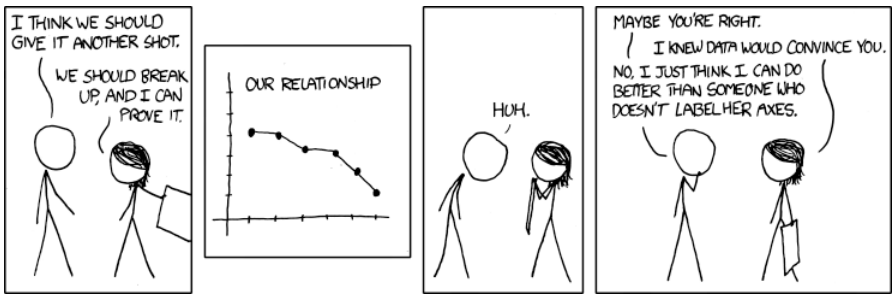
September 7, 2016 Physics 131 Prof. E. F. Redish

- **Theme Music: Wynton Marsalis**
  Where or When?
- **Cartoon: Randall Munroe**
  XKCD



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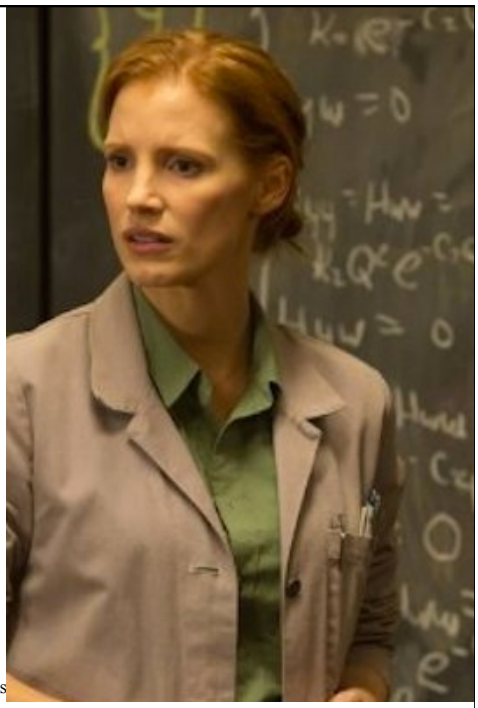
The Equation of the Day

Functions

$$x(t)$$



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Foothold Ideas: Estimation – Quantifying experience

- **Don't** look up data online or get it from friends!*
- **Don't** use your calculator! Use 1-digit arithmetic
- **Do** figure out your estimations by starting with something you can plausibly know and scale up or down
- **Do** check your answer to see if it's reasonable
- **Do** learn a small number of Useful numbers
- **Measure** your body parts

** Sometimes on exams or homework we will give you or tell you to look up some numbers that you might in principle be able to estimate but that would take too much time.*

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Reading questions: Estimation

- When would we need to use estimation techniques like this outside of physics?
- If we make an assumption, can that assumption be considered wrong on an exam? for example, if you wanted us to estimate how much one's hair grows in a year, and I assume it grows an inch/minute. This is clearly wrong, but its my assumption for the problem.
- When we guess something to start an estimation, it might vary from person to person. How can we know who is right when sometimes the value can be somehow abstract or hard to specifically calculate?

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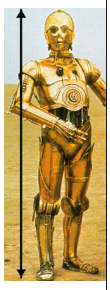
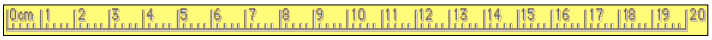
My personal scales

	inches	centimeters
First digit of thumb		
Open handspan		
Forearm (cubit)		
Full height		





Useful numbers (people)

Numbers	
Number of people on the earth	~7 billion (7×10^9)
Number of people in the USA	~ 300 million (3×10^8)
Number of people in the state of Maryland	~ 5 million (5×10^6)
Number of students in a large state university	~30-40 thousand (3×10^4)

Useful numbers (distances)

Macro Distances	
Circumference of the earth	~24,000 miles (1000 miles/ time zone at the equator)
Radius of the earth*	$2/\pi \times 10^7$ m
Distance across the USA	~3000 miles
Distance across DC	~10 miles

Useful numbers (bio)

Bio Scales	
Size of a typical animal cell	~10-20 microns (10^{-5} m)
Size of a bacterium, chloroplast, or mitochondrion	~1 micron (10^{-6} m)
Size of a medium-sized virus	~0.1 micron (10^{-7} m)
Thickness of a cell membrane	~5-10 nm (10^{-8} m)

Powers of 10 (going smaller)

https://www.youtube.com/watch?v=5CKd0aPSWe8

Cat television

- When we do science, we don't try to solve the entire universe at once.
- We restrict our considerations to a limited set of data and try to understand it. Only when we get it do we try to expand further to more situations.
- This is like looking out a window onto a small segment of the world. Since cats like to do this, I call the process "choosing a channel on cat television."

The Main Question

(for this term, at least)

- Start by choosing a big question and then refining it:

How do things move?

Why choose this?

-concepts of measurement, rate of change, and force are basic – set frame for what are appropriate terms to use to think about motion.

-ties to everyday experience so can use and learn to build/refine intuition

i.e., they don't need any causes.

Foothold ideas: Measuring "where"

- In order to specify where something is we need a coordinate system. This includes:
  1. Picking an origin
  2. Picking perpendicular directions
  3. Choosing a measurement scale

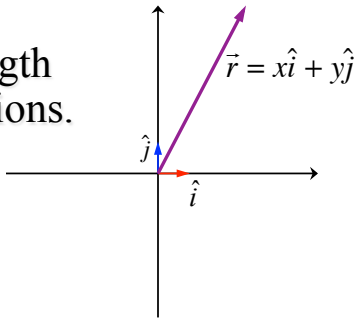
Can position be negative? What would that mean?

- Each point in space is specified by three numbers: (x, y, z), and a position vector– an arrow showing the displacement from the origin to that position.
- Vectors add like successive displacements or algebraically by $\vec{A} = A_x\hat{i} + A_y\hat{j}$ $\vec{B} = B_x\hat{i} + B_y\hat{j}$

$$\vec{A} + \vec{B} = (A_x + B_x)\hat{i} + (A_y + B_y)\hat{j}$$

Notation

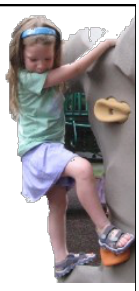
- We specify the directions we are talking about by drawing two little arrows of unit length in two perpendicular directions.
- "x" and "y" are called the coordinates and can be positive or negative.



- Note that if x is negative, it means $x\hat{i}$ is a vector pointing in the direction opposite to $\hat{i}$

https://phet.colorado.edu/sims/vector-addition/vector-addition_en.html

Foothold ideas: Vectors (2-D coordinates)



- We have 2 directions to specify. We must
  - Choose a reference point (origin)
  - Pick 2 perpendicular axes (x and y)
  - Choose a scale
- We specify our x and y directions by drawing little arrows of unit length in their positive direction. $\hat{i}, \hat{j}$
- A position vector (displacement from the origin) is written

$$\vec{r} = x\hat{i} + y\hat{j} = (x, y)$$

- x and y have units, $\hat{i}, \hat{j}$ do not.

Foothold ideas: Measuring "when"

- Time is a coordinate just like position
  - We need an origin (when we choose $t = 0$)
  - a direction (usually times later than 0 are +)
  - a scale (seconds, years, millennia)
- Note the difference between
  - clock reading, t
  - a time interval, Δt
- Positions can now be specified as functions of time: $x(t)$ and $y(t)$

This is like the difference between position and length!

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