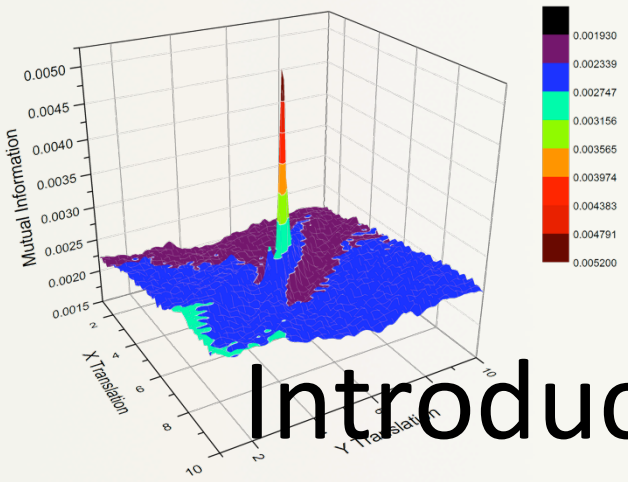
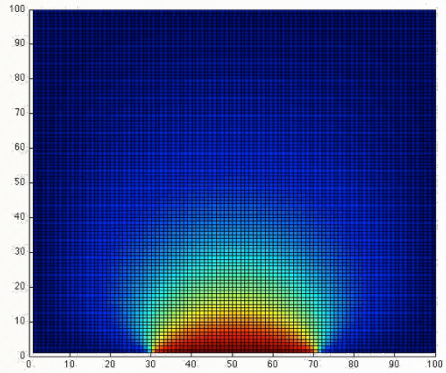




Introduction to the Course

CS 111: Introduction to Computational Science

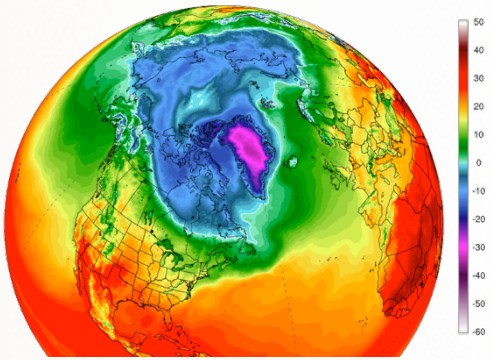
Spring 2019 Lecture #1

Ziad Matni, Ph.D.

$$\frac{\partial \sigma_{rr}}{\partial r} + \frac{1}{r}\frac{\partial \sigma_{r\theta}}{\partial \theta} + \frac{\partial \sigma_{rz}}{\partial z} + \frac{1}{r}(\sigma_{rr} - \sigma_{\theta\theta}) + F_r = \rho \frac{\partial^2 u_r}{\partial t^2}$$

$$\frac{\partial \sigma_{r\theta}}{\partial r} + \frac{1}{r}\frac{\partial \sigma_{\theta\theta}}{\partial \theta} + \frac{\partial \sigma_{\theta z}}{\partial z} + \frac{2}{r}\sigma_{r\theta} + F_\theta = \rho \frac{\partial^2 u_\theta}{\partial t^2}$$

$$\frac{\partial \sigma_{rz}}{\partial r} + \frac{1}{r}\frac{\partial \sigma_{\theta z}}{\partial \theta} + \frac{\partial \sigma_{zz}}{\partial z} + \frac{1}{r}\sigma_{rz} + F_z = \rho \frac{\partial^2 u_z}{\partial t^2}$$



A Word About Registration for CS 111

FOR THOSE OF YOU NOT YET REGISTERED:

- This class is currently **FULL** at 80 students
  - I may move the max. up depending on physical space
- If **you are on the waitlist**, you will be added automatically IF others drop the course
  - **If you do not get in by end of the week, you will not get in ☹**
- If you are not on the waitlist, you will likely not get into this class

Your Instructor

Your instructor: **Ziad Matni, Ph.D** *(zee-ahd mat-knee)*

Email: ***zmatni@ucsb.edu***

(please put **CS111** at the start of the subject header)

My office hours:
Mondays 1:00 PM – 3:00 PM, at **SMSS 4409**

Your TAs

- **Steven Munn**
- **Shiyu Ji**
- **Nick Chen (Reader)**

Sections will take place in **PHELPS 2510**

You!

With a show of hands, tell me… how many of you…

A. Are Freshmen? Sophomores? Juniors? Seniors? Other?

B. Are Engineering & CS majors?

C. Other majors?

D. Have taken **Linear Algebra**? **Differential Equations**?

E. *Liked* **Linear Algebra**? **Differential Equations**?

F. Are "comfortable" with Python? Prefer Python to other languages? Have never used Python?

G. Have written anything using LaTeX?

H. Have never used Gradescope?

Class Material

- Will be posted on our Main Website: https://ucsb-cs111.github.io/s19/
- No required textbook, but lots of good information in:
  Numerical Computing with Matlab by **Cleve Moler**
  - Online chapters – see syllabus
  - Obv. drawback: it's written for MATLAB
  - But it's ok! Because what's some syntax between CS friends!??!

- Need a refresher on Linear Algebra concepts?
  - Check out **Prof. Gil Strang**'s videos from MIT Coursera
  - Syllabus has link
  - He also has online courses on differential equations…

Software / Web Tools

- Piazza for Q&A
- Gradescope for Assignments
- LaTeX for Assignments
  - Overleaf.com or others
- Python 3.7
  - Anaconda
  - Includes Jupyter notebook, Spyder IDE

You'll discuss how to install these on your computers in sections this week

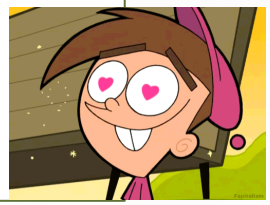
Sections are all in ***PHELP 2510***

What the !@#* is a LaTeX???

- A very popular *markup* language/system
  with high-quality typesetting
- Used to produce technical and scientific documentation.
- Allows you to consistently produce this:

$$E_i[\eta_n^k - \eta]^2 \leqslant K_i \frac{1}{\left|T_k\left(-\frac{M+m}{M-m}\right)\right|^{2n}} \|f_0 - f\|^2, \qquad (1)$$

$$K_i = E_i\left(\int_a^b x^2(t)dt\right); \quad \frac{1}{\left|T_k\left(-\frac{M+m}{M-m}\right)\right|} = \max_{m \leqslant \lambda \leqslant M} |R_k(\lambda)|.$$



Other LaTeX Examples

```
Here is a very simple table showing data lined up in columns.
Notice that I include the table in a ``center'' environment to display
it properly.
The title is created simply as another paragraph in the center environment,
rather than as part of the table itself.
\begin{center}
Numbers of Computers on Earth Sciences Network, By Type.

\begin{tabular}{lr}
Macintosh&175\\
DOS/Windows PC&60\\
Unix Workstation or server&110\\
\end{tabular}
\end{center}
```

Here is a very simple table showing data lined up in columns. Notice that I include the table in a "center" environment to display it properly. The title is created simply as another paragraph in the center environment, rather than as part of the table itself.

Numbers of Computers on Earth Sciences Network, By Type.

Macintosh	175
DOS/Windows PC	60
UNIX Workstation or server	110

```
Here is a more complicated table that has been boxed up, with a multi-column
header and paragraph entries set in one of the columns.
\begin{center}
\begin{tabular}{|l|c|p{3.5in}|}
\hline
\multicolumn{3}{|c|}{Places to Go Backpacking}\\ \hline
Name&Driving Time&Notes\\
&(hours)&\\ \hline
Big Basin&1.5&Very nice overnight to Berry Creek Falls from
either Headquarters or ocean side.\\ \hline
Sunol&1&Technicolor green in the spring. Watch out for the cows.\\ \hline
Henry Coe&1.5&Large wilderness nearby suitable for multi-day treks.\\ \hline
\end{tabular}
\end{center}
```

Here is a more complicated table that has been boxed up, with a multi-column header and paragraph entries set in one of the columns.

Places to Go Backpacking		
Name	Driving Time (hours)	Notes
Big Basin	1.5	Very nice overnight to Berry Creek Falls from either Headquarters or ocean side.
Sunol	1	Technicolor green in the spring. Watch out for the cows.
Henry Coe	1.5	Large wilderness nearby suitable for multi-day treks.

Menu h01

Source Rich Text Recompile

h01.tex

```
\documentclass[11pt]{article}

\newcommand{\numpy}{{\tt numpy}}    % tt font for numpy

\topmargin -.5in
\textheight 9in
\oddsidemargin -.25in
\evensidemargin -.25in
\textwidth 7in

\begin{document}

$$\mbox{\Large \bf CS 111: Review Quiz: Due by 6:00pm Monday, April 8}$$

\medskip

{\bf Note: You will get full credit for this quiz just by handing it in.}
The purpose of the quiz is to review some of the math background
for the class, and to help you decide if there is anything you want to
brush up on.  If any of these questions baffles you,
it will be easier to pick up the concept right now than struggle with it
later.  The TAs will answer questions about the quiz in discussion
section on April 11.



\begin{enumerate}
```

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1. Let
$$A = \begin{pmatrix} 3 & -1 & 2 \\ 0 & 1 & 2 \\ 1 & 0 & -1 \end{pmatrix}.$$
What is A^T? What is A^2? What is $A^T A$? (Do these computations both by hand and with `numpy`.)

2. The notation $||x||_2$ means the Euclidean norm (also called the 2-norm, or just the length) of the vector x. What is $||(3, 1, 4, 1, 5)^T||_2$?

3. Consider the following system of three equations in three unknowns.
$$\begin{aligned} 2x_1 - 3x_2 + x_3 &= 1 \quad (1) \\ 2x_2 + 3x_3 &= 7 \quad (2) \\ x_1 + x_3 &= 4 \quad (3) \end{aligned}$$
First write this system in the form $Ax = b$, where A is a matrix and x and b are vectors. Second, write two lines of `numpy` code that use `np.array()` to create A and b as `numpy` arrays.

4. What vector x solves the system above?

5. Write down a 2-by-2 matrix A and a 2-vector b such that $Ax = b$ has no solution. Explain in a sentence why there are no solutions.

6. Write down a 2-by-2 matrix A and a 2-vector b such that $Ax = b$ has more than one solution. Give two different solutions.

7. Is there a 2-by-2 matrix A and a 2-vector b such that $Ax = b$ has exactly two solutions? Why or why not?

8. Recall that a number λ is an *eigenvalue* of a matrix A if there is some vector x (an *eigenvector*) for which $Ax = \lambda x$. Give an eigenvalue of the following matrix, and a corresponding eigenvector.
$$\begin{pmatrix} 4 & -1 \end{pmatrix}$$

Grading

WHAT?	*HOW MANY?*	*HOW MUCH?*
• Assignments	7-8	30%
• Midterm Exams	2	40%
• Final Exam	1	30%

- Assignments:
  - Written up on **LaTeX**
  - Saved as **PDFs**
  - Uploaded to **Gradescope**
  - I'll drop the lowest assignment grade (one)

Policies

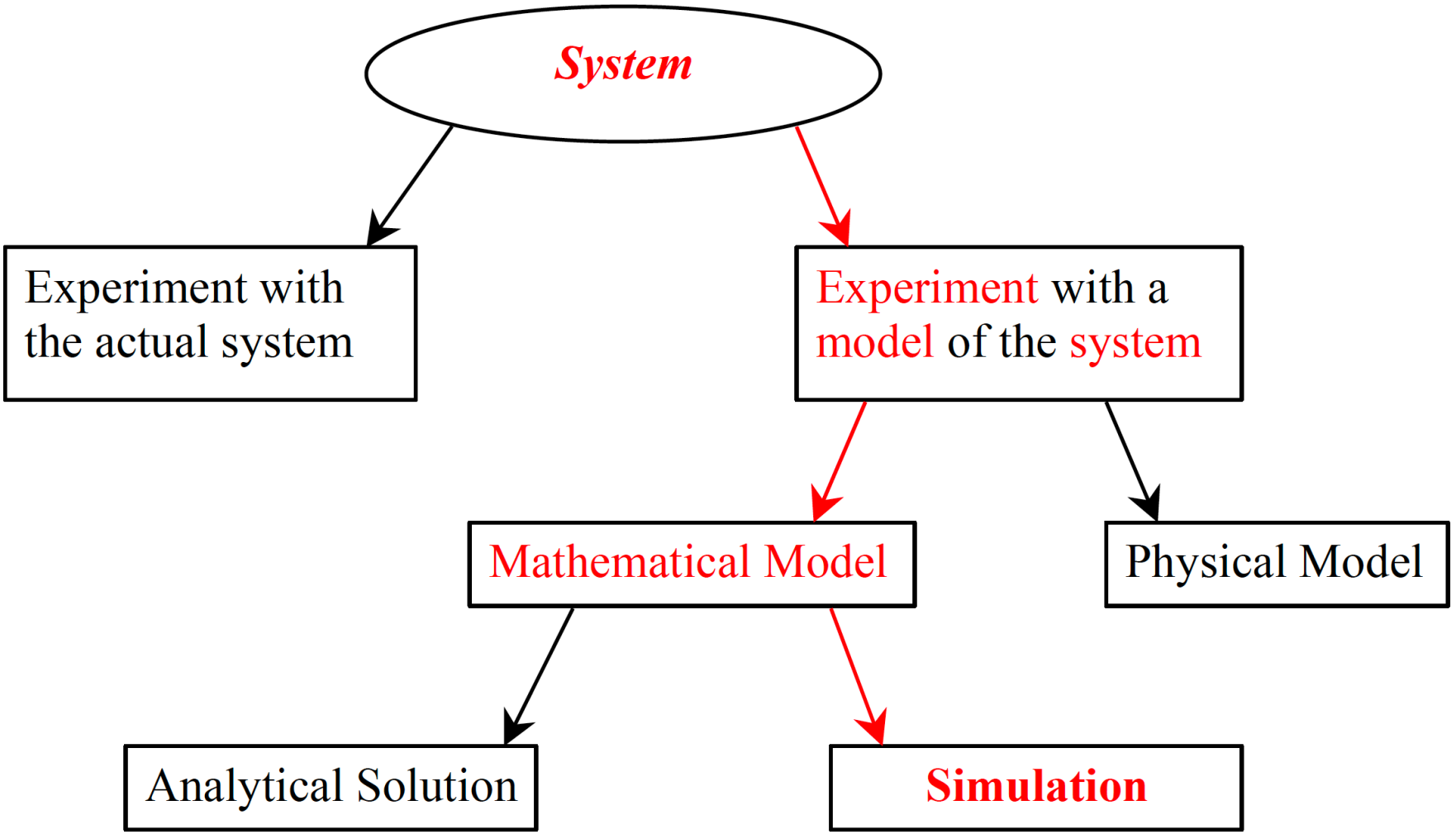
- Assignments have strict due dates
- If they're late AND within +24 hours: 20% penalty
- If they're late BEYOND +24 hours: zero grade

- No make up for any exam or assignment
- Re-grade requests for assignments + exams must be done within *1 week*

Plagiarism

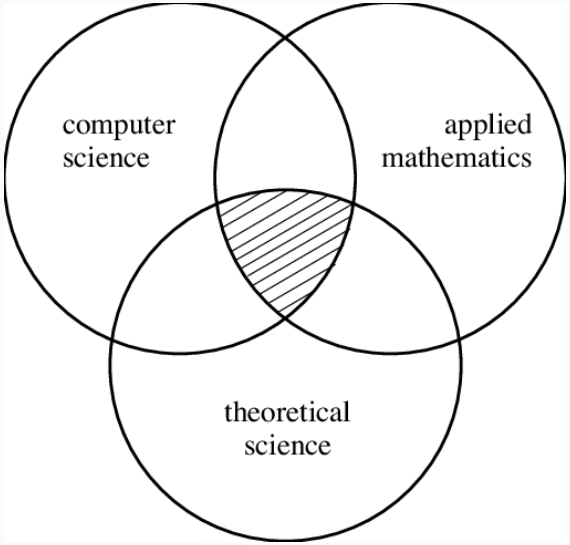
Taken very seriously! If you are caught plagiarizing:

- You will be reported to the University
- You will get a zero:
  - On the assignment (at minimum)
  - In the class, i.e. an **F** (among other penalties)
- **Please familiarize yourselves with the University's and my Academic Integrity and Honesty Policy**
  - **http://judicialaffairs.sa.ucsb.edu/AcademicIntegrity.aspx**
- **How does this apply to CS 111?**


System
Experiment with the actual system
Experiment with a model of the system
Mathematical Model
Physical Model
Analytical Solution
Simulation

Applications Of Computational Science

- Urban complex systems and other Data Sciences
- Computational finance
- Computational biology
- Computational science in engineering



Python Crash Course

get to know these…

- Comments
- **import** statements
- Basic variable types: **int**, **str**, **float**, **bool** (True/False)
- Other variable types: **list**, **tuples**
- Converting from one string type to another
- Standard output: **print()**
- Standard input: **input()** # gets input as str
- Conditionals
- For-loops
- While loops
- Functions
- File I/O

Useful Python Modules

- `math` # common math & trig functions
- `numpy` # fundamental package for scientific computing
- `matplotlib`
  # plotting package for 2D + 3D plots
- `scipy`
  # contains the above + other important
  # numerical algorithms/stats modules

Review of Some Linear Algebra

- N equations, N unknowns (**Ax** = **b**)
- Matrix view vs. Column view
- How to multiply matrices
- How to find inverse, transpose matrices
- Are matrices associative, distributive, commutative?
- Special matrices: I, U, L
- Determinants
- Eigenvalues and eigenvectors

N Linear Equations in *N* Unknowns

Example: How can we solve:

$$2x - y = 0$$

$$-x + 2y = 3$$

Using classical algebra?

Using matrix algebra? Column view (vector analysis)

A Note on Homework #1

- It's a Review Quiz
  - Concepts of Linear Algebra & Diff. Equations

- You will be given the document in BOTH **.pdf** and **.tex**
  - Use the **.tex** file as your template to create a LaTeX document
  - You will turn in your assignment as **.pdf** only on Gradescope
  - Section this week will review how you should do this

Your To-Dos

- For Thursday:
  - Brush up on your Python & Linear Algebra & Diff. Eqs.
    - We will do that in class too
  - READ UP (online) on **numpy**, **matplotlib**, and **scipy**
  - Go to your first section (Th. afternoon)
  - We'll explore more with Python and linear algebra

- For next week:
  - Turn in homework #1 (Review Quiz) – due Monday, April 8th

</LECTURE>

Use of Python

- We will be using the **numpy** module extensively
  - Numerical computing with arrays and matrices
  - https://docs.scipy.org/doc/numpy/reference/
  - http://www.numpy.org/

- Also, read more about **scipy** and **matplotlib**:
  - **scipy**: More advanced numerical computing, including sparse matrices
  - https://docs.scipy.org/doc/scipy/reference/
  - **matplotlib**: Plotting and visualization
  - https://matplotlib.org/contents.html

- A note on installs:
  - Don't have to install piece-wise, just install Anaconda (https://www.anaconda.com/distribution/)

Examples in **numpy**

Create a 2x2 matrix $\begin{bmatrix} 2 & 3 \\ -1 & 2 \end{bmatrix}$

```
import numpy

A = numpy.array( [ [2, 3] , [-1, 2] ] )          # array()
print(numpy.linalg.matrix_rank(A))               # .linalg
MyX = numpy.round(10*numpy.random.rand(5))       # .round(), .rand()
b = A @ MyX                                  # @ operator: matrix multp.

X = numpy.linalg.solve(A,b)                      # solve()
```

Let's Do this In Python!

We turn to a demonstration using

Jupyter Notebook

You will get the entire transcript posted on our class' Main Website