EP 3MN4
Numerical Methods for Engineering
Undergraduate Studies
Fall 2023
Course Outline

CALENDAR/COURSE DESCRIPTION

This course is a core course for all engineering students. It provides the fundamentals of computational methods that are involved in solving mathematical models of physical systems. The mathematical models can be presented in different types of equations to demonstrate the relationship between the controlling variables. This course will teach engineering students how to use the computational methods for solving linear, nonlinear, integral, and differential equations.

PRE-REQUISITES AND ANTI-REQUISITES

Prerequisite(s): None
Antirequisite(s): ENGPHYS 2CE4, CHEMENG 2E04, CIVENG 2E03, MECHENG 3F04, COMPSCI 4X03, MECHTRON 3X03, SFWRENG 4X03

INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION

Dr. Mahmoud Ahmed

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Office Hours:
Monday – 10:30 am
Or by appointment

TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION

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Office Hours:
by appointment

COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION

http://avenue.mcmaster.ca/

COURSE INTENDED LEARNING OUTCOMES

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

- Identify the truncation error when exact mathematical formulations are represented by approximations.
- Determine the roots of non-linear equations.

- Introduce how optimization can be used to determine minima and maxima of both one-dimensional and multidimensional functions.
- Acquaint with linear algebraic equations and their relationship to matrices and matrix algebra.
- Know how to represent a system of linear algebraic equations in matrix form.
- Acquaint with direct and indirect (iterative) methods for solving simultaneous systems of linear algebraic equations in matrix form.
- Understand how to solve systems of nonlinear equations with successive substitution, and the Newton-Raphson methods.
- Use the numerical methods for integrating given functions and numerical differentiation.
- Solve initial-value problems and boundary-value problems for ordinary differential equations using different numerical methods.
- Understand the solution schemes of elliptic and hyperbolic partial differential equations using finite difference methods along with the discretization errors and stability conditions for each method.
- Use MATLAB or other tools to compute the solutions of mathematical models of physical systems using appropriate numerical methods.
- Develop algorithms in a pseudocode leading to a well-structured program in a variety of computer languages to compute the solutions of mathematical models using a suitable numerical scheme.

MATERIALS AND FEES

Required Texts:
Numerical Methods for Engineers– EIGHTH EDITION
by: Steven Chapra and Raymond Canale

Recommended Additional Texts:
1. Numerical Methods for Engineers and Scientists
   By: Joe D. Hoffman, Second Edition, 2002

2. Numerical Analysis
   By: R.L. Burden, J.D.Faires, Annette M. Burden, Tenth Edition, 2016

3. Lecture notes provided by the instructor

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

Other Materials:
MATLAB programing is a mandatory component in this class. Students must obtain a valid program and license for MATLAB prior to the first lab

COURSE FORMAT AND EXPECTATIONS

The course is organized as follows:
- 3 classroom-based lectures per week
- 1 lab per week (3 hours)

- There is one assignment per week and it includes two main parts. The first part accounts for 10 % and must be completed and submitted by the end of the laboratory period. The second part is take- home and accounts for 25 %. It must be completed and submitted by noon on the following Monday.
- The mid-term and final examinations will be closed book.
  In the exam: an 8.5" x 11" crib sheet is allowed with the following restrictions:
  Only final formulas are allowed
  Derivations or examples are not permitted
  Instead of having one 8.5" x 11" crib sheet with text on both sides, it is also allowed to have two 8.5" x 11" crib sheets with text only on one side

COURSE SCHEDULE

Date/Week	Topic	Readings
Week-1	Error Analysis and the Taylor Series	Ch-3, and Ch-4
Week -2	Solutions of Equations in One Variable (Roots Finding)	Ch-5, and Ch-6
Week -3	Solutions of Linear Algebraic Equations Solution of Non-linear Equations	Ch-9, Ch-10, and Ch-11
Week -4	Unconstrained Optimization	Ch-13, and Ch-14
Week -5	Curve Fitting and Interpolation	Ch-17, and Ch-18
Week -6	Mid-term recess	
Week -7	Numerical Integration	Ch-21, and Ch-22
Week -8	Numerical Differentiation	Ch-23
Week -9	Numerical Solution of Ordinary Differential Equations (Initial-Value Problems)	Ch-25, and Ch-26
Week -10	Numerical Solution of Ordinary Differential Equations (Boundary-Value Problems)	Ch-27
Week -11	Numerical Solutions to Partial Differential Equations (Elliptic Equations)	Ch-29
Week -12	Numerical Solutions to Partial Differential Equations (Parabolic Equations)	Ch-30
Week -13	Finite-Element Method	Ch-31
Week-14	Review	***Study Guides for the Final Examination***

ASSESSMENT

Component	Due Date	Weight
Assignments		35 %
Two mid-term examinations		25 %
Project		10 % + (up to 5% Bonus)
Final Exam		30 %
Total		100 %

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 grade in the course.

Outcomes	Indicators
• Solve initial-value problems and boundary-value problems for ordinary differential equations using different numerical methods.	1:1
• Develop algorithms in a pseudocode leading to a well-structured program in a variety of computer languages to compute the solutions of mathematical models using a suitable numerical scheme.	1:2
• Understand the solution schemes of elliptic and hyperbolic partial differential equations using finite difference methods along with the discretization errors and stability conditions for each method.	5:2

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

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 is 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.

PHYSICAL AND MENTAL HEALTH

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

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.

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.

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.

COURSE POLICY ON MISSED WORK, EXTENSIONS, AND LATE PENALTIES

1. It is the students' responsibility to regularly check the course webpage (ex. Avenue to Learn) for updates and announcements.
2. Missed work without an approved MSAF will be assigned a zero
3. For approved MSAF missed work grades will be transferred to the final exam.
4. For computational assignments a late penalty of 5% per day will be assigned.

SUBMISSION OF REQUEST FOR RELIEF FOR MISSED ACADEMIC WORK

In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar "Requests for Relief for Missed Academic Term Work".

1. **Relief for missed academic work worth less than 25% of the final grade resulting from medical or personal situations lasting up to three calendar days:**

    - Use the McMaster Student Absence Form (MSAF) on-line self-reporting tool. No further documentation is required.
    - Students may submit requests for relief using the MSAF once per term.
    - An automated email will be sent to the course instructor, who will determine the appropriate relief. Students must immediately follow up with their instructors. Failure to do so may negate the opportunity for relief.
    - The MSAF cannot be used to meet a religious obligation or to celebrate an important religious holiday.
    - The MSAF cannot be used for academic work that has already been completed attempted.
    - An MSAF applies only to work that is due within the period for which the MSAF applies, i.e. the 3-day period that is specified in the MSAF; however, all work due in that period can be covered by one MSAF.
    - The MSAF cannot be used to apply for relief for any final examination or its equivalent. See *Petitions for Special Consideration* above.

2. **For medical or personal situations lasting more than three calendar days, and/or for missed academic work worth 25% or more of the final grade, and/or for any request for relief in a term where the MSAF has been used previously in that term:**

    - Students must report to their Faculty Office to discuss their situation and will be required to provide appropriate **supporting documentation**.
    - If warranted, the Faculty Office will approve the absence, and the instructor will determine appropriate relief.

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.