Course Outline for MATH 2004-A (Multivariable Calculus for Engineering or Physics), Fall 2021

Alexander Bors

Basic information on the course:

- **Department/Unit:** School of Mathematics and Statistics (Faculty of Science)

- **Instructor:** Alexander Bors

- **Instructor office location/phone:** Not applicable due to the pandemic – please contact me by e-mail.

- **Instructor e-mail:** `AlexanderBors (at) cunet (dot) carleton (dot) ca`. Whenever possible, I will answer course-related e-mails within one workday. In case I get lots of e-mails with similar questions or questions of general interest, I may answer them by sending an e-mail to all course participants.

- **Office hours (online via Zoom):** Tuesdays, 4:30-5:30pm.

- **TAs for this course:** to be announced.

- **Brightspace page of this course:** `https://brightspace.carleton.ca/d2l/home/64342`.

- **Lectures (live and online via Zoom):** Tuesdays and Thursdays, 2:30-4pm. The first lecture is on Thursday, September 9, and the last is on Thursday, December 9. Lectures will also be recorded and shared in the Carleton Mediaspace.

- **Tutorials (online via Zoom):** Thursdays, 4:30pm-5:30pm. Tutorials for this course start on September 23.

1 Course description

This course covers the basics of multivariable calculus (that is, calculus for real functions in several variables). This is a very important theory for engineers, because in order to accurately describe and study shapes embedded into three-dimensional space using mathematics, one-dimensional calculus is not strong enough. For a detailed list of topics

covered, see the course calendar in Section 9. The aim is to introduce the students to the most important results and computation methods from this discipline and discuss some applications (such as the computation of the lengths of curves, of the areas of surfaces, and of the volumes of solids of revolution). At the end of this course, the students will be able to identify a large range of problems that can be tackled with multivariable calculus, and solve those problems.

2   Preclusions

The prerequisites for this course are 69.1005 or MATH 2007, and 69.1104 or MATH 1107.

3   Learning outcomes

By the end of this course, students will

- understand the intricacies of multivariate differentiation as opposed to differentiation in a single variable;

- be able to handle multivariate integration (line integrals; iterated integrals);

- see how this theory can be used to study shapes (curves, surfaces, solids) in three-dimensional space rigorously;

- be familiar with some other applications of this theory, such as the determination of maxima and minima of multivariate functions.

4   Textbook

This course is based on the textbook **The ABC's of Calculus, Volume 2** by Angelo Mingarelli. You can buy access to this book for 120 days via this link: `https://mingarelli.com/books/the-abcs-of-calculus-multi-variable/`. There is also a free solutions manual for this book, available under `https://people.math.carleton.ca/~angelo/calculus/ABC2-Solutions-Apr22-2021-Pandemic.pdf`.

5   Evaluation

The evaluation for this course consists of the following parts:

- 2 online tests: 30% of the total grade (15% each). Each test has 2 hours duration. The tests will be randomized, multiple-choice, and held in Brightspace. They are scheduled for October 12 and November 9, respectively. Students will have a 24-hour time window to access each test, and there are no lectures on the days of the tests.

Instead, there will be special Zoom sessions on those days from 2:30-4:30pm, in which I will be available for technical support and answering clarification questions.

- 3 assignments: 45% of the total grade (15% each). Each assignment is released on a Thursday and is due on Friday of the following week. An assignment consists of a list of problems with weighted scores that students need to solve by hand (writing on paper, a tablet PC, etc.). The handwritten solutions will then need to be uploaded in Brightspace (more detailed instructions on this will follow in due course).

- 1 online final exam: 25% of the total grade. The final exam will have a duration of 3 hours, will have the same format as the tests (randomized, multiple-choice questions in Brightspace) and will be held during the exam period (December 11–23) – the exact date and time will be announced in due course.

Some more important remarks concerning evaluation:

- Attendance of the lectures and tutorials is not relevant for the evaluation, but still highly recommended.

- Standing in a course is determined by the course instructor subject to the approval of the Faculty Dean. This means that grades submitted by the instructor may be subject to revision. No grades are final until they have been approved by the Dean.

- Please make sure you are familiar with Carleton's Academic Integrity Policy, available under `https://carleton.ca/registrar/academic-integrity/`. Violations of this policy (including plagiarism, see the next section) are not tolerated and will be reported to the Faculty Dean in the presence of proper evidence.

6   Plagiarism

Not quite without irony, the following important information concerning plagiarism has been copied from `https://carleton.ca/teaching-regulations/appendices/`.

The University Academic Integrity Policy defines plagiarism as "presenting, whether intentionally or not, the ideas, expression of ideas or work of others as one's own." This includes reproducing or paraphrasing portions of someone else's published or unpublished material, regardless of the source, and presenting these as one's own without proper citation or reference to the original source. Examples of sources from which the ideas, expressions of ideas or works of others may be drawn from include but are not limited to: books, articles, papers, literary compositions and phrases, performance compositions, chemical compounds, art works, laboratory reports, research results, calculations and the results of calculations, diagrams, constructions, computer reports, computer code/software, material on the internet and/or conversations.

Examples of plagiarism include, but are not limited to:

- any submission prepared in whole or in part, by someone else;

- using ideas or direct, verbatim quotations, paraphrased material, algorithms, formulae, scientific or mathematical concepts, or ideas without appropriate acknowledgment in any academic assignment;

- using another's data or research findings without appropriate acknowledgement;

- submitting a computer program developed in whole or in part by someone else, with or without modifications, as one's own; and

- failing to acknowledge sources through the use of proper citations when using another's work and/or failing to use quotations marks.

Plagiarism is a serious offence that cannot be resolved directly by the course's instructor. The Associate Dean of the Faculty conducts a rigorous investigation, including an interview with the student, when an instructor suspects a piece of work has been plagiarized. Penalties are not trivial. They can include a final grade of "F" for the course or even suspension or expulsion from the University.

7   Requests for Academic Accommodations

You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:

- **Pregnancy obligation:** write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For accommodation regarding a formally-scheduled final exam, you must complete the Pregnancy Accommodation Form, found under `https://carleton.ca/equity/contact/form-pregnancy-accommodation/`.

- **Religious obligation:** write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, see here: `https://carleton.ca/equity/focus/discrimination-harassment/religious-spiritual-observances/`.

- **Academic Accommodations for Students with Disabilities:** The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or `mailto:pmc@carleton.ca` for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with me to ensure accommodation

arrangements are made. Please consult the PMC website for the deadline to request accommodations for the formally-scheduled exam (if applicable).

- **Survivors of Sexual Violence:** As a community, Carleton University is committed to maintaining a positive learning, working and living environment where sexual violence will not be tolerated, and where survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit `https://carleton.ca/equity/focus/sexual-violence-prevention-survivor-support/`.

- **Accommodation for Student Activities:** Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation will be provided to students who compete or perform at the national or international level. Write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. See also `https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf`.

8 Special Information Regarding Fall 2021 Pandemic Measures

While this course will be fully online, instructors are still supposed to include the following general information in each course outline.

All members of the Carleton community are required to follow COVID-19 prevention measures and all mandatory public health requirements (e.g. wearing a mask, physical distancing, hand hygiene, respiratory and cough etiquette) and mandatory self-screening (see `https://carleton.ca/covid19/cuscreen/`) prior to coming to campus daily.

If you feel ill or exhibit COVID-19 symptoms while on campus or in class, please leave campus immediately, self-isolate, and complete the mandatory symptom reporting tool (see `https://carleton.ca/covid19/cuscreen/symptom-reporting/`). For purposes of contact tracing, attendance will be recorded in all classes and labs. Participants can check in using posted QR codes through the cuScreen platform where provided. Students who do not have a smartphone will be required to complete a paper process as indicated on the COVID-19 website (see `https://carleton.ca/covid19/`).

All members of the Carleton community are required to follow guidelines regarding safe movement and seating on campus (e.g. directional arrows, designated entrances and exits, designated seats that maintain physical distancing). In order to avoid congestion, allow all previous occupants to fully vacate a classroom before entering. No food or drinks are permitted in any classrooms or labs.

For the most recent information about Carleton's COVID-19 response and required measures, please see the University's COVID-19 webpage, `https://carleton.ca/covid19/`, and review the Frequently Asked Questions (FAQs), `https://carleton.ca/covid19/faq/`. Should you have additional questions after reviewing, please contact `mailto:covidinfo@carleton.ca`.

Please note that failure to comply with University policies and mandatory public health requirements, and endangering the safety of others are considered misconduct under the Student Rights and Responsibilities Policy, `https://carleton.ca/studentaffairs/student-rights-and-responsibilities/`. Failure to comply with Carleton's COVID-19 procedures may lead to supplementary action involving Campus Safety and/or Student Affairs.

9   Detailed course calendar

The following is an overview of the course, listing important events and deadlines on a weekly basis.

- **Week 1 (Sep 6–12):**

  - Th, Sep 9: Lecture 1: Vectors in the Plane and Space (textbook sections 1.1–1.10; homework problem sets 1–4).

- **Week 2 (Sep 13–19):**

  - Tu, Sep 14: Lecture 2: Rotations of Axes and Translations in the Plane (textbook sections 2.1–2.6; homework problem sets 5–9).

  - Th, Sep 16: Lecture 3: Planar Curves and Conic Sections (textbook sections 2.7 and 2.8; homework problem sets 10–16).

- **Week 3 (Sep 20–26):**

  - Tu, Sep 21: Lecture 4: Applications to Area and the Length of Curves (textbook sections 2.9–2.10; homework problem sets 17 and 18).

  - Th, Sep 23:

    * Lecture 5: Polar Coordinates and Applications (textbook sections 2.11–2.14; homework problem sets 19–22).
    * Tutorial 1.
    * Assignment 1 released.

- **Week 4 (Sep 27–Oct 3):**

  - Tu, Sep 28: Lecture 6: Limits, Continuity, and Partial Derivatives (textbook sections 3.1–3.3; homework problem sets 23–25).

- Th, Sep 30:

  * Lecture 7: Multivariate Differentiability, Directional Derivatives and Gradients (textbook sections 3.4–3.5; homework problem sets 26–28).
  * Tutorial 2.

- Fr, Oct 1: Assignment 1 due.

- **Week 5 (Oct 4–10):**

  - Tu, Oct 5: Lecture 8: The Chain Rule, Implicit Differentiation, Tangent Planes and Normal Lines (textbook section 3.6; homework problem sets 29 and 30).
  - Th, Oct 7:

    * Lecture 9: Conservative Fields, Divergence and Curl (textbook section 3.7; homework problem set 31).
    * Tutorial 3.

- **Week 6 (Oct 11–17):**

  - Tu, Oct 12: Test 1.
  - Th, Oct 14:

    * Lecture 10: Line Integrals (textbook sections 4.1–4.3; homework problem sets 32–34).
    * Tutorial 4.
    * Assignment 2 released.

- **Week 7 (Oct 18–24):**

  - Tu, Oct 19: Lecture 11: Double Integrals and Iterated Integrals (textbook sections 5.1 and 5.2; homework problem sets 35–38).
  - Th, Oct 21:

    * Lecture 12: Applications to the Volume under a Surface (textbook section 5.3; homework problem set 39).
    * Tutorial 5.

  - Fr, Oct 22: Assignment 2 due.

- **Week 8 (Oct 25–31):** Fall break (no classes).

- **Week 9 (Nov 1–7):**

  - Tu, Nov 2: Lecture 13: Change of Variables in Double Integrals (textbook section 5.4; homework problem set 40).
  - Th, Nov 4:

  ∗ Lecture 14: Three-dimensional Plots (textbook section 5.5; homework problem set 41).
  ∗ Tutorial 6.

- **Week 10 (Nov 8–14):**

  – Tu, Nov 9: Test 2.
  – Th, Nov 11:

    ∗ Lecture 15: Parametric Equations of Surfaces (textbook section 5.6; homework problem set 42).
    ∗ Tutorial 7.

- **Week 11 (Nov 15–21):**

  – Tu, Nov 16: Lecture 16: Surface Integrals and Some Applications (textbook sections 6.1 and 6.2; homework problem set 43).
  – Th, Nov 18:

    ∗ Lecture 17: Green's Theorem (textbook section 6.3; homework problem set 44).
    ∗ Tutorial 8.

- **Week 12 (Nov 22–28):**

  – Tu, Nov 23: Lecture 18: Stokes' Theorem (textbook section 6.4; homework problem set 45).
  – Th, Nov 25:

    ∗ Lecture 19: Triple Integrals (textbook sections 6.5 and 6.6; homework problem set 46).
    ∗ Tutorial 9.
    ∗ Assignment 3 released.

- **Week 13 (Nov 29–Dec 5):**

  – Tu, Nov 30: Lecture 20: Describing Solids in Cylindrical and Spherical Coordinates (textbook section 6.7; homework problem set 47).
  – Th, Dec 2:

    ∗ Lecture 21: The Divergence Theorem (textbook section 6.8; homework problem set 48).
    ∗ Tutorial 10.
  – Fr, Dec 3: Assignment 3 due.

- **Week 14 (Dec 6–12):**

- – Tu, Dec 7: Lecture 22: Taylor Polynomials, Maxima and Minima, Lagrange Multipliers (textbook sections 7.1–7.3; homework problem sets 49 and 50).
- – Th, Dec 9:
  - ∗ Lecture 23: Volumes of Solids of Revolution, Centroids and Centers of Mass, and the Area of a Surface (textbook sections 7.4–7.6; homework problem set 51).
  - ∗ Tutorial 11.

- **Exam period (Dec 11–23):** Final exam (exact date and time to be announced).