ACM 95a/100a Introductory Methods of Applied Mathematics for the Physical Sciences

Winter 2022

Lectures: Via pre-recorded videos on YouTube: links will be posted on Piazza on Mon, Wed, & Fri at 11am PT.
Instructor: Konstantin (Kostia) Zuev
Email: kostia@caltech.edu (please include “95a” or “100a” in the subject line)
Office Hour: Tue 1pm-2pm, outdoor Chalkboard Space on the West side of Annenberg (or by appointment)
Head TA: Max Popken (mpopken@caltech.edu)
TAs and OHs: https://piazza.com/caltech/winter2022/acm95a100a/staff
TA Office Hours: In person and via Zoom, you are welcome to attend as many office hours as you like.

Course Description
This course introduces students to the fundamental concepts and methods of applied mathematics. The course consists of two parts: complex analysis and ordinary differential equations (initial value problems). The list of topics includes:

- **Complex Analysis**: complex numbers, complex plane, Euler’s formula, regions in the complex plane, functions of complex variable, limits and continuity, stereographic projection, complex derivative, the Cauchy-Riemann equations, analytic functions, complex exponential, trigonometric functions, logarithmic function, branches, branch cuts, branch points, power function, roots of unity, contour integrals, equivalence theorem, the Cauchy-Goursat theorem, deformation of paths, Cauchy’s integral formula, derivatives of analytic functions, Morera’s theorem, sequences and series, Taylor series, power series, circle of convergence, ratio test, Cauchy-Hadamard formula, continuity, integration, and analyticity of power series, Laurent series, zeros and singularities of analytic functions, residues, Cauchy’s residue theorem, improper integrals, Jordan’s lemma, analytic continuation.

- **Ordinary Differential Equations (initial value problems)**: differential equations, general terminology, 1st order linear ODEs, 2nd order linear ODEs, existence and uniqueness, superposition principle, Wronskian, fundamental set of solutions, Abel’s theorem, reduction of order, variation of parameters, Green’s functions, the Laplace transform, applications to initial value problems, shifting theorems, initial value problems with discontinuous and impulsive forcing, convolution integral, the Mellin inversion formula, linear vs nonlinear ODEs, numerical methods for 1st order nonlinear IVPs, Euler's method, backward Euler's method, approximation errors, Heun's method, Runge-Kutta methods, Adams methods, n-th order nonlinear IVPs, power series solutions, Airy's equations, ordinary and singular points, Fuchs' theorem, Euler's equations, the method of Frobenius.

Prerequisites
- Ma 1 abc, Ma 2 or equivalents.
- Some familiarity with MATLAB, e.g. ACM 11, is desired.

Textbooks

- Comprehensive Lecture Notes and Videos (will be posted on Piazza)
- **Complex Analysis**:
  - E.B. Saaf and A.D. Snider, *Fundamental of Complex Analysis with Applications to Engineering and Science*
  - J.W. Brown and R.V. Churchill, *Complex Variables and Applications*
  - M.J. Ablowitz and A.S. Fokas, *Complex Variables: Introduction and Applications*
- **Ordinary Differential Equations**:
  - W.E. Boyce and R.C. DiPrima, *Elementary Differential Equations and Boundary Value Problems*
  - E.A. Coddington, *An Introduction to Ordinary Differential Equations*
Grading

Your final grade will be based on your total score. Your total score is a weighted average of Problem Sets (60%), Midterm exam (20%), and Final exam (20%). You can increase your total score by up to 5% if you participate actively in Piazza discussions in the Q&A section. Every answer submitted before TAs or instructor answer, which is later endorsed as “good answer” by TAs or instructor, gets 1% of the total score. There are no fixed thresholds for grades, but if your total score is 90% (80%, 70%, 60%), you are guaranteed at least “A” (“B”, “C”, “D”).

Problem Sets

There will be seven Problem Sets. Problems (and solutions) will be posted on Piazza. For assignment and due dates see “Important Dates” below. Late submissions will not be accepted, but the Problem Set with the lowest score will be dropped and not counted toward your total score. Submitting wrong files or files in a wrong format is considered as a late submission. Extensions may be granted for academic, personal, or medical reasons. For extensions, please email the Head TA.

Exams

There will be two exams: Midterm and Final. The Head TA will offer a review session before each exam. Both exams are take-home, self-timed, closed-book, but open-notes (your notes): only material written or typed by your own hand may be used during exams. You can use your computer only as a typing device and for basic arithmetic operations. No other electronic devices are permitted.

Collaboration Policy

A detailed collaboration policy is given on the course website at: http://www.its.caltech.edu/~zuev/teaching/2022Winter/CollaborationACM95a100a.pdf

In general, collaboration is (very) encouraged everywhere except for the exams. Let’s help each other and learn together! If you get stuck with a homework problem, I encourage you to discuss it with other students. But remember that you will have to prepare and submit your solution by yourself. No collaboration is allowed on the exams.

Piazza

This term we will be using Piazza for most class interactions and discussions. Piazza is designed such that you can get a quick help from your classmates, TAs, and instructor. Instead of emailing questions to the teaching staff, I strongly encourage you to post your questions on Piazza because a) you will get answers much faster b) your classmates may also benefit from seeing the answers to your questions. If you wish, you could ask questions on Piazza anonymously (for classmates, but not for the TAs and instructor). If you think that your question may partially reveal the solution, you could ask your question in a “private mode”, so that only TAs and instructor will see your question. If you want to find classmates for collaboration on coursework, you can fill out a simple form “Search for Teammates” on Piazza, and I will help you to find other students.

Important Dates (All times are Pacific Times)

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<th>Available</th>
<th>Due</th>
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<tbody>
<tr>
<td>Problem Set 1</td>
<td>1pm Fri, Jan 07</td>
<td>9pm Fri, Jan 14</td>
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<td>Problem Set 2</td>
<td>1pm Fri, Jan 14</td>
<td>9pm Fri, Jan 21</td>
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<td>Problem Set 3</td>
<td>1pm Fri, Jan 21</td>
<td>9pm Fri, Jan 28</td>
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<td>Problem Set 4</td>
<td>1pm Fri, Jan 28</td>
<td>9pm Fri, Feb 04</td>
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<td>Head TA Review</td>
<td>11am Fri, Feb 04</td>
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<td>Midterm Exam</td>
<td>1pm Fri, Feb 04</td>
<td>9pm Tue, Feb 08</td>
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<td>Problem Set 5</td>
<td>1pm Fri, Feb 11</td>
<td>9pm Fri, Feb 18</td>
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<td>Problem Set 6</td>
<td>1pm Fri, Feb 18</td>
<td>9pm Fri, Feb 25</td>
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<td>Problem Set 7</td>
<td>1pm Fri, Feb 25</td>
<td>9pm Fri, Mar 04</td>
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<td>Head TA Review</td>
<td>11am Wed, Mar 09</td>
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<td>Final Exam</td>
<td>1pm Wed, Mar 09</td>
<td>9pm Wed, Mar 16</td>
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1 If you are interested in being a TA next year, try to be active on Piazza and help other students by answering their questions.
Websites

- Course website: [http://www.its.caltech.edu/~zuev/teaching/2022Winter/ACM95a100a.htm](http://www.its.caltech.edu/~zuev/teaching/2022Winter/ACM95a100a.htm)
- Links to video lectures, lecture notes, problem sets, exams, solutions, updates, announcements, and class discussions will be managed via Piazza. Here is the Piazza page: [http://www.piazza.com/caltech/winter2022/acm95a100a/home](http://www.piazza.com/caltech/winter2022/acm95a100a/home)
- Problem sets and exams will be graded via Gradescope.
  - If you are a **registered student**, you will be enrolled on Gradescope by the end of the 1st week of classes, and you will receive a notification from Gradescope about your enrollment.
  - If you are a **registered student**, but have not been enrolled on Gradescope by the end of the 1st week of classes, please email the Head TA as soon as possible and ask to enroll you to Gradescope. Your absence on Gradescope means that, according to my records, you are not registered.
  - If you want just to **audit the course**, it is fine, you will have access to Piazza and all course materials there (please email me and I will enroll you on Piazza), but you will not have access to Gradescope and your solutions will not be graded. If you audit the course this year, you should not register for the course in future years.

To submit your solution via Gradescope, you need to create a single PDF (not images) that contains the whole solution (for example, by scanning your solution), and then upload it to Gradescope. Here are some useful links:
  - Scanning on a mobile device: [https://help.gradescope.com/article/0chl25eed3](https://help.gradescope.com/article/0chl25eed3)
  - Submitting an assignment: [https://help.gradescope.com/article/ccbpppziu9](https://help.gradescope.com/article/ccbpppziu9)

Should you have any questions regarding Gradescope, please ask on Piazza: we will have many experts there.

Suggested Study Process

To get the most out of ACM 95a/100a this term, here is my suggestion on the study process:

- Watch Video Lectures and review the corresponding Lecture Notes on the same day they are released.
- If something is not clear, ask on Piazza, and help your classmates by answering their questions.
- Very briefly summarize my notes in your own notes, learn to extract the essence.
- Start working on each Problem Set on the same day it is released (or as soon as possible after that)
- Aim at finishing each Problem Set and Exam at least 1 day before they are due.
- If you get stuck with a problem, ask for hints on Piazza (unless it is an exam problem, and then you are screwed ;-))

Wellness

It is very important to us that you succeed in ACM 95a/100a. It is also very important to us that you maintain your mental wellness throughout the course. A few points are not worth losing sleep over. Everyone on the course staff is available to chat, and you can always attend office hours for a non-academic conversation if necessary. You can also visit the counseling center ([https://wellness.caltech.edu/counseling](https://wellness.caltech.edu/counseling)) if you find you need help beyond the course staff. If you have a temporary health condition or permanent disability (either mental health or physical health related), you should contact accessibility services ([http://cass.caltech.edu/](http://cass.caltech.edu/)) if you have not already. Additionally, if there is something we can do to make your experience better, please let us know. All participants in this course must be treated with respect by other members of the community in accordance with the honor code. If you feel unwelcome or unsafe in any way, no matter how minor, we encourage you to talk to the Instructor or one of the Deans. We view these sorts of honor code violations as completely unacceptable, and we take them very seriously.

Honor Code

“No member of the Caltech community shall take unfair advantage of any other member of the Caltech community.”