THOMPSON RIVERS UNIVERSITY | Mathematics and Statistics

Course Outline

MATH 3650 – 01
Numerical Analysis (3,1,0)
Fall 2024

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Thompson Rivers University is located on the Tk'emlups te Secwepemc territory that is situated in the Southern interior of British Columbia within the unceded traditional lands of the Secwepemc Nation.

Class times and office hours

Tuesday: 9:30–10:30 OM 2642
Thursday: 9:30–10:30 OM 2642
Wednesday: 11:30–12:30 HOL 204
Friday: 9:30–10:30 OM 2642
Office: to be set during first class

Students must attend all classes. Both theory and practice will be covered at all sessions.

Calendar Description

This course introduces standard numerical methods, including algorithms for solving algebraic equations (linear and nonlinear, single equations and systems) and for polynomial approximation and interpolation.

Education Objectives/Outcomes

On completion of the course students will be expected to:

- appreciate the power and limitations of numerical computations
- understand the purpose of the algorithms discussed in the course and the steps in these algorithms;
- apply programs that implement these algorithms to solve applied problems
- analyse the accuracy and convergence of these algorithms.

Prerequisites

MATH 2110 (Calculus III) and MATH 2120 (Linear Algebra I) or equivalent;
coding experience in a procedural language.

Corequisites

Required seminar MATH 3650S

Texts/Materials

R L Burden, D J Faires and A M Burden *Numerical Analysis*, 10th edition

Student Evaluation

Assignments (×5) 25%
Midterm exams (×2) 50%
Final project 25%

Midterms will take place during scheduled classes. Assignments and final projects are individual work. Problems will be randomised. Students must attend class to receive their assignment. Students missing a class, where an assignment is handed out, might pick it up in person at the instructor's office. All submissions must be electronic and uploaded via the moodle shell. No other submission, electronic or hard copy, will be accepted, including by e-mail.

All grading will follow the verbal descriptions outlined in TRU policy (ED 03-5)
`https://tru.ca/__shared/assets/ED_03-5_Grading_Systems35364.pdf`

In the event a student misses a test, a mark of 0 will be given unless the student contacts the instructor prior to the exam, informing the instructor of the particular situation. Attendance at all scheduled quizzes and midterms is mandatory, and the responsibility is on the student to seek remedy for a missed test. Students, who require special accommodation, are encouraged to contact Accessibility Services.

Submission penalty or bonus

Assignments submitted early will receive a bonus of 2 points per day up to a maximum of 10 (centigrade scale). Late assignments will receive a penalty of 10 points per day up to a maximum of 50. If an assignment is still not submitted 5 days past the deadline, it will receive a grade of 0.

Final projects submitted early will receive a bonus of 2 points per day up to a maximum of 10. Late projects will receive a penalty of 20 points for the first day and a grade of 0 afterwards.

Timing will be based on moodle records. Bonus or penalty points will be counted according to calendar dates. For instance, if the deadline is September 20th, an assignment submitted any time on September 19th will receive a bonus of 2 points. An assignment submitted at 00:01 at night on September 21st will receive a penalty of 10 points.

Attendance Regulations

A registered student, who does not attend the first two events (e.g., lectures/labs/etc.) of the course and who has not made prior arrangements acceptable to the instructor, may, at the discretion of the instructor, be considered to have withdrawn from the course and have his/her course registration deleted. A registered student is expected to attend a minimum of 90% of lectures and seminars for which he/she is enrolled. In the case of deficient attendance without cause, a student may, on recommendation of the instructor to the instructor's Dean or Chairperson, be withdrawn from a course. Admission to a lecture or seminar may be refused by the instructor for lateness, class misconduct, or failure to complete required work.

Prior Learning Assessment and Recognition/Challenges

Students may receive credit for Prior Learning Assessment and Recognition (PLAR) by writing a challenge examination designed by a qualified specialist approved by the Department of Mathematics and Statistics. More information can be obtained from the Office of the Registrar.

Academic Integrity Policy

TRU students are required to comply with the standards of academic integrity set out in Student Academic Integrity policy (ED 5-0), available at TRU website. Cheating, academic misconduct, fabrication and plagiarism could result in failure of a course or even suspension from TRU.

All submitted papers must be the student's individual work. All workings, including code, must be shown. Final answers, including graphs, without workings will receive no score. No group work or external aid is allowed. Memorising solutions, copying problem solutions or code off the web, solution manuals or other sources is considered plagiarism and will be reported.

Use of Technology

This course will require the use of fairly advanced technology. Please, read attentively.

Midterms will be closed book tests. A scientific (non-graphing) calculator will be required. A calculator with a basic memory feature (able to store at least one intermediate result) is strongly recommended. It is the student's responsibility to know to operate their calculator efficiently. No answer will receive score unless properly substantiated.

All assignments and projects must be typed and submitted as a *single* pdf file. Multiple files or other file types will not be accepted. Figures must be imbedded and of high quality (good resolution, minimised white space, judicious use of colour, axes labels, captions, legends in place). Interactive and 3D figures are not allowed. The choice of graphing (Octave/MATLAB, R, Excel, Maple, Mathematica etc.) and text editing (Word, LaTeX etc.) software is up to the student. It must be capable of imbedding figures, formatting mathematical formulae, automatic numbering and referencing of figures, tables and equations, and displaying code without altering its layout such as indentation. Low quality papers (grammar, spelling, flow, layout, math formatting, figures) will be penalised.

LaTeX (pronounced la–tex with x read as in Mexico in Spanish or j in Alejandro) is open source and free to instal on all platforms. TeXLive distribution is recommended. Overleaf is an on-line third party interface that might be used instead of one's own installation. Bear in mind that no excuses as to files mishandled by Overleaf or server inaccessibility will be accepted. User's guide and reference manual might be gotten here: `https://faculty.tru.ca/ynec/tmp/LLLaTeX.pdf` .
Documentation of specific packages is here: `https://ctan.org` .
Octave is an open source MATLAB clone (heartily recommended for smaller or older computers): `https://www.gnu.org/software/octave/` .
On MacOS the Homebrew package manager is expedient if you are not fluent in this kind of installation. To instal Homebrew visit `brew.sh`, whereupon you can instal both TeXLive, Texshop (editing environment) and Octave. On Linux similar package managers can be used.
Microsoft Office might be gotten here: `https://www.tru.ca/its/students/software/office-365.html` .
MATLAB is available here (toolboxes you would want to instal are curve fitting, optimisation, PDEs and statistics – be judicious with the number of additional toolboxes): `https://www.mathworks.com/academia/tah-portal/thompson-rivers-university-31429268.html` .

The assignments and final projects will require coding. The choice of language is up to the student. All code must be submitted as part of the assignment. If separate languages are used for computation and plotting, both sets of code must be submitted. It is acceptable to screen capture the code into images and imbed those in the submitted pdf file as long as the image is of good quality. In LaTeX use the `verbatim` environment or the `listings` package for this purpose.

Text editing help: a LaTeX template that includes commands for math formatting and figure/code imbedding as well as a text sample on par with expectations, is provided on the course webpage.

Coding/graphing help: I can help those coding in Octave/MATLAB, C or Fortran, and to a more limited extent R, Java, Python, Mathematica and similar languages.

The course will be managed through the webpage `https://faculty.tru.ca/ynec/`. It is the student's responsibility to check for updates and messages sent to myTRU e-mail account. The moodle shell will be used to submit and return assignments only.

Math Help Centre

All students are welcome to consult with a math tutor on a drop-in basis. at the Math Help Centre, which is located in the Science building, room S201. More information is available here:
`https://www.tru.ca/science/programs/math/math_help_centre.html` .

Course Topics

1. **Preliminaries** ..... **Ch 1**
   Round-off error and computer arithmetic
   Algorithms and convergence

2. **Solution of equations in one variable** ..... **Ch 2**
   Bisection method
   Fixed-point iteration
   Newton-Raphson and secant methods
   Error analysis for iterative methods
   Accelerating convergence
   Zeroes of polynomials and Müller's method

   Assignment 1

3. **Interpolation and polynomial approximation** ..... **Ch 3**
   Lagrange polynomials
   Divided differences
   Hermite interpolation

   Assignment 2

4. **Numerical integration** ..... **Ch 4**
   Romberg integration
   Adaptive quadrature
   Gaussian quadrature
   Multiple integrals
   Improper integrals

   Assignment 3

5. **Ordinary differential equations** ..... **Ch 5**
   Euler's methods
   Runge-Kutta method
   Stiff differential equations

   Assignment 4

6. **Direct methods for solving linear systems** ..... **Ch 6**
   Gaussian elimination, Gauss-Jordan method
   Pivoting strategies
   Linear algebra and matrix inversion
   Matrix determinants
   LU factorisation
   Special matrices (positive definite, tridiagonal)

7. **Iterative techniques in matrix algebra** ..... **Ch 7**
   Norms of vectors and matrices
   Eigenvalues and eigenvectors
   Iterative techniques for solving linear systems (Jacobi, Gauss-Seidel)
   Relaxation techniques for solving linear systems

   Assignment 5

8. **Numerical solution of non-linear systems of equations** ..... **Ch 10**
   Fixed point methods
   Newton's method
   Quasi-Newton methods
   Steepest descent techniques