

**ENG PHYS 3D03**  
**Principles of Nuclear Engineering**  
Winter 2021  
Course Outline

**CALENDAR/COURSE DESCRIPTION**

The course will start on Monday, January 11, 2021.

Lecture: Zoom (Mon, Wed, Thu) 13:30pm - 14:20pm.

Gain the same knowledge of nuclear engineering being taught to 3<sup>rd</sup> level nuclear engineering students in the top ranked universities in the world through lecture, lab, and self-oriented learning.

In this course, you will be investigating the system-level interdependence between nuclear technology and its human-system contexts. The inquiry activities will prompt you to develop multi-dimensional solutions that are aligned with the sustainability focus of engineering at McMaster.

Since it is important for educators and students to understand these complex learning processes, we continue a research project on inquiry learning and multidisciplinary knowledge integration. Students will be invited to participate in questionnaires and focus group interviews with a small extra participation mark towards the course. Participation is optional. More details will be presented in class by a researcher.

**PRE-REQUISITES AND ANTI-REQUISITES**

Prerequisite(s): N/A

Antirequisite(s): N/A

In order to master the knowledge and skills of basic nuclear engineering that will enable students to compete with the nuclear engineering students in the world in their near future, instructors recommend students to also take 3O04, 4D03, 4NE3, 4P03, 4 PP3 and 4UN2.

**INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION**

**Dr. S. Nagasaki**  
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**Office Hours:**  
By appointment

Laboratory Supervisor  
**Mr. Denis Melanson**  
meland2@mcmaster.ca

**Office Hours:**  
By appointment

**TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION**

Stephanie Bysice  
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**Office Hours:**  
By appointment

**COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION**

<http://avenue.mcmaster.ca/>

**COURSE OBJECTIVES**

A successful student will be able to do the following by the end of the course:

- Conceptualize and explain the fundamental physical phenomena and processes relevant to nuclear reactors.
- Describe and explain the fundamental physical and chemical processes relevant to nuclear fuel cycle and radioactive waste management. (Expected to apply this knowledge in 4<sup>th</sup> year)
- Understand the physics, chemistry, and biology of radiation, interaction of radiation with matter (including human body), and fundamentals of radiation detection. Apply these physics, chemistry, and biology principles to design radiation shielding (labs & assignment).
- Construct systems architecture of how nuclear power plants are designed and operated and how the safety of a nuclear power plant is secured.
- Design and conduct an inquiry project, integrating ethical and social dimensions in the analyses of a nuclear engineering topic of choice (part of ELSA).

**Note:** Many students may have to create and/or hunt for jobs outside of Canada. CANDU is a unique and excellent reactor, but it is minor in the world market. So, in this course, students will mainly learn the nuclear engineering related to BWRs and PWRs. More about CANDU reactors will be taught in the last part of the course.

**MATERIALS AND FEES**

**Required Texts:**

- Introduction to Nuclear Reactor Theory, by John R. Lamarsh.

This is sold at the university book store, and also available at <http://www.ans.org/store/item-300030/>.

This is also available in the university library.

This is an expensive book, but all nuclear stream students in the world read this.

- Other materials students are recommended to study will be posted in Avenue to Learn.

**Calculator:**

Only the McMaster Standard Calculator (the Casio FX-991 MS or MS Plus calculator) will be permitted in examination. These are available at the Campus Store.

**Other Materials for your further studies:**

- M. Benedict, T. H. Pigford, H. Levi, Nuclear Chemical Engineering, McGraw-Hill (1981).

- G. F. Knoll, Radiation Detection and Measurement, Wiley (2010).

Students can have a lot of information from the WWW sites of International Atomic Energy Agency, American Nuclear Society, Canada Nuclear Society and other international organizations (e.g. OECD, Canada-CNSC, Canada- CAN, OPG, US-NRC, NEI, WANO, EPRI etc.) and academic societies.

## COURSE OVERVIEW

**Schedule may change. New schedule is announced in AtoL.**

Lectures will be conducted by zoom.

1/6/W

### Radiation decay

1/11/M [Guidance & Group Inquiry Learning \(grouping/confirmation\)](#); Stability of nucleus

1/13/W Radiation decay 1

1/14/Th Radiation decay 2

### Reactor Physics

1/18/M Interaction of neutron with matter

1/20/W Fission reaction and chain reaction, Diffusion of neutron

1/21/Th Neutron Moderation with/without Absorption

1/25/M Fermi theory in reactor 1

1/27/W Fermi theory in reactor 2

1/28/Th [Presentation of team study \(progress results; 2 min presentation; one-page PPT\)](#)

2/1/M Multi-regional reactor 1

2/3/W Multi-regional reactor 2

### Reactor Kinetics

2/4/Th Reactor kinetics (Point reactor kinetics) 1

2/8/M Effect of temperature on reactivity

2/10/W Reserved for Make-Up

### Reactor Design

2/11/Th Burn-up and reactivity control

2/15-19 Mid-term Recess

2/22/M Reactor design BWR and PWR1

2/24/W [Presentation of team study \(progress results; 2 min presentation; one-page PPT\)](#)

2/25/Th Reactor design BWR and PWR2

### Nuclear Material, Nuclear Fuel Cycle & Radioactive Waste Management

3/1/M Radiation Damage, Basics of nuclear fuel

3/3/W Enrichment & Reprocessing

3/4/Th Radioactive Waste Management

### **CANDU (Dr. Victor Snell)**

- 3/8/M Design of CANDU reactor system
- 3/10/W Safety of CANDU
- 3/11/Th Future of CANDU

### **Health Physics (Mr. Derek Cappon)**

- 3/15/M Health Physics 1
- 3/17/W Health Physics 2
- 3/18/Th Reserved for Make-Up

### **Presentation of Team Study**

- 3/22/M Presentation 1
- 3/24/W Presentation 2
- 3/25/Th Presentation 3
- 3/29/M Presentation 4
- 3/31/W Presentation 5
- 4/1/Th Presentation 6
- 4/5/M Presentation 7
- 4/7/W Presentation 8
- 4/8/Th Reserved for Make-Up

### **Laboratory Schedule**

Each of the laboratory experiments occurs over a single 3-hour session. Experiments begin at 2:30pm. **Attendance and completion of each laboratory experiment and submission of all lab reports are mandatory.** Details of Labs will be explained in the guidance. The laboratory manual is available on Avenue to Learn.

If the labs are conducted by online style, the lab videos will be posted on AtoL. Students will be required to access the video and zoom on time. TAs will check the attendance. At the last of lab, TAs will provide the data only for the attendance.

### The followings are **Tables for Neutron Activation Analysis**

**Table 1** – Neutron Activation Properties of Isotopes in Nature

[http://www3.sympatico.ca/bdiacon/Table\\_1\\_Properties\\_of\\_Isotopes.htm](http://www3.sympatico.ca/bdiacon/Table_1_Properties_of_Isotopes.htm)

**Table 2** – Neutron Activation Properties of Isotopes Useful in Neutron Activation Analysis

[http://www3.sympatico.ca/bdiacon/Table\\_2\\_Isotopes\\_Useful\\_for\\_NAA.htm](http://www3.sympatico.ca/bdiacon/Table_2_Isotopes_Useful_for_NAA.htm)

**Table 3** – Gamma Ray Energy Peaks& Intensities Arranged by Increasing Energy

[http://www3.sympatico.ca/bdiacon/Table\\_3\\_Gamma\\_Rays\\_Arranged\\_by\\_Energy.htm](http://www3.sympatico.ca/bdiacon/Table_3_Gamma_Rays_Arranged_by_Energy.htm)

**Table 4** – Gamma Ray Energy Peaks& Intensities Arranged by Increasing Half-Life

[http://www3.sympatico.ca/bdiacon/Table\\_4\\_Isotopes\\_Arranged\\_by\\_Half-Life.htm](http://www3.sympatico.ca/bdiacon/Table_4_Isotopes_Arranged_by_Half-Life.htm)

**Table 5** – Thorium Decay Series Arranged by Increasing Energy

[http://www3.sympatico.ca/bdiacon/Table\\_5\\_Thorium\\_Decay\\_Series.htm](http://www3.sympatico.ca/bdiacon/Table_5_Thorium_Decay_Series.htm)

**Table 6** – Uranium Decay Series Arranged by Increasing Energy

[http://www3.sympatico.ca/bdiacon/Table\\_6\\_Uranium\\_Decay\\_Series.htm](http://www3.sympatico.ca/bdiacon/Table_6_Uranium_Decay_Series.htm)

<b>ASSESSMENT</b>
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Component	Weight
Assignments (total 5 assignments)	15% (3% per assignment)
Lab. Reports	30%
Group Study	25% 2% per progress presentation (2min) x 2 15% final presentation 6% final report
Final Exam	30%
<b>Total</b>	<b>100%</b>

Attendance in the lecture (**except Laboratories and final presentation**) is not checked.

The progress and final presentations, the full attendance during final presentation (8 days), submission of progress memos, the questions to other group's presentation at final presentation, and the final report are required for the grade of Group Study. Details will be explained in the 1<sup>st</sup> class.

Final Exam is mandatory. If a student does not take the Final Exam, he/she must be failed.

**Assignments:**

Assignments will be posted on Avenue to Learn. Assignments received after the deadline (one week) will not be graded.

**Group Study:**

4 - 5 students/group. Two progress presentations (2 min using one-page PPT), two progress memos (one page), final presentation (15 min) and final report are required. The oral presentation material by PPT or PDF file for final presentation should be submitted in advance. Details will be explained in the class.

The grade will be evaluated by rubrics, the presentation and the questions & answers, and the report. One presentation and one report per group.

**Each group decide its own subject on nuclear energy system in 21<sup>st</sup> century, and conduct the self-oriented/self-directed study from the viewpoint of environmental, economic and societal sustainability.**

**Potential topics:**

- (i) feasibility of implementation of nuclear power station in Alberta,
- (ii) possibility of export of CANDU reactor to India,
- (iii) reality of reprocessing/Pu use in Canada,
- (iv) why 22 municipalities in Canada have expressed their interest to host the used nuclear fuel repository, and
- (v) contribution of nuclear energy to the best energy mix in Australia, for example.

**Laboratory:**

The labs will be scheduled with the Laboratory Supervisor. In the event that labs become unavailable for any reason, virtual data will be supplied to each student so that the lab reports can be completed. Details will be explained in the

first lecture. **On-time attendance will be required.** A late penalty of 10% per delay will be deducted from the laboratory report mark. Delay for more than 1 hour without any reasonable reason is not admitted.

Laboratory reports will be due within two weeks following completion of each laboratory to the Drop Box on Avenue to Learn (one week of Winter Break is not included in the two weeks); a late penalty of 15% per day will be deducted.

**Attendance and Laboratory reports to all Labs required are mandatory.**

Students are reminded of the university policy on academic dishonesty related to assignment and laboratory work. In addition to the pursuit of knowledge, all labs have the goal of teaching students the craft of properly writing an experimental laboratory report.

### MSAF

If you submit the MSAF, you will have **three (3) extra days** to due date of Assignment/Lab report. The weight of assignment and Lab report does **not transfer** to Final Exam.

## ACCREDITATION LEARNING OUTCOMES

The Learning Outcomes defined in this section are measured for accreditation purposes only, and will not be directly taken into consideration in determining a student's actual grade in the course.

Outcomes	Indicators
<b>1. Understand the fundamental physics, chemistry, biology and mathematics relevant to design and manage the nuclear reactor, nuclear fuel cycle and radioactive waste management.</b>	1.4 Assignment, Lab. Report
<b>2. Understand the relationship between nuclear technology and global society.</b>	1.4 Group Study
<b>3. Demonstrate the ability to apply the knowledge on nuclear science and engineering relevant to nuclear engineering to design the nuclear power systems.</b>	4.2 Assignment, Lab. Report
<b>4. Demonstrate the ability to integrate the knowledge on nuclear science and engineering with safety criteria and regulations</b>	4.6 Assignment, Group Study
<b>5. Critically evaluate and apply knowledge and skills procured through self-directed and self-identified sources.</b>	12.1 Group Study

For more information on Accreditation, please visit: <https://www.engineerscanada.ca>

## ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of

credit with a notation on the transcript (notation reads: “Grade of F assigned for academic dishonesty”), and/or suspension or expulsion from the university.

It is your responsibility to understand what constitutes academic dishonesty. For information on the various types of academic dishonesty please refer to the Academic Integrity Policy, located at <http://www.mcmaster.ca/academicintegrity>

The following illustrates only three forms of academic dishonesty:

1. Plagiarism, e.g. the submission of work that is not one’s own or for which other credit has been obtained.
2. Improper collaboration in group work.
3. Copying or using unauthorized aids in tests and examinations.

#### ACADEMIC ACCOMMODATIONS

Students who require academic accommodation must contact Student accessibility Services (SAS) to make arrangements with a Program Coordinator. Academic accommodations must be arranged for each term of study. Student Accessibility Services can be contact by phone at 905.525.9140 ext. 28652 or e-mail at [sas@mcmaster.ca](mailto:sas@mcmaster.ca). For further information, consult McMaster University’s Policy for [Academic Accommodation of Students with Disabilities](#).

#### NOTIFICATION OF STUDENT ABSENCE AND SUBMISSION OF REQUEST FOR RELIEF FOR MISSED ACADEMIC WORK

1. The [McMaster Student Absence Form](#) is a self-reporting tool for Undergraduate Students to report absences DUE TO MINOR MEDICAL SITUATIONS that last up to 3 days and provides the ability to request accommodation for any missed academic work. Please note this tool cannot be used during any final examination period.
2. You may submit a maximum of 1 Academic Work Missed request per term. It is YOUR responsibility to follow up with your Instructor immediately (NORMALLY WITHIN TWO WORKING DAYS) regarding the nature of the accommodation. Relief for missed academic work is not guaranteed.
3. If you are absent for reasons other than medical reasons, for more than 3 days, or exceed 1 request per term you MUST visit the Associate Dean's Office (JHE/H301). You may be required to provide supporting documentation.
4. This form must be submitted during the period of absence or the following day, and is only valid for academic work missed during this period of absence.
5. It is the prerogative of the instructor of the course to determine the appropriate relief for missed term work in his/her course.
6. You should expect to have academic commitments Monday through Saturday but not on Sunday or statutory holidays. If you require an accommodation to meet a religious obligation or to celebrate an important religious holiday, you may submit the Academic Accommodation for Religious, Indigenous and Spiritual Observances (RISO) Form to the Associate Dean’s Office. You can find all paperwork needed here: <https://www.eng.mcmaster.ca/programs/academic-advising>

#### NOTICE REGARDING POSSIBLE COURSE MODIFICATION

The instructor and university reserve the right to modify elements of the course during the term. The university may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes. It is the responsibility of the student to check their McMaster email and course websites weekly during the term and to note any changes.

#### TURNITIN.COM STATEMENT

In this course we will be using a web-based service (Turnitin.com) to reveal plagiarism. Students will be expected to submit their work electronically to Turnitin.com and in hard copy so that it can be checked for academic dishonesty. Students who do not wish to submit their work to Turnitin.com must still submit a copy to the instructor. No penalty will be assigned to a student who does not submit work to Turnitin.com. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, etc.). To see the Turnitin.com Policy, please go to <http://www.mcmaster.ca/academicintegrity/>.

#### ON-LINE STATEMENT FOR COURSES REQUIRING ONLINE ACCESS OR WORK

In this course, we will be using Avenue to Learn. Students should be aware that, when they access the electronic components of this course, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in this course will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure, please discuss this with the course instructor.

#### REFERENCE TO RESEARCH ETHICS

The two principles underlying integrity in research in a university setting are these: a researcher must be honest in proposing, seeking support for, conducting, and reporting research; a researcher must respect the rights of others in these activities. Any departure from these principles will diminish the integrity of the research enterprise. This policy applies to all those conducting research at or under the aegis of McMaster University. It is incumbent upon all members of the university community to practice and to promote ethical behaviour. To see the Policy on Research Ethics at McMaster University, please go to <http://www.mcmaster.ca/policy/faculty/Conduct/ResearchEthicsPolicy.pdf>.