Physics 512 Syllabus, 2021 (Preliminary)

This course focuses on equipping students with the tools needed to solve problems in physics using computers. The course will be taught using python, and students are strongly encouraged to have at least some familiarity with basic python coding by the beginning of the course. Assessment is via hands-on problem sets (40%), a final coding project (30%), and a take-home exam (30%). *Numerical Recipes, 3rd edition* covers many of the course subjects and it is strongly recommended. Lectures will consiste of a mix of blackboard derivations and live coding examples demonstrating the principles in action. We anticipate tutorial sessions will be carried out in-person, and will focus on helping students implement class concepts into working code. Students are encouraged to provide examples of computing challenges they face that can be used as practical examples.

Lectures will be held in Rutherford 115 from 11:35 AM to 12:55 PM on Tuesdays and Thursdays. Office hours and tutorials will be scheduled in consultation with the class/TAs.

In the event of extraordinary circumstances beyond the University's control, the content and/or evaluation scheme in this course is subject to change

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Topics covered:

- Brief introduction/review of python and coding practices.
- Floating point math/roundoff error. How to optimize *e.g.* numerical derivatives. Resource: "What every computer scientist should know about floating point arithmetic." by David Goldberg.
- Function interpolation and numerical integration. Error analysis of various techniques.
- Integration of ODEs. Runge Kutta methods. Stiff equations, and implicit techniques.
- Linear algebra and linear least-squares fitting. Singular value decomposition and its application to numerically unstable models. Legendre and Chebyshev polynomials. Iterative solutions to large problems using conjugate gradient.
- Nonlienar least-squares fitting. Newton's method, Levenberg-Marquardt, and Markov Chain Monte Carlo.

- Discrete Fourier transforms. Convolutions and applications to image processing. Aliasing and the Nyquist theorem. Stationary noise and matched filters.
- Random variables. Transformation method, rejection method, and ratio-of-uniforms.
- Partial differential equations. Eulerian and Lagrangian techniques. Advection equation, stability analysis, and the CFL condition. Inviscid fluid flow, numerical dissipation, and the Lax method.
- Brief introduction to machine learning.

Language Policy:
In accord with McGill University's Charter of Student Rights, students in this course have the right to submit in English or in French any written work that is to be graded. This does not apply to courses in which acquiring proficiency in a language is one of the objectives.

Conformément à la Charte des droits de l'étudiant de l'Université McGill, chaque étudiant a le droit de soumettre en français ou en anglais tout travail écrit devant être noté, sauf dans le cas des cours dont l'un des objets est la maîtrise d'une langue.

Academic Integrity:
McGill University values academic integrity. Therefore, all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the Code of Student Conduct and Disciplinary Procedures. (Approved by Senate on 29 January 2003) (See McGill's guide to academic honesty for more information.)

L'université McGill attache une haute importance à l'honnêteté académique. Il incombe par conséquent à tous les étudiants de comprendre ce que l'on entend par tricherie, plagiat et autres infractions académiques, ainsi que les conséquences que peuvent avoir de telles actions, selon le Code de conduite de l'étudiant et des procédures disciplinaires (pour de plus amples renseignements, veuillez consulter le guide pour l'honnêteté académique de McGill.