

EP4D03_6D03
Nuclear Reactor Analysis (Reactor Physics)
Fall 2021
Course Outline

CALENDAR/COURSE DESCRIPTION

This is a course on nuclear fission reactors. The course aims to:

- Explain the concepts, physical processes, and quantities important in the context of the fission chain reaction
- Formulate and explain the basic descriptive equations (neutron-transport and neutron-diffusion equations)
- Show how to solve the neutron-diffusion equation for specific simple reactors
- Show how to solve for the evolution of neutron flux and power in simple time-dependent situations
- Explain the importance and effects of saturating fission products (Xe-135)
- Cover other miscellaneous topics in reactor physics.

PRE-REQUISITES AND ANTI-REQUISITES

Prerequisite(s): EP3D03. Registration in the final level of an Engineering Physics program.

Antirequisite(s):

INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION

Dr. Benjamin Rouben
NRB B121
roubenb@mcmaster.ca

Office Hours:
Tuesdays 3:30-4:40 pm on MSTeams, also by
appointment or any time by e-mail

TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION

Office Hours:
By appointment

COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION

[On Avenue to Learn.](#)

COURSE OBJECTIVES

By the end of this course, students should be able to:

- Describe and use in problems the important quantities which relate to the fission chain reaction, e.g., neutron flux and current, absorption, fission and radiative- capture cross sections, reactor multiplication constant, reactivity, buckling, fuel irradiation and burnup.
- Explain the neutron-diffusion equation and the various terms in it.
- Solve time-independent problems in non-multiplying media but with external neutron sources, to find the neutron-flux and current distribution in space.
- Solve time-independent problems in multiplying media to find the neutron-flux distribution and its absolute value, the reactor multiplication constant, and/or the reactor dimensions, given sufficient reactor data.
- Use the equation for subcritical multiplication to derive the value of system reactivity and/or device reactivity in an approach to critical.
- Solve time-dependent problems to calculate the evolution of flux and power following insertion of reactivity in a reactor.
- Explain the $^{135}\text{Xe}/^{135}\text{I}$ kinetics and solve problems relating to the effects of xenon in steady state and in transients.
- Describe the CANDU design. Explain the functions of its reactivity devices.
- Describe the characteristics of CANDU lattice reactivity with fuel irradiation/burnup, such as plutonium peak, discharge burnup.

MATERIALS AND FEES

Required Texts:

Primary reference text: Nuclear Reactor Analysis, by James J. Duderstadt & Louis J. Hamilton, John Wiley & Sons, Inc., ISBN: 0-471-22363-8

Calculator:

Only the McMaster Standard Calculator will be permitted in tests and examinations. This is available at the Campus Store.

Other Materials:

Instructor's presentations ("Learning Modules").

There are also a large number of other books on reactor physics, for example:

- The Essential CANDU - a textbook about the CANDU nuclear reactor (chapters 4 and 5) (<http://www.nuceng.ca/candu/>)
- John R. Lamarsh & Anthony J. Baratta, Introduction to Nuclear Engineering, Prentice Hall, ISBN: 0-20182-498-1

COURSE OVERVIEW

The material to be covered will tentatively follow as much as possible the schedule below. But note that some change between one week and another may be made, for best presentation of material.

Week 1: Fission and Other Nuclear Reactions, CANDU Nuclear Reactor
 Week 2: Flux and Current, Neutron Cycle, Neutron Balance
 Week 3: Source-Sink Problems
 Week 4: The Finite Reactor in 1 Energy Group, Flux Shape in Various Reactor Geometries
 Week 5: Statics Problems
 Week 6: Diffusion in Two Energy Groups
 Week 7: Mid-Term Examination
 Week 8: Subcritical Multiplication, Approach to Critical
 Week 9: Irradiation, Burnup, Evolution of Lattice Properties
 Week 10: Delayed Neutrons, Fast Kinetics, Kinetics Problems
 Week 11: Xenon-Iodine Kinetics
 Week 12: Reactivity Coefficients, Course Review.

ASSESSMENT

Component	Weight
Quizzes	10%
Assignments	20%
Midterm Exam	30%
Final Exam	40%
Total	100%

Notes:

Any missed component will be entered as zero in the calculation of the grade.

A passing mark on the final exam is a requirement for a passing mark in the course.

6D03 students (i.e., graduate students) will have an extra assignment, worth an additional 20 marks. The total mark, including the extra assignment, will then be renormalized to a maximum of 100 per cent.

ACCREDITATION LEARNING OUTCOMES
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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
Competence in Specialized Engineering Knowledge	1.4
Demonstrates an ability to identify reasonable assumptions (including identification of uncertainties and imprecise information) that could or should be made before a solution path is proposed.	2.1
Demonstrates an ability to identify a range of suitable engineering fundamentals (including mathematical techniques) that would be potentially useful for analyzing a technical problem.	2.2

An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.	3
Selects appropriate model and methods and identifies assumptions and constraints.	3.2
An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, economic, environmental, cultural and societal considerations.	4

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. 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 e-mail and the course web page on 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.

X = e-mail, LearnLink, Avenue to Learn, web pages, capa, Moodle, ThinkingCap, etc.

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>.