of state law relating to public records disclosure, the University of California Policies Applying to the Disclosure of Information from Student Records and the Berkeley Campus' implementation of that policy assure Berkeley students the following rights:
1. To inspect and review their student records.
2. To have withheld from public disclosure, absent their prior consent, personally identifiable information from their student records.
3. To inspect records maintained by campus offices concerning disclosure of confidential information from their student records.
4. To seek corrections of their records through a request to amend the records, or a request for a hearing to challenge the content of their records, or to include a written statement therein.

5. To file complaints with the Office of the Chancellor or with the U.S. Department of Education regarding violations of the rights accorded by federal law or University policy. Campus policy defines "public records" which may be released without prior student consent, describes the record access rights of applicants who have not been admitted or enrolled at the Berkeley campus, and describes the conditions under which students may waive the right of access to their records." (http://registrar.berkeley.edu/academic-policies-procedures/ferpa)

The teaching team takes very seriously the FERPA protections of students. The teaching team will not comply with third party requests for student grades, records, or information. If students have any FERPA related concerns they may contact the teaching team or the UC Berkeley Office of the Registrar.

Students may contact the teaching team about personal issues related to course performance. The teaching team will do its best to maintain the confidentiality of this information. However, students should be aware that the teaching team is legally required to report Title IX violations (such as sexual violence and harassment) to the Office of Prevention of Harassment and Discrimination.

Sexual Violence and Harassment

The teaching team will not tolerate behavior that creates a hostile or unsafe environment for any of the students. The teaching team is legally required to report Title IX violations (such as sexual violence and harassment) to the Office of Prevention of Harassment and Discrimination.

Students that have been the victim of sexual harassment or violence should consult the following resources:

Confidential resources:

- **The Confidential Care Advocate** [For 24-hour hotline (510) 643-2005; for scheduling appointments (510) 642-1988]
- **The Social Services branch of the Tang Center** [(510) 642-6074; (855) 817-5667 after-hours emergency]

Non-confidential resources:

- **The UC Police Department** [911 or (510) 642-3333].
- **The Office of the Prevention of Harassment and Discrimination** (OPHD) [(510) 643-7985]
- **The Gender Equity Resource Center** (http://ejce.berkeley.edu/)

bCourses

Lecture materials will be placed on bCourses either before or soon after each class. A recorded version of the lecture, including both audio the full PowerPoint presentations, will be posted on the web one week after they are given. Homework solutions will be posted on bCourses after the due date. Essential course communications will be posted to bCourses, so be certain to check bCourses frequently (at the very least once a day).

Professional Boundaries

- The Instructor, GSI, and readers seek to maintain a professional relationship with the students.
- Members of the teaching team will always strive to treat every student with respect and similarly students should respect the teaching team.
- Romantic/sexual relationships between members of the teaching team and students are prohibited.
- All course-related contact from students should be conducted using the teaching team's emails listed in this syllabus.
- Social media requests from members of the teaching team will not be sent to students.
- Students should not send social media requests to members of the teaching team; such requests will not be entertained until after final grades have been submitted.
- Students with existing social media connections to the teaching team may not use those connections to contact the members with course related questions or issues. Such contact could give an unfair advantage to those students and as such the teaching team will refuse contact of this nature.

Mental Health Resources

Individual Counseling - Located in University Health Services (UHS), Tang Center
2222 Bancroft Way
510-642-9494
http://uhs.berkeley.edu/students/counseling
Counseling and Psychological Services (CPS) provides brief counseling to students with personal, academic and career concerns. Professional counselors can meet with students to talk about a number of concerns such as adjusting to school, deciding on a career or major, dealing with family or relationship issues, and coping with personal crises. All undergraduate and graduate students are eligible for CPS services, regardless of their insurance coverage.

Look for the Signs: Depression, Suicide, and How to Help
http://uhs.berkeley.edu/lookforthesigns

Suicide Prevention at Cal — UHS Tang Center
http://uhs.berkeley.edu/students/counseling/suicideprevention.shtml

Be Well to Do Well
http://uhs.berkeley.edu/bewell/

Schedule of Lectures and Reading Assignments

Date	Lecture	Week	Lecture Topics	Reading	Homework
Wed Jan 20	1	1	Introduction/Overview	Ch. 1	
Fri Jan 22	2		Nuclear Mass, Mass defect		
			Bethe-Wesizäcker	Ch. 3, secs. 2, 3	
Mon Jan 25	3	2	Bethe-Wesizäcker/Relativity		HW 1 Assigned
Wed Jan 27	4		Radioactive decay – Part 1	Ch. 6, secs. 1, 3-8	
Fri Jan 29	5		Radioactive decay/Dating		
Mon Feb 1	6	3	Radioactive Dose		HW 1 due, HW 2 assigned
Wed Feb 3	7		Quantum Mechanics #1	Ch. 2	
Fri Feb 5	8		Quantum mechanics #2		
Mon Feb 8	9	4	Quantum mechanics #3	Ch. 3, secs. 1, 3, 4, 6	HW 2 due, HW 3 assigned
Wed Feb 10	10		Nuclear Force/Particle Physics	Ch. 18 (optional)	
Fri Feb 12	11		Nuclear Structure #1	Ch. 5, sec. 1	
Mon Feb 15		5	*No Class – President's Day*		HW 4 assigned
Wed Feb 17	12		Nuclear Structure #2	Ch. 5, secs. 2-3	HW 3 due
Fri Feb 19	13		Nuclear Structure #3		
Mon Feb 22	14	6	Nuclear Rotation		HW 4 due, HW 5 assigned
Wed Feb 24	15		Alpha Decay #1		
Fri Feb 26			**First Exam**		
Mon Mar 1	16	7	Alpha Decay #2	Ch. 6, sec. 2, Ch. 8	
Wed Mar 3	17		β-decay #1 - General Info	Ch. 9	HW 5 due, HW 6 assigned
Fri Mar 5	18		β-decay #2 – Excited States	Ch. 10	
Mon Mar 8	19	8	Gamma Decay #1	Ch. 10	
Wed Mar 10	20		Gamma Decay #2		HW 6 due, HW 7 assigned
Fri Mar 12	21		Applications of Decay *(β-delayed n in reactors, medical applications*)		

Mon Mar 15	22	9	EM Int. w/matter	Ch. 7, sec. 1	
Wed Mar 17	23		Nuclear Reactions #1	Ch. 11, secs. 4-7, 9-12	HW 7 due, HW 8 assigned
Fri Mar 19	24		Nuclear Reactions #2	Ch. 12, secs. 1-5	
		Mon Mar 22 - Fri Mar 26		*SPRING BREAK - NO CLASSES*	
Mon. Mar 29	25	10	Nuclear Reactions #3		
Wed. Mar 31	26		Nuclear Reactions #4		HW 8 due, HW 9 assigned
Fri. Apr 2	27		Reactions #5/(n,x)		
Mon. Apr 5	28	11	Fission #1	Ch. 13, secs. 1-4	
Wed. Apr 7	29		Fission #2		
Fri. Apr 9			**Second Exam**		
Mon. Apr 12		12	*Review of Fission and Reactions*		
Wed. Apr 14	30		***Neutronics with Darren!***	Ch 13, secs. 5-9	HW 9 due, HW 10 assigned
Fri. Apr 16	31		Nuclear Reactors		
Mon. Apr 19	32		Nuclear Weapons	Ch 14, Addt'l material on bcourses	
Wed. Apr 21	33	13	Nuclear Data Pipeline	Nuclear Data Review Article	
Fri. Apr 23	34		Nuclear Detectors	Ch. 7, sec. 2-6	HW 10 due, HW 11 assigned
Mon, Apr 26	35		Medical Isotope Production		
Wed, Apr 28	36		Nuclear Astrophysics	Ch. 19, sec. 3-6	HW 11 due
Fri, Apr 30			Course review (IOU all a tour of the 88-Inch Cyclotron!)		
Mon. May 3-7		16	**(RRR Week) – No class**		

*An optional course review will be scheduled sometime during RRR week.

May 12 8:00-11:00 AM Final Exam