18.300 Principles of Continuum Applied Mathematics

Instructor: Stuart Thomson

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Spring 2020

Lectures | TR 1:00–2:30pm (2-139)
Office Hours | TBA
Course website | http://math.mit.edu/classes/18.300/2020sp/index.html

Course description

Physical systems arising in Nature are often comprised of a large number of constituent particles, motivating the construction of mathematical models at the macroscopic level relating continuous quantities such as density, velocity, and temperature. Models of this type often take the form of partial differential equations (p.d.e.) and are derivable from conservation laws, which may then be analysed using a suite of mathematical tools.

Part I of this course will establish some of the fundamental mathematical techniques utilised in physical applied mathematics including dimensional analysis and scaling; perturbation methods; dynamical systems; and conservation laws.

The second part of the course will build on the fundamental notions established in Part I where we come to consider the modelling of continuous media, namely solids, fluids, and gases. We will then see how such models may be manipulated and analysed to study some real-world phenomena.

Physical applied mathematics is a discipline constantly in flux with the discovery of new phases of matter, ever-more sophisticated experimental techniques, and major advances in scientific computing. Thus, the final component of this course will be an investigation into and survey of the modern landscape of contemporary physical applied mathematics.

Grading

The grading for this course will be based on 5 problem sets, one in-class exam, and a final project on an area of contemporary physical applied mathematics of your choosing. The grade percentages are as follows:

| Problem sets | 70% |
| Midterm exam | 30% |

The principal aim of the final projects is to allow you to explore the landscape of physical applied mathematics on your own terms. The final project is thus graded as follows: if there is clear evidence of a well-thought-out and well-researched paper, you will receive your full problem set grades. Otherwise, problem set grades will be deducted 50%. This includes submission of a satisfactory project proposal, which I will help with.
Textbooks

There are many textbooks and materials relating to the content of this course and as such I will not prescribe any particular one. Some class materials will also be made available online. Some additional references which you may find useful are as follows:

<table>
<thead>
<tr>
<th>Title</th>
<th>Author</th>
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<tbody>
<tr>
<td>Linear and Nonlinear Waves</td>
<td>G. B. Whitham</td>
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<tr>
<td>Mathematical Models in the Applied Sciences</td>
<td>A. C. Fowler</td>
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<tr>
<td>Introduction to the Foundations of Applied Mathematics</td>
<td>M. H. Holmes</td>
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<tr>
<td>Nonlinear Dynamics and Chaos</td>
<td>S. H. Strogatz</td>
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<td>Applied Solid Mechanics</td>
<td>P. D. Howell et al.</td>
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<tr>
<td>Elementary Fluid Dynamics</td>
<td>D. H. Acheson.</td>
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Problem Sets

Problem sets will typically be issued on Tuesdays and will be due the following Thursday (see Calendar below for a tentative schedule of submission dates). Collaboration is actively encouraged, however all submitted work must be written on your own and the names of any collaborators must be listed at the top of your problem set. The first unexcused problem set will receive 75% of your score with no further unexcused problem sets accepted. Finally, all problem sets will contribute toward your final grade and are intended to assess your deeper understanding of the material beyond the lectures.

<table>
<thead>
<tr>
<th>Week, Dates</th>
<th>Topics</th>
<th>Comments</th>
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<tbody>
<tr>
<td>1, Feb 4th &amp; 6th</td>
<td>Foundations and techniques</td>
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<tr>
<td>2, Feb 11th &amp; 13th</td>
<td></td>
<td>Problem Set 1 due</td>
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<tr>
<td>3, Feb 18th &amp; 20th</td>
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<td>Presidents’ Day (no class Tuesday)</td>
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<tr>
<td>4, Feb 25th &amp; 27th</td>
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<td>Problem Set 2 due</td>
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<tr>
<td>5, Mar 3rd &amp; 5th</td>
<td>Classical continuum mechanics</td>
<td>Project proposal due</td>
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<td>6, Mar 10th &amp; 12th</td>
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<td>7, Mar 17th &amp; 19th</td>
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<td>Problem Set 3 due</td>
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<tr>
<td>8, Mar 24th &amp; 26th</td>
<td></td>
<td>Spring vacation (no classes)</td>
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<td>9, Mar 31st &amp; Apr 2nd</td>
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<td>10, Apr 7th &amp; 9th</td>
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<td>Midterm exam</td>
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<td>11, Apr 14th &amp; 16th</td>
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<td>Problem Set 4 due</td>
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<td>12, Apr 21st &amp; 23rd</td>
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<td>13, Apr 28th &amp; 30th</td>
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<td>14, May 5th &amp; 7th</td>
<td>Final presentations</td>
<td>Problem Set 5 due</td>
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<tr>
<td>15, May 12th</td>
<td></td>
<td>Final projects due &amp; last day of classes</td>
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