CS 100: Prelude

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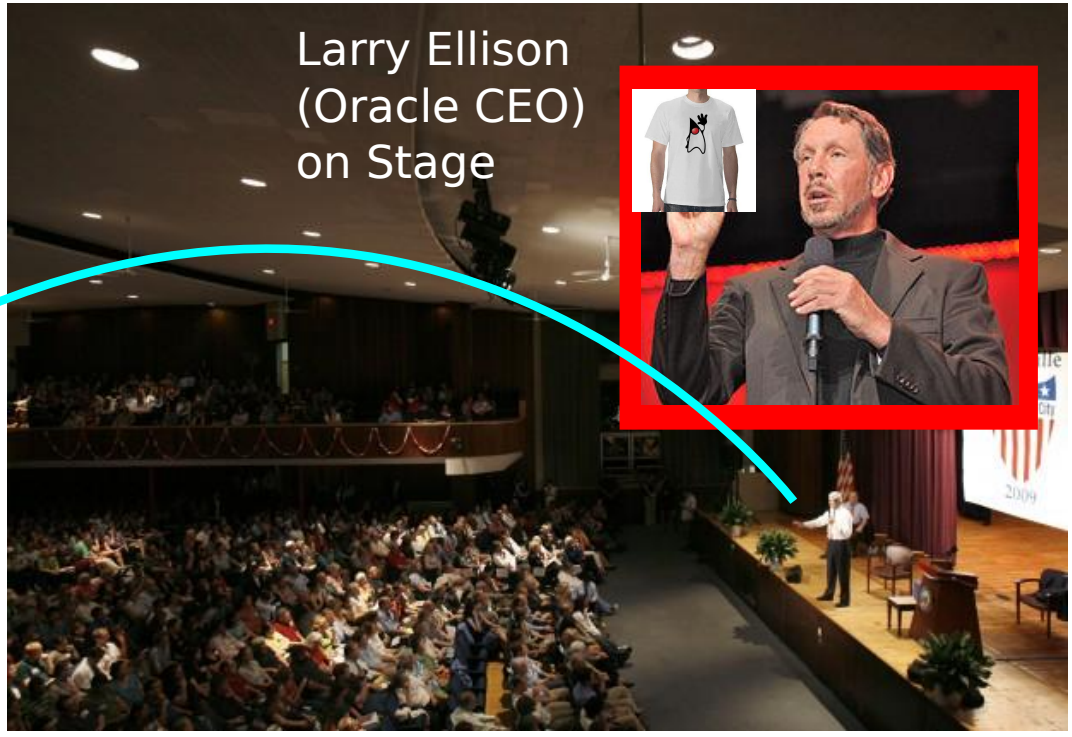
Week 1-1

The T-Shirt Launcher

Gosling wishes to fire a T-Shirt into the hands of Ellison on Stage.

James Gosling
(Java Inventor)
at T-Shirt Launcher



- Distance from Gosling to Ellison: 80 meters
- Ellison's elevation: 2 meters
- T-shirt launcher firing speed: 20 meters/second
- Launch angle: ???

Calculating a Trajectory

Gosling is awesome and remembers that the firing angle can be calculated using the following formula

$$\theta = \arctan\left(\frac{v^2 \pm \sqrt{v^4 - g(gx^2 + 2yv^2)}}{gx}\right)$$

- v is firing speed: 20 meters/second
- g is the gravitational constant: 9.8 m/s^2
- x is the target distance: 80 meters
- y is the target elevation: 2 meters

How would you solve the firing angle θ?

Typical Solution

- Grab a calculator/computer/table of sqrt/arctan values
- Plug in numbers v, g, x, y which are given
- Computer numeric answer for the angle θ
- *Fire ze missles* (er t-shirt)

Solving for the Firing Angle

Computer spreadsheets and other software are also frequently used to calculate square roots.

- Wikip: Square Root

The computation of trigonometric functions is a complicated subject, which can today be avoided by most people because of the widespread availability of computers. . .

- Wikip: Trigonometric Functions

Consider

1. Sometimes you don't have a fancy calculator
2. Is it impossible at those times to compute a square root?
3. Important: How do the machines do it anyway?

An al-Khwārizmī for Square Roots

The Babylonian Algorithm to computer the square root of S

- Initialize: Set x to a guess
- Repeat
  - Calculate $x_{next} = \frac{1}{2}\left(x + \frac{S}{x}\right)$
  - Set x to be x_{next}
  - If x^2 is close enough to S, quit

Let's see if it works, try calculating $\sqrt{18}$

Computing $\sqrt{18}$

```
s = 18   # Find my square root
x = 4    # A guess
# Repeate these steps
xnext = (1/2) * (x + 18 / x)
x = xnext
x
4.2500000000000000000
x^2 - 18
.062500000000000000
# Pretty close, but can we get closer?

xnext = (1/2) * (x + 18/ x)
x = xnext
4.24264705882352941176
x = xnext
x^2 - 18
.00005406574394463663
```

al-Khwa-what?

Abū ʿAbdallāh Muḥammad ibn Mūsā al-Khwārizmī (780-850 AD)

- Say that 5 times fast
- Well, algorithm is close enough

In the twelfth century, Latin translations of his work on the Indian numerals introduced the decimal positional number system to the Western world. His Compendious Book on Calculation by Completion and Balancing presented the first systematic solution of linear and quadratic equations in Arabic. In Renaissance Europe, he was considered the original inventor of algebra, although it is now known that his work is based on older Indian or Greek sources.

- Wikipedia

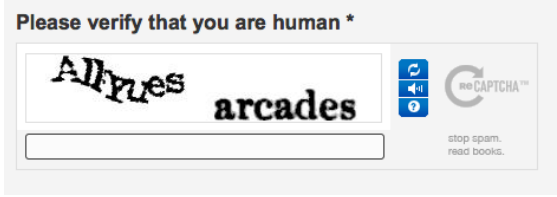
Algorithm

A series of well-defined steps that guarantee you get a correct answer.

- Something needs to do the steps
- That something usually has some primitive operations
- That something is frequently called a computer
- Computers take many forms

Algorithms you probably know

- Add 127 and 314
- Draw a 5-pointed star
- Type the words in this image



- Stand on one foot
- Classify these pictures as a cat or a dog

Which of these are computers good at?

Rise of the Machines?

Computers can execute algorithms fast which means

- They can add/subtract/multiply/divide numbers very fast
- Can draw cool pictures and produce stunning graphics

But computers are only as good as the algorithms that humans plug into them. Lots of things we can do without even thinking about it are hard to program including

- Image processing: *what text does this image contain*
- Object identification: *cat or dog?*
- Stability control: *standing on one foot*

Source: Capital Wired

Back to the Launcher: How about arctan?

A helpful formula

$$\arctan z = z - \frac{z^3}{3} + \frac{z^5}{5} - \frac{z^7}{7} + \cdots = \sum_{n=0}^{\infty} \frac{(-1)^n z^{2n+1}}{2n+1}; \qquad |z| \leq 1$$

Construct an algorithm using this formula to compute $\arctan z$

- What specific steps would you go through to compute arctan of 0.5?
- Write those steps as instructions another Human can understand
- This is is surprisingly difficult. . .

Science is what we understand well enough to explain to a computer. Art is everything else we do. -Donald Knuth

Probably something like...

Algorithm

- Initialize A to be input Z
- Initialize COUNT to be 3
- Initialize SIGN to be negative
- Repeat as long as you like
  - Compute

$$NEXT = Z^{COUNT}/COUNT$$

  - If SIGN is negative
    - Set A to be $A - NEXT$
    - Set SIGN to be positive
  - If SIGN is positive
    - Set A to be $A + NEXT$
    - Set SIGN to be negative
  - Set COUNT to be COUNT+2

Execution

```
z = 0.75
a = z
a = a - z^3/3
.60937500000000000000
a = a + z^5/5
.65683593750000000000
a = a - z^7/7
.63776681082589285715
a = a + z^9/9
.64610955374581473215

arctan(0.75)
.64350110879328438680
```

Folks Who had a Similar Problem

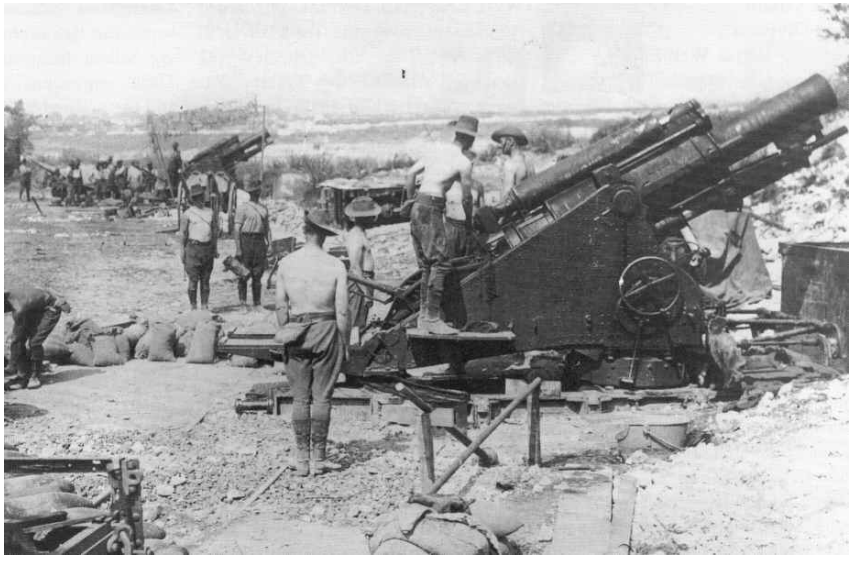


Image Source

WWI and WWII

Artillery: Allies shell Germans, Germans Shell Allies

- No computers
- No electronic calculators
- Very limited mechanical calculators
- How did they know how far to raise the gun?

Artillery Table

German Table: Degrees for given Distance/Elevation

Range		Quadrant Elevation	Drift	For 1/30 Fuze Only Fuze Setting at 0 Meters Remaining Flight	Time of Flight	Maximum Ordinate		1/16 deg Changes the Point of Impact by	Means (50 percent) Dispersion			Angle of Impact	Velocity
						Distance	Height		Range	Width	Height		
yd	m	deg	mils	deg from cross	sec	m	m	m	m	m	m	deg	m/s
	1	2*	3	4	5	6	7	8	9	10	11	12*	13
6671	6100	4 15	3	150	11.92	3515	177	43	72	3.0	12	9 1	336
6780	6200	5 2	3	153	12.22	3580	187	42	72	3.0	12	9 6	332
6890	6300	5 4	4	157	12.53	3645	197	41	72	3.1	13	9 12	329
6999	6400	5 7	4	160	12.84	3710	207	40	72	3.2	13	10 1	326
7108	6500	5 9	4	164	13.15	3775	218	39	72	3.3	14	10 7	323
7218	6600	5 12	4	167	13.47	3840	229	39	73	3.4	14	10 13	320
7327	6700	5 15	4	171	13.79	3905	240	38	73	3.4	15	11 3	317
7437	6800	6 1	4	175	14.11	3970	252	37	73	3.5	15	11 9	314
7546	6900	6 4	4	178	14.44	4035	264	36	73	3.6	16	11 15	312
7655	7000	6 7	4	182	14.77	4100	276	35	73	3.7	16	12 5	309
7765	7100	6 10	4	186	15.10	4165	289	35	73	3.8	17	12 12	307
7874	7200	6 13	4	190	15.43	4230	302	34	73	3.9	17	13 2	305
7983	7300	7 0	5	193	15.77	4295	316	33	73	4.0	18	13 9	303
8093	7400	7 3	5	197	16.11	4360	330	33	73	4.1	18	14	301
8202	7500	7 6	5	201	16.45	4424	345	32	73	4.2	19	14 7	299
8311	7600	7 9*	5	205	16.80	4488	360	32	73	4.3	19	14 14*	297
8421	7700	7 12	5	209	17.15	4552	376	31	73	4.4	20	15 5	295
8530	7800	7 15	5	213	17.50	4616	393	30	73	4.5	21	15 13	293
8640	7900	8 3	5	217	17.86	4680	410	30	74	4.6	21	16 4	291
8749	8000	8 6	5	221	18.22	4744	428	29	74	4.7	22	16 12	289

Image Source

"Computers"

Image Source

Computing ARCTAN's is more fun than a barrel of monkies!

The Original Computers

The First World War required large numbers of human computers. Computers on both sides of the war produced map grids, surveying aids, navigation tables and artillery tables.
With the men at war, most of these new computers were women and many were college educated. The British Army established a computing office for women at Girton College.
The first female computer hired by the (US) Army in 1918 was Elizabeth Webb Wilson (1898–1975). Wilson was a graduate from George Washington University and had won her school's mathematics prize.
The Human Computer and the Birth of the Information Age By David Alan Grier

The Computing Profession Grows and Dies

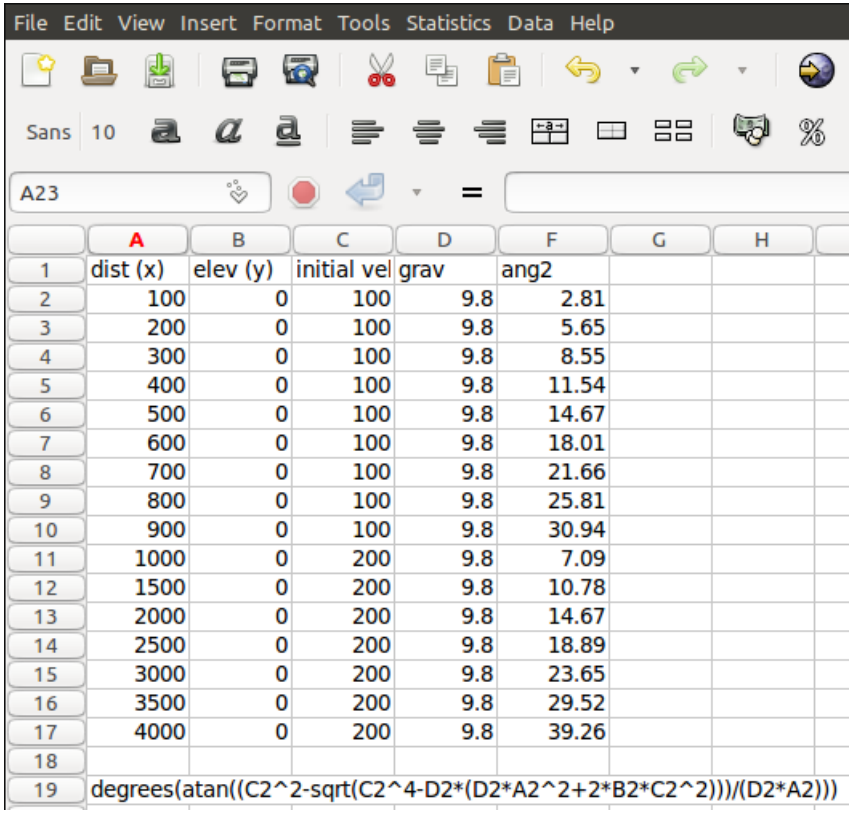
Archibald edited the journal MATHEMATICAL TABLES AND OTHER AIDS TO COMPUTATION. The journal attracted a wide readership during the Second World War, when the demand for computers expanded.

Near the end of the Second World War, the journal began publishing reports on the new electronic computing machines. It published the first reports on the ENIAC and the early Bell Labs computers.

A few scientists, such as MIT's Philip Morse, argued that human computers still had plenty to do in the electronic computer era and in 1954, he organized a large conference for human computers. This conference produced the final legacy of the human computer, THE HANDBOOK OF MATHEMATICAL FUNCTIONS. The HANDBOOK showed how to calculate most of the higher mathematical functions in common use.

The Human Computer and the Birth of the Information Age By David Alan Grier

Today: Spreadsheets are your friend



	A	B	C	D	F	G	H
1	dist (x)	elev (y)	initial vel	grav	ang2		
2	100	0	100	9.8	2.81		
3	200	0	100	9.8	5.65		
4	300	0	100	9.8	8.55		
5	400	0	100	9.8	11.54		
6	500	0	100	9.8	14.67		
7	600	0	100	9.8	18.01		
8	700	0	100	9.8	21.66		
9	800	0	100	9.8	25.81		
10	900	0	100	9.8	30.94		
11	1000	0	200	9.8	7.09		
12	1500	0	200	9.8	10.78		
13	2000	0	200	9.8	14.67		
14	2500	0	200	9.8	18.89		
15	3000	0	200	9.8	23.65		
16	3500	0	200	9.8	29.52		
17	4000	0	200	9.8	39.26		
18							
19	degrees(atan((C2^2-sqrt(C2^4-D2*(D2*A2^2+2*B2*C2^2)))/(D2*A2)))						

Tables of mathematical calculations are no sweat

- Write the formula
- Change the input data
- Paste formula, voila!
- But how does the magic happen?

But not all code is so numeric...

Check out http://code.org

- "Tutorials for beginners" will be your HW 2, get started now
- Register here: http://learn.code.org/join/QMMGKP
- Learn to program using programming blocks
- Let's try a couple

Goals for the Course

- Understand basics of how and why computers work
- Learn to program a little bit: Python plus other stuff
- Be able to post stuff to the web
- Understand a bit about computer security
- Be able to identify when it's right to make the machine do versus doing it by hand
- Discuss the way computers have changed how we do things and the new problems they have created

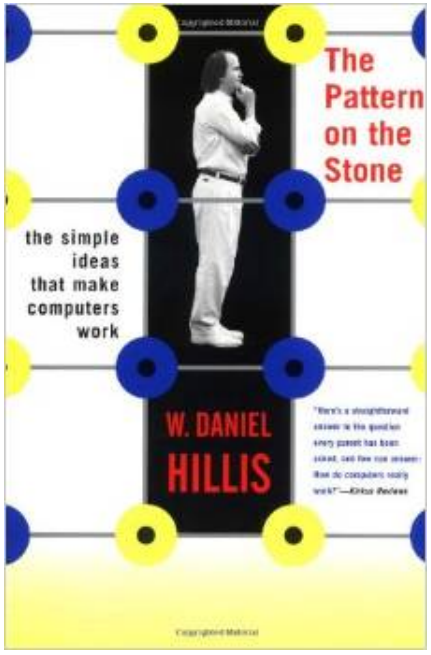
Prerequisites

- Coursework: None
- Language: Can read/write/speak English
- Math: can do arithmetic, understand formulas less complex than trajectory calculations (!)
- Have access to a computer, can install software on it

Mechanics of Lecture

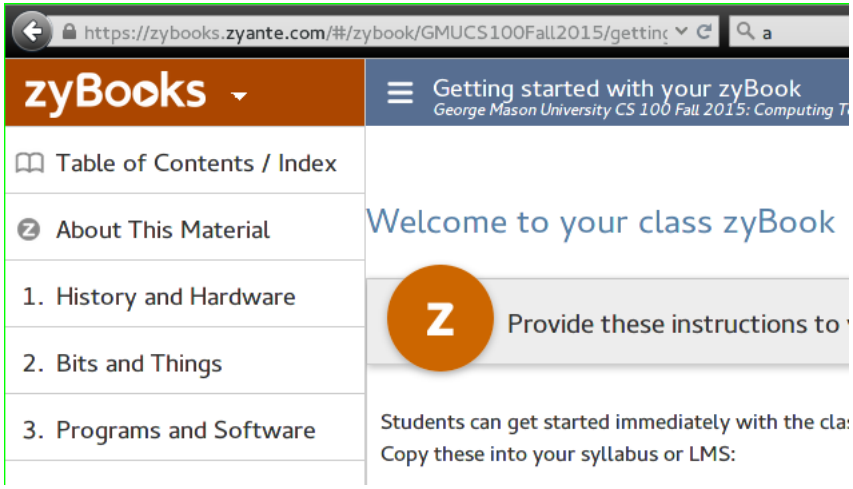
- Discuss Aspects of Computing
- Work on problems together, hand some in for credit
- Demonstrate programs and programming
- Various activities associated with computing

Textbooks 1/3



The Pattern On The Stone: The Simple Ideas That Make Computers Work
by W. David Hillis. Basic Books (1999)
Unifies the course at a high level
Copy on reserve at the Johnson Center Library

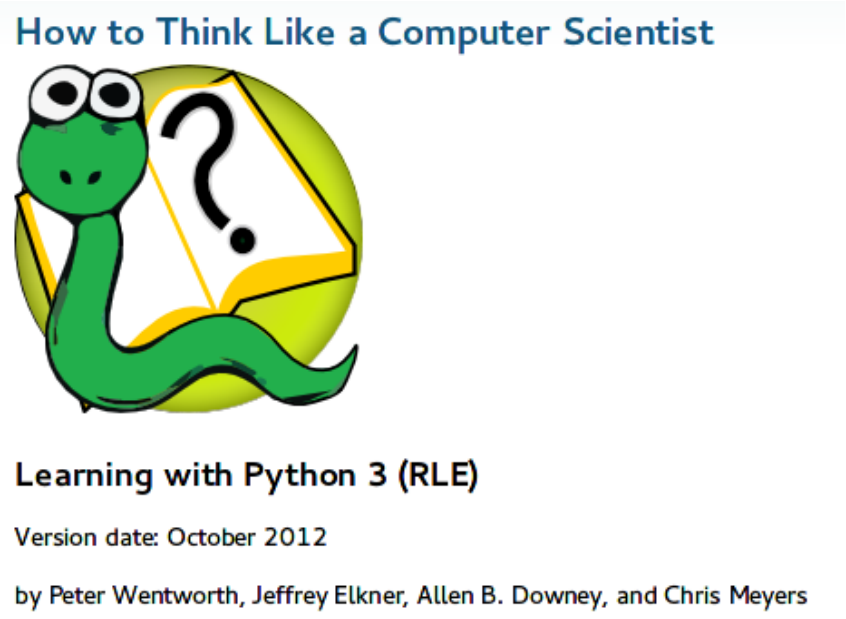
Textbooks 2/3



Computing Technology For All
by Zyante

- Purchase online at Zyante, class code GMUCS100Fall2015.
- Provides practical information and online exercises to illustrate computing.
- Completing activities and exercise in the textbook is worth 5% of your grade

Textbooks 3/3



How to Think Like a Computer Scientist: Learning with Python 3 by Peter Wentworth, Jeffrey Elkner, Allen B. Downey, and Chris Meyers
Available for free online.

We're on the Web

Piazza: Most course business

Should all have received an invitation to join the Piazza class (piazza.com)

- HW Questions
- Review questions
- Announcements
- Schedule

Blackboard only for

- Assignment submission
- Grades

Mail me for

- Personal appointments
- Unresolvable grading disputes

Coursework

Component	Count	Weight
Homework Assignments	5-7	30%
In-lecture Work	5-7	5%
Zyante Exercises		5%
Term Paper	1	10%
Mini-Exams	3-4	30%
Final Exam	1	20%

Next Time

- Read *Pattern* Chapters 0 and 1
- Start playing with code.org
- HW 1 will be posted tomorrow, due next week