Engineering Physics
ENG PHYS 715
Advanced Nuclear Reactor Thermalhydraulics
Graduate Studies
Fall 2026 or Winter 2027
Course Outline

INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION

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JHE
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343-550-3981

Office Hours:
Friday – 2:30 pm to 3:30 pm and 5 pm to 6 pm
Or by appointment

CALENDAR/COURSE DESCRIPTION

This course will examine today's issues of nuclear reactor thermalhydraulics and in particular the numerical and experimental methods applied to study the important phenomena. It is assumed that students have a strong undergraduate background in heat transfer, fluid mechanics, and numerical methods.

COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION

The official means of communication with students is via the course webpage on Avenue to Learn.
It is the students' responsibility to check the course webpage for updates and announcements regularly.

CLASS FORMAT

Course Dates: 8/09/2026- 10/12/2026
Units: 3 (all one-term graduate courses are 3 units)
Course Delivery Mode: All classes are in-person
Course Description:.

The principal objectives of the course are to present the graduate students and researchers with practical knowledge in:

1) Fundamentals of phase changes phenomena, thermo-physical behavior of nucleation and evaporation.
2) Introduction to two-phase flow. 2-phase flow distribution. Flow Boiling, CHF, Transition Boiling and Psot Dryout Boiling.
3) Homogenous Methods for Two-Phase Flow Predictions.
4) Numerical methods and solution of homogeneous simulations
5) Closure Relationships for Two-Phase Flow Modeling in Homogenous Systems
6) Separated-Flow Methods for Two-Phase Flow Predictions, Slip Methods and Closure Relations for Two-Phase Modeling in separated Systems.

7) Two-fluid Approach to Two-Phase Modeling and Closure Relationships in Two-fluid formulations
8) Physical modeling of ONB, CHF and film boiling
9) Nuclear Thermalhydraulic Phenomena
10) Experimental Methods in Two-Phase Flow
11) Up-to-date critical reviews of the state of knowledge in nuclear safety related thermalhydraulics, and thermalhydraulic behavior in nuclear accidents

This course will be taught by means of lectures and a number of invited speakers will speak to the class on special topics. The course does not follow any specific textbook and there are no required books. At the start of the course, a book list of helpful supplementary reading will be provided.

Assignments will consist of:

a) a numerical project (and hence adequate knowledge and experience in numerical modeling is assumed).

- Students must submit a working MATLAB code, all input files and a written report.
- Both the code structure and layout, accuracy and accompanying report will be scrutinized.
- The report should be approximately 12 to 17 pages (including figures) and should follow the publication and layout format for the American Nuclear Society journals. Each report will be graded according to the quality of the write-up, presentation of the results, depth of analysis and discussion, understanding and conformance with journalistic style.
- A progress report is due (2 pages max) by the March 2, 2012.

b) a literature review of a relevant topic (approved by the instructor)

- presentation of an in-class topical seminar based on the review (30 minutes).
- The report will be based on the background description, theoretical completeness and a review of relevant new progress (journals) in the field.

MARKING SCHEME

Literature Review Report	20%
Oral Presentation of Literature Review	15%
Numerical Project Progress Report	10%
Final Computer Code and Accuracy Assessment:	30%
Final Report	25%

Letter grades will be assigned using the official McMaster scoring system as published by the Office of the Registrar.

POLICY REMINDERS

Academic dishonesty consists of misrepresentation by deception or by other fraudulent means and 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 kinds of academic dishonesty please refer to the Academic Integrity Policy, specifically Appendix 3, located at http://www.mcmaster.ca/senate/academic/ac_integrity.htm

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.

The Faculty of Engineering is concerned with ensuring an environment that is free of all adverse discrimination. If there is a problem that cannot be resolved by discussion among the persons concerned, individuals are reminded that they should contact their Department Chair, the Sexual Harassment Officer or the Human Rights Consultant, as soon as possible.

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.

The course is scheduled as follows:

- C01: lecture Friday, September 11 1:00 – 2:30 pm & 3:30 - 5:00 pm see Mosaic or Avenue for location
- C02: lecture Friday, September 18 1:00 – 2:30 pm & 3:30 - 5:00 pm see Mosaic or Avenue for location
- C03: lecture Friday, September 25 1:00 – 2:30 pm & 3:30 - 5:00 pm see Mosaic or Avenue for location
- C04: lecture & Preliminary Test Friday, October 2 1:00 – 2:30 pm & 3:30 - 5:00 pm see Mosaic or Avenue for location
- C05: lecture Friday, October 9 1:00 – 2:30 pm & 3:30 - 5:00 pm see Mosaic or Avenue for location
- C06: lecture Friday, October 23 1:00 – 2:30 pm & 3:30 - 5:00 pm see Mosaic or Avenue for location
- C07: lecture & Mid-Term Test Friday, October 30 1:00 – 2:30 pm & 3:30 - 5:00 pm see Mosaic or Avenue for location
- C08: lecture Thursday, November 12 1:00 – 2:30 pm & 3:30 - 5:00 pm see Mosaic or Avenue for location
- C09: lecture Friday, November 13 1:00 – 2:30 pm & 3:30 - 5:00 pm see Mosaic or Avenue for location
- C10: lecture Friday, November 20 1:00 – 2:30 pm & 3:30 - 5:00 pm see Mosaic or Avenue for location
- C11: lecture Friday, November 27 1:00 – 2:30 pm & 3:30 - 5:00 pm see Mosaic or Avenue for location
- C12: lecture Friday, December 4 1:00 – 2:30 pm & 3:30 - 5:00 pm see Mosaic or Avenue for location

- C13: lecture — Thursday, December 10 — 1:00 – 2:30 pm & 3:30 - 5:00 pm — see Mosaic or Avenue for location
- Final Exam — Friday, December 18 — 1:00 – 4:00 pm — see Mosaic or Avenue for location

Recordings of the lecture are permitted for personal study, and students are requested to respect the privacy rights and intellectual property of others.

There are no formal prerequisites; however, prerequisite knowledge of basic thermofluids, mechanics of materials, and mathematics is beneficial
NOTE - **some numerical program experience in MATLAB or PYTHON is required**.

To complete the course, a minimum attendance rate of 75% is required.

COURSE INTENDED LEARNING OUTCOMES

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

- Understand thermalhydraulic behaviour in reactor systems, including heat transfer, fluid flow, phase changes, nucleation, and evaporation.
- Learn the basics of two-phase flow, two-phase flow distribution, flow boiling, Critical Heat Flux, transition boiling, and post-dryout boiling.
- Gain a comprehensive understanding of thermalhydraulic-induced hazards in nuclear power reactors.
- Predict two-phase flow with homogeneous methods using numerical methods.
- Appreciate closure relationships and slip methods in two-phase flow modelling
- Learn experimental methods in two-phase flow.
- Review nuclear safety-related thermalhydraulic in nuclear accidents.

COURSE SCHEDULE

A weekly breakdown of the course schedule

Date/Week	Topic	Readings
Week 1 – Sep 8-11	Fundamentals of phase changes phenomena, thermo-physical behavior of nucleation and evaporation	
Week 2 - Sep 14-18	Introduction to two-phase flow. 2-phase flow distribution. Flow Boiling, CHF, Transition Boiling and Post Dryout Boiling	
Week 3 - Sep 21-25	Homogenous Methods for Two-Phase Flow Predictions	
Week 4 - Sep 28-Oct 2	Numerical methods and solution of homogeneous simulations	
Week 5 - Oct 5-9	Closure Relationships for Two-Phase Flow Modeling in Homogenous Systems	
Week 6 - Oct 12-16	Mid-Term Recess	
Week 7 – Oct 19-23	Separated-Flow Methods for Two-Phase Flow Predictions, Slip Methods and Closure Relations for Two-Phase Modeling in separated Systems	
Week 8 - Oct 26-30	Two-fluid Approach to Two-Phase Modeling and Closure Relationships in Two-fluid formulations	
Week 9 - Nov 2-6	Physical modeling of ONB, CHF and film boiling Part 1	
Week 10 - Nov 9-13	Physical modeling of ONB, CHF and film boiling Part 2	

Week 11 - Nov 16-20	Nuclear Thermalhydraulic Phenomena Part 1
Week 12 - Nov 23-27	Nuclear Thermalhydraulic Phenomena Part 2
Week 13 - Nov 30-Dec 4	Experimental Methods in Two-Phase Flow
Week 14 - Dec 7-10	Up-to-date critical reviews of the state of knowledge in nuclear safety related thermalhydraulics, and thermalhydraulic behavior in nuclear accidents

This lecture schedule is based upon current university and public health guidelines and may be subject to changes during the term. Any changes to the schedule or course delivery will be communicated on the course announcements section on Avenue to Learn. Please check the announcements prior to attending class.

REQUIRED/OPTIONAL MATERIALS AND FEES

Required Texts:
None

Recommended Additional Texts:
To be provided during the lectures

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

Other Materials:
None

COURSE ASSESSMENT DETAILS

Component	Due Date	Weight
Preliminary Test	October 2	30%
Mid Term Test	October 30	30%
Final Exam	December 18	40%
Total		100%

GRADING SCALE

Grade	Points	Equivalent Percentages	Pass/Fail
A+	12	90 – 100	P+
A	11	85 – 89	P
A-	10	80 – 84	P
B+	9	77 – 79	P
B	8	73 – 76	P
B-	7	70 – 72	P
F	0	69 and under	F

COURSE POLICY ON MISSED WORK, EXTENSIONS, AND LATE PENALTIES

- The Students are expected to meet the test and exam deadlines.

GENERATIVE AI

Students may freely use generative AI in this course so long as the use of generative AI is referenced and cited following citation instructions given in the syllabus. Use of generative AI outside assessment guidelines or without citation will constitute academic dishonesty. It is the student's responsibility to be clear on the expectations for citation and reference and to do so appropriately.

APPROVED ADVISORY STATEMENTS

EQUITY, DIVERSITY, AND INCLUSION

Every registered student belongs in this course. Diversity of backgrounds and experiences is expected and welcome. You can expect your Instructor to be respectful of this diversity in all aspects of the course, and the same is expected of you.

The Department of Engineering Physics and the Faculty of Engineering are committed to creating an environment in which students of all genders, cultures, ethnicities, races, sexual orientations, abilities, and socioeconomic backgrounds have equal access to education and are welcomed and treated fairly. If you have any concerns regarding inclusion in our Department, in particular if you or one of your peers is experiencing harassment or discrimination, you are encouraged to contact the Chair, Associate Undergraduate Chair, Academic Advisor or to contact the Equity and Inclusion Office.

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. **It is your responsibility to understand what constitutes academic dishonesty.**

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. For information on the various types of academic dishonesty please refer to the *Academic Integrity Policy*, located at https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/

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.

AUTHENTICITY / PLAGIARISM DETECTION

Some courses may use a web-based service (Turnitin.com) to reveal authenticity and ownership of student submitted work. For courses using such software, students will be expected to submit their work electronically either

directly to Turnitin.com or via an online learning platform (e.g. A2L, etc.) using plagiarism detection (a service supported by Turnitin.com) so it can be checked for academic dishonesty.

Students who do not wish their work to be submitted through the plagiarism detection software must inform the Instructor before the assignment is due. No penalty will be assigned to a student who does not submit work to the plagiarism detection software. **All submitted work is subject to normal verification that standards of academic integrity have been upheld** (e.g., on-line search, other software, etc.). For more details about McMaster's use of Turnitin.com please go to www.mcmaster.ca/academicintegrity.

COURSES WITH AN ON-LINE ELEMENT

McMaster is committed to an inclusive and respectful community. These principles and expectations extend to online activities including electronic chat groups, video calls and other learning platforms.

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, 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 a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure, please discuss this with the course instructor.

ONLINE PROCTORING

Some courses may use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the *Code of Student Rights & Responsibilities* (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online**.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

ACADEMIC ACCOMMODATION OF STUDENTS WITH DISABILITIES

Students with disabilities who require academic accommodation must contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's *Academic Accommodation of Students with Disabilities* policy.

PHYSICAL AND MENTAL HEALTH

For a list of McMaster University's resources, please refer to the Student Wellness Centre.

Academic Accommodation for Religious, Indigenous or Spiritual Observances (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office ***normally within 10 working days*** of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

Copyright and Recording

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

Extreme Circumstances

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.