CS 1112
Introduction to Computing Using MATLAB

DR. CURRAN MUHLBERGER

WWW.CS.CORNELL.EDU/COURSES/CS1112
Who is Dr. Muhlberger?

And why should scientists learn to code?
About you... in CS 1112

- Undergraduates, graduates, researchers, and professionals who want (need) to learn computing
- No prior programming experience needed, but some “mathematical maturity” assumed

- You will...
  - Learn programming concepts and **good programming habits**
  - Practice problem analysis and decomposition
  - Become a **code detective**—find out “whodunit”

- Develop a “**spirit of experimentation**”
  - Not thoughtless trial-&-error but purposeful **try-then-analyze**

- Why should you learn computing?
Today’s lecture

- An example problem
- Computational problem solving
- Tour of MATLAB
- CS 1112 vs. CS 1110
- Course logistics

Lab/discussion sections start tomorrow; exercise due Sunday!
Problem: how to compute square roots?

- Suppose $A > 0$

- Observation: If $A$ is the area of a square ... then I can just measure the side length—that is $\sqrt{A}$

- Solution idea: Make a square with area $A$

- Real task: Make a sequence of increasingly square rectangles, each with area $A$
How to make a rectangle “more square”?

- If a square and a rectangle both have area \( A \) …

- then \( \sqrt{A} \) is between the length and width of the rectangle
An improvement strategy

Recipe: \( L_{\text{new}} = \frac{(L + A/L)}{2} \)

Current: \( A/L \)

Next: \( A/L_{\text{new}} \)

The average of the length and width.
A MATLAB program to make “increasingly square” rectangles

% The first rectangle...
L1 = A;
W1 = 1;
% The second rectangle...
L2 = (L1+W1)/2;
W2 = A/L2;
% The third rectangle...
L3 = (L2+W2)/2;
W3 = A/L3;
% and so on...
Some takeaways

▪ It paid to have a geometric sense
▪ A complicated computation was reduced to a sequence of elementary calculations
▪ A program is like a formula (or sequence of formulas)
Course Goals

- Develop your “computational senses,” senses that you need in computer problem-solving

- Develop a facility with the Matlab programming environment
A sense of geometry
What is the best itinerary to visit Boston, Miami, LA, Dallas?

3! = 6 possibilities

Add Seattle, NYC Austin, Denver

7! = 5040

If a computer can process 1 billion itineraries a second, how long does it take to solve a 20-city problem?

Nearly a century…
A sense of approximation & error

\[ \pi \]

\[ 1/3 = .33333... \]
A sense of randomness and probability

Random walk
Brownian motion in water
Course Goals

▪ Develop your “computational senses,” senses that you need in computer problem-solving

▪ Develop a facility with the Matlab programming environment
Computer problem-solving

Key: Algorithmic thinking

**Algorithm:**
A step-by-step procedure that takes you from a prescribed set of inputs to a prescribed set of outputs

**Program:**
The algorithm expressed in a specific language, e.g., Matlab
Computer problem-solving — Programming

- Developing instructions for the computer to execute (in order to solve some problem)
- The steps must be logical
- Use a particular language and follow the rules of the language (grammar/syntax)
Example: *Adding songs from the internet to your music library*

- Find a website with MP3 or other audio files
- Register with the music site, if required for music downloading. (Don’t steal music.)
- Click on the music file to download it onto your computer
- Drag the file to your library

Reference: iTunes
Example: *Adding songs from the internet to your music library*

- Drag the file to your library
- Click on a music file to download it onto your computer
- Find a website with MP3 or other audio files
- Register with the music site, if required for music downloading. (Don’t steal music.)

*These steps are out of order! Illogical!*
Example: *Adding songs from the internet to your music library*

- Find a website with MP3 or other audio files
- Register with the music site, if required for music downloading. (Don’t steal music.)
- Click on the music file to download it onto your computer
- Drag the file to your library

Reference: iTunes
Example: *Adding songs from the internet to your music library*

- Find a website with MP3 or other audio files
- Register with the music site, if required for music downloading. (Don’t steal music.)
- To download the computer onto your music file click it on
- file Drag your librAry to

*Bad grammar (syntax)!*
Computer programming is...

- a tool used by computer scientists, engineers, and other professionals
- not all of computer science

Think about astronomy: Telescope is a tool used by astronomers; astronomy is not about telescopes...
Course Goals

▪ Develop your “computational senses,” senses that you need in computer problem-solving

▪ Develop a facility with the Matlab programming environment
Matlab is the vehicle we use

With the Matlab environment, you can easily

- Develop programs
- Display results & ideas graphically
- Interact with large data sets (process text, image, and other files)

Matlab has extensive libraries of mathematical, statistical, simulation, and other tools. It is heavily used in engineering & sciences, both in industry and academia.
Demo!
Choices for introductory programming

- **CS 1112** – this course, Matlab
- **CS 1110** – Python

Each course satisfies the Engineering Computing Requirement. In 1112 you *will* learn procedural programming in depth and be introduced to object-oriented programming.

Each course can serve as the prerequisite for CS/ENGRD 2110 Object-Oriented Programming & Data Structure
CS 1112 focuses on computational science & engineering

Approximation, randomness, model building, sensitivity of models

- Lecture examples and homework illustrate above themes
  - Edge detection
  - Ranking web pages
  - Congressional apportionment
Some past programming assignments

- Find the US population center from census data
- Organize protein data using structure arrays
- Mozart’s musical dice game

![Path distance tool (like that in Google Earth)](image)

![Root finding tool](image)

Draw the “Betsy Ross Flag”

![Pyramid of Khufu, Egypt](image)

Total distance: 8379.3 feet

Select a path using multiple mouse clicks. Click outside the map to stop.

Select a path using multiple mouse clicks. Click outside the map to stop.
## Course comparison

<table>
<thead>
<tr>
<th>CS 1112</th>
<th>CS 1110</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ No prior programming experience</td>
<td>▪ No prior programming experience</td>
</tr>
<tr>
<td>▪ One semester of Calculus</td>
<td>▪ No Calculus</td>
</tr>
<tr>
<td>▪ <em>Focus on computational science &amp; engineering</em></td>
<td>▪ <em>Focus on software development</em></td>
</tr>
<tr>
<td>▪ Matlab</td>
<td>▪ Python</td>
</tr>
</tbody>
</table>
Online organization
CS 1112 requirements

- Attend **lecture** and be engaged
  - Synchronous modality
  - Laptops **not** required – take handwritten notes!

- Attend **lab/discussion**—get individual attention/help on weekly exercises!

- Monitor course **announcements on website**

- Do homework: 6 **programming projects**

- Take 2 **prelims** and a **final exam** at their scheduled times

- Adhere to the **Code of Academic Integrity**

4 credits $\rightarrow$ $4 \times 3 = 12$ hrs/week

In class: 2 hr lec + 1 hr dis = 3 hrs/week

**Outside class:** 9 hrs/week
Learning and integrity

- Learning is something *you* do; we can only facilitate

- Computers facilitate duplication; duplication does not facilitate learning
  - No value in being a delivery vehicle for the write answer
  - In real engineering, there is no “right answer” to copy

- Respect yourself and others
  - Craft your own programs; build confidence in your own answers
Staying healthy

- Uphold the behavioral compact
- You may always attend an online lecture or discussion instead of your assigned in-person one
Assessing your learning

- Best five* of six projects (40%)
  - Your lowest-scored project is eligible to be dropped only if you scored at least 50% on it

- Discussion exercises (5%)

- Prelim 1 (15%)

- Prelim 2 (15%)

- Final exam (24%)

- Other (1%)
  - Surveys, etc.

---

Not a competition!

Grades are based on absolute performance, not rankings
Course Materials

- **Insight Through Computing**
  
  *A Matlab introduction to Computational Science and Engineering*

- **MATLAB Student Version**
  
  Download your own copy, or use *MATLAB Online* (web browser based)
What to do now?

- Pick a course
  Take CS 1112 or CS 1110
  (add/drop: lecture and discussion and optional AEW)
- Check course website
- Start reading (see listing on course website)
- Attend discussion tomorrow