

# Lecture 1

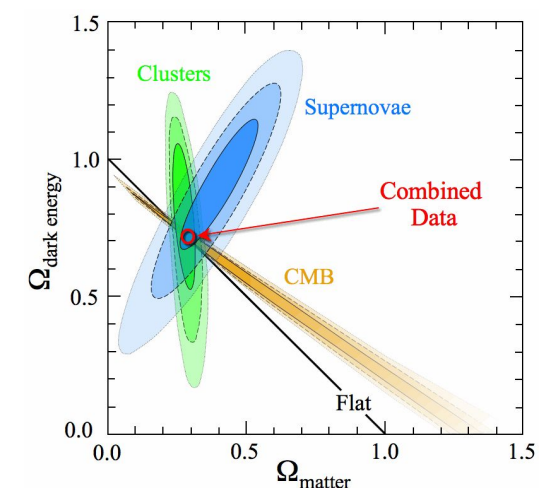
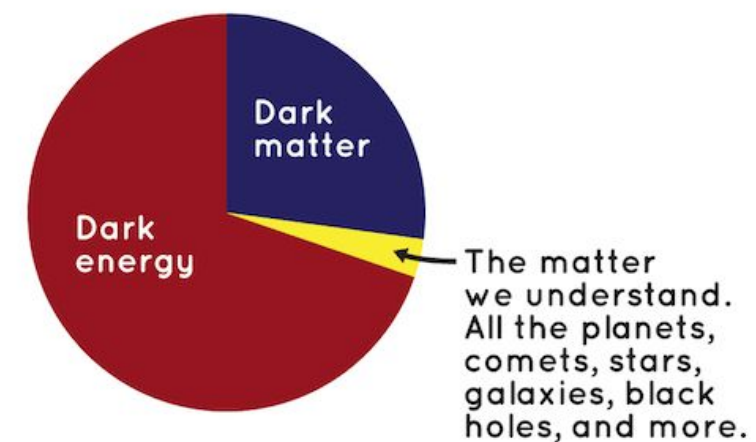
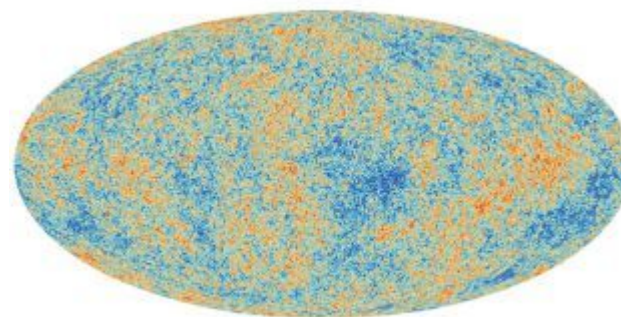
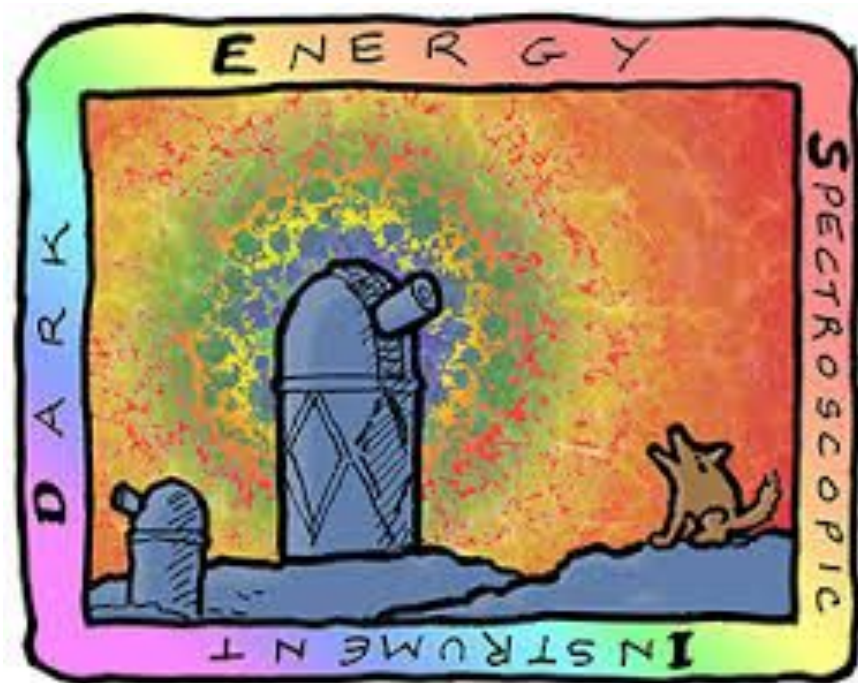
## Introductions

Ellie Kitanidis

Stanford Pre-Collegiate Studies  
Summer Institutes, 2019

# Introductions

- Who am I?
  - Ellie Kitanidis (“kitten eat us”)
  - Cosmologist, physics PhD at UC Berkeley
  - Was a physics major at Stanford University
  - My research:



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    - Or any fact about yourself!

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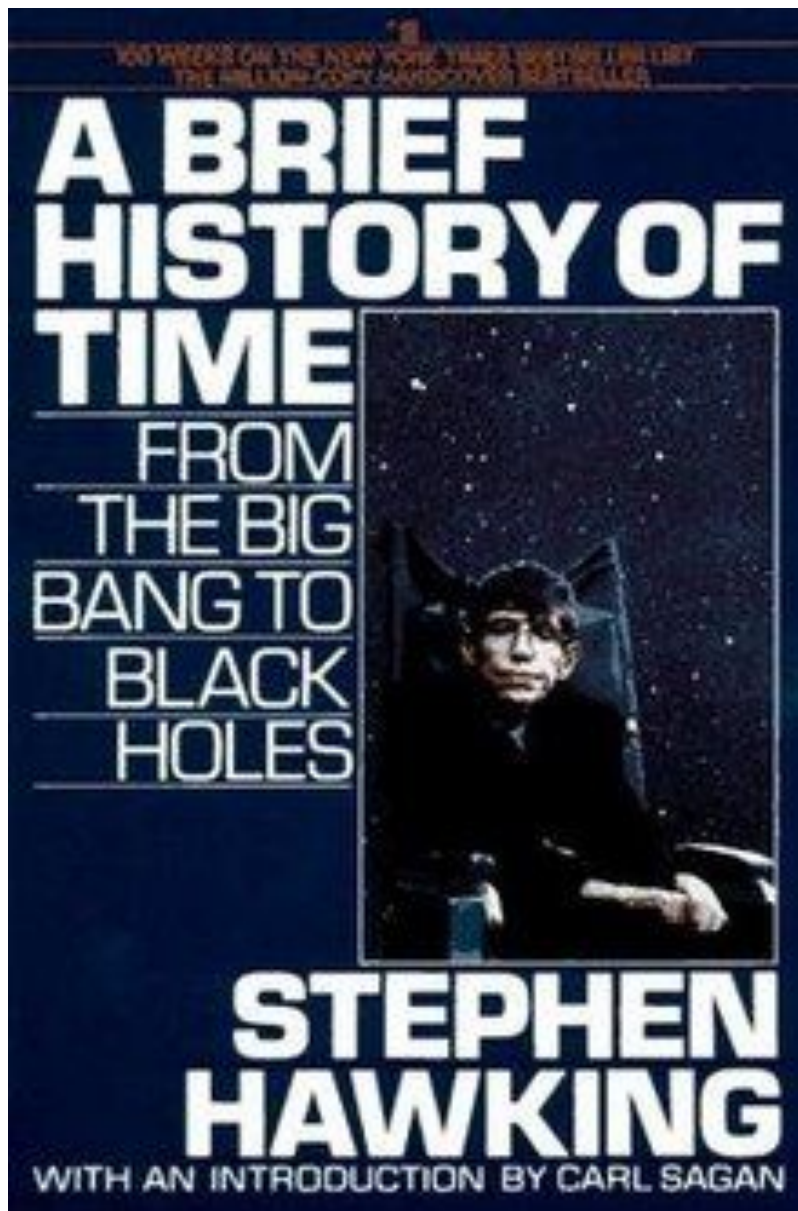
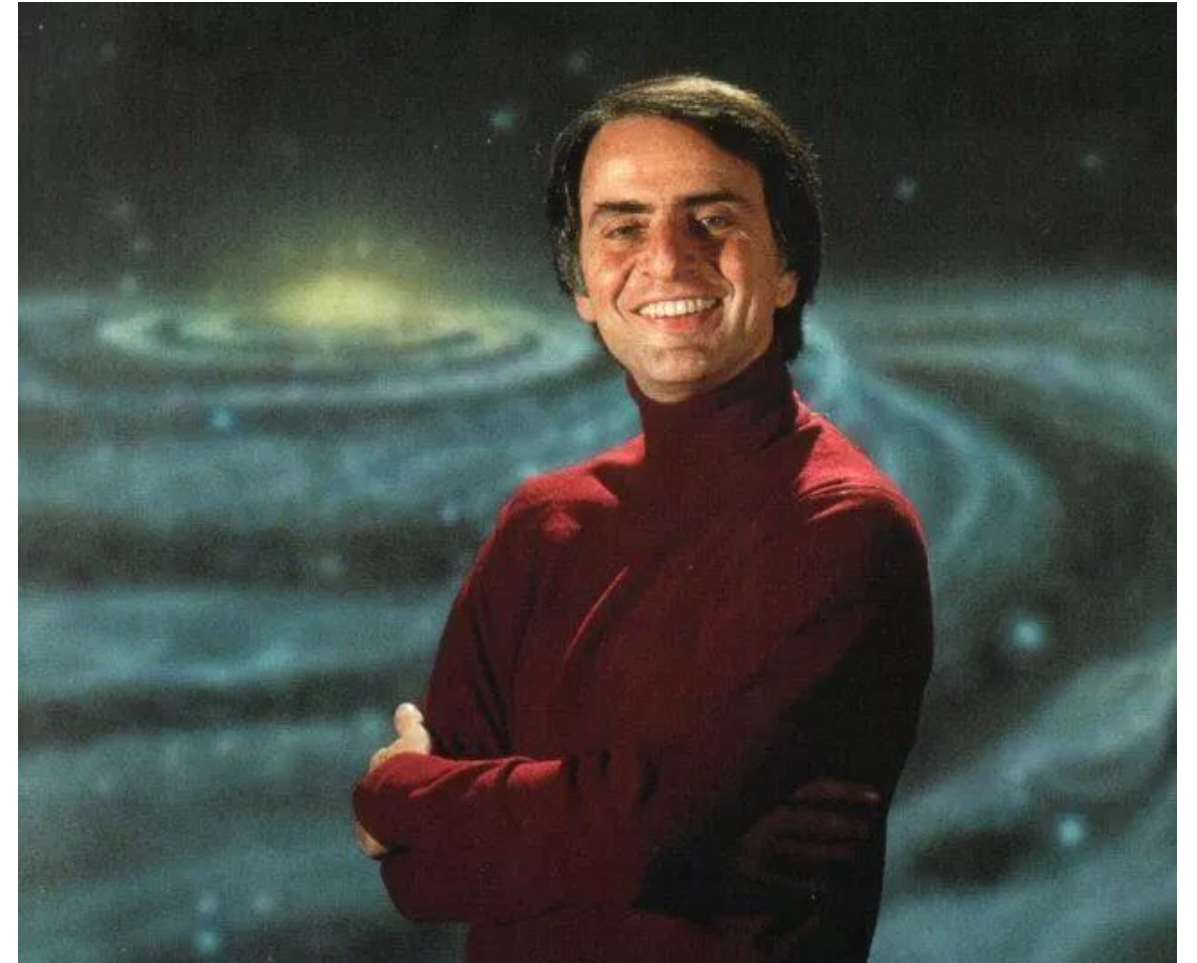
Not makeup and hair!





# Introductions

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- **What is cosmology?**

Ancient Greek for “study of the world”

**κόσμος + λογία**

# Introductions

- **What is cosmology?**

*The branch of physics devoted to understanding the structure, dynamics, composition, origin, and fate of the universe.*



# A brief history of cosmology

COSMOLOGY MARCHES ON

[www.sciencefray.com](http://www.sciencefray.com)





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# Cosmology: what it is and isn't

- On cosmological scales, it's all about **gravity**.
  - **Strong force**: short range ( $10^{-15}$  m or less)
  - **Weak force**: short range ( $10^{-18}$  m or less)
  - **Electromagnetism**: long range, but universe is charge neutral on large scales!

Course info

Syllabus

Final projects

Course website:

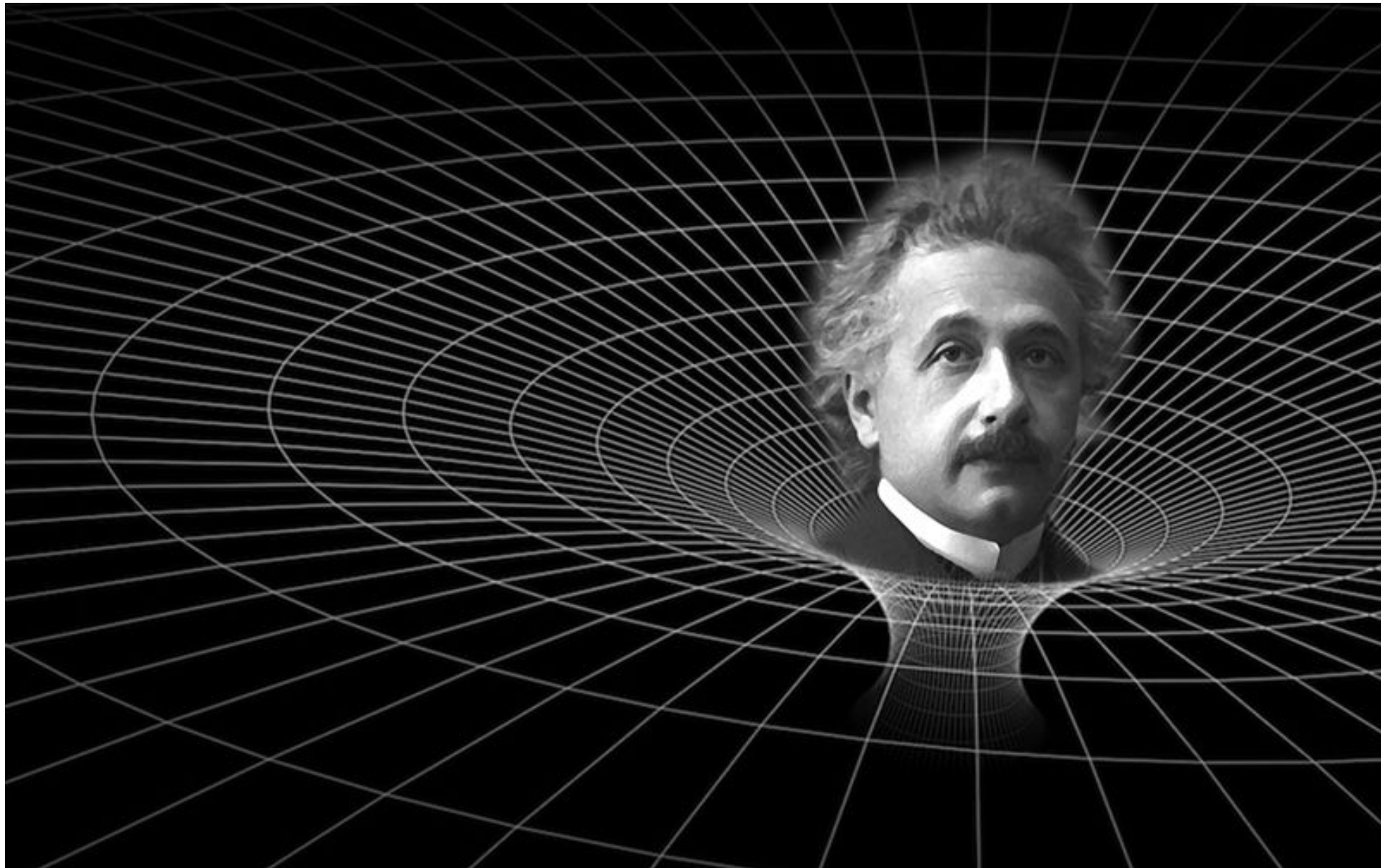
[ekitanidis.github.io/cosmo-spcs](https://ekitanidis.github.io/cosmo-spcs)

# Course methodology

- Ask questions!
  - Good reasons to ask a question:
    - You want to know the answer
    - You are confused
  - Not-so-good reason to ask a question:
    - To sound smart and impressive
- Take advantage of resources:
  - Check out list of supplementary material
  - Talk to your TAs
  - Talk to your classmates
- Let me know if the content or pace need to be adjusted!

# Course topics overview

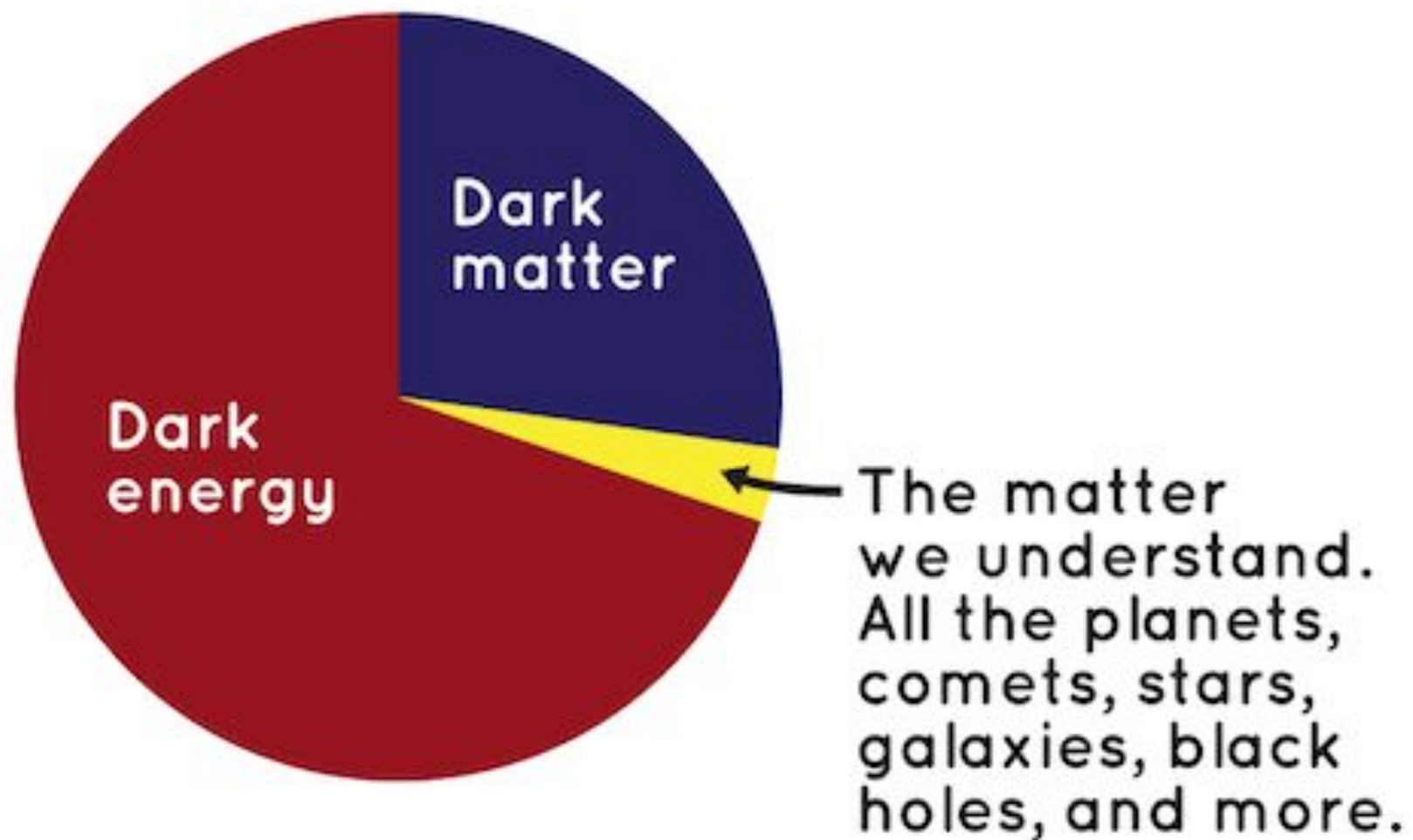
- Relativity and spacetime





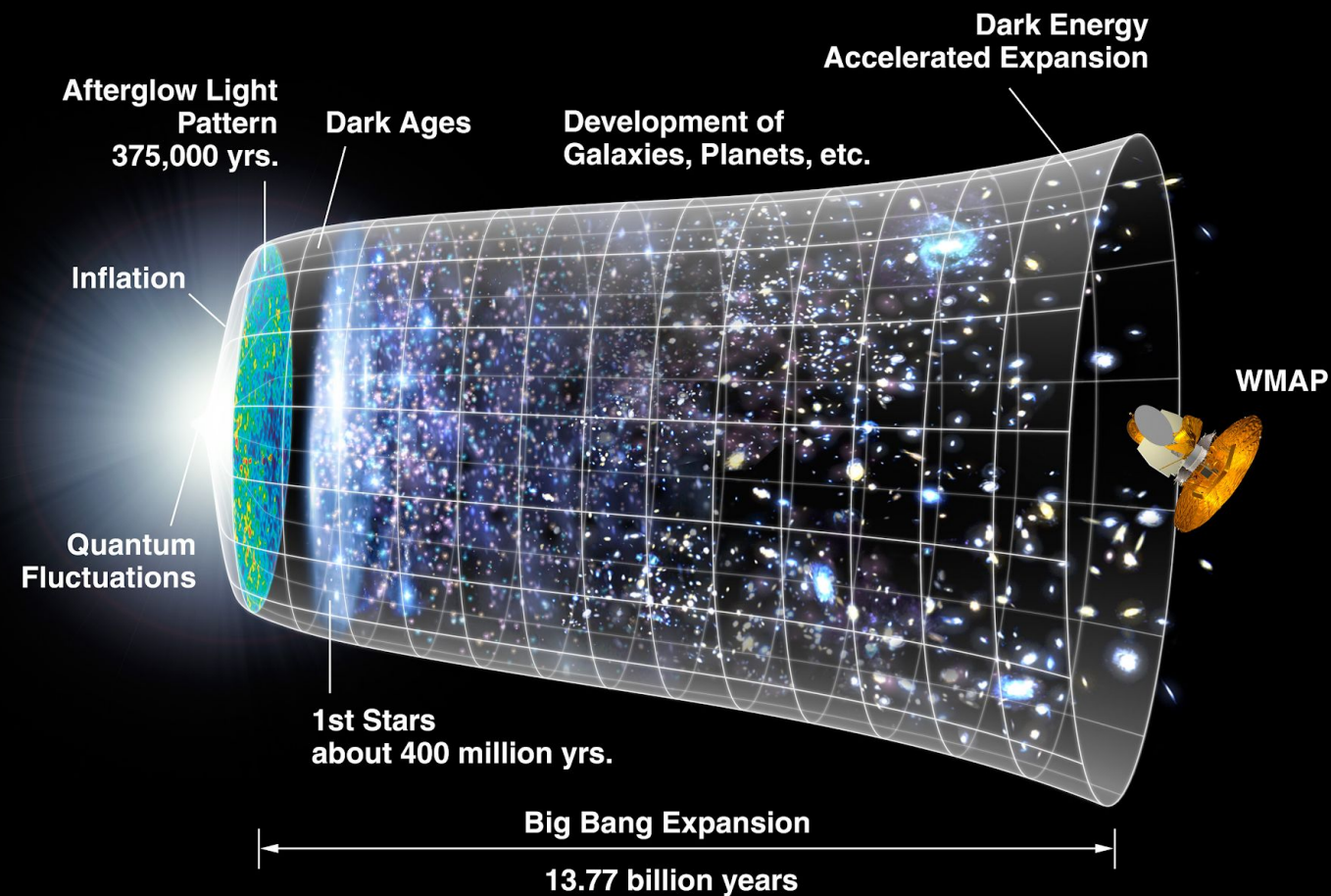
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- Dark energy and dark matter



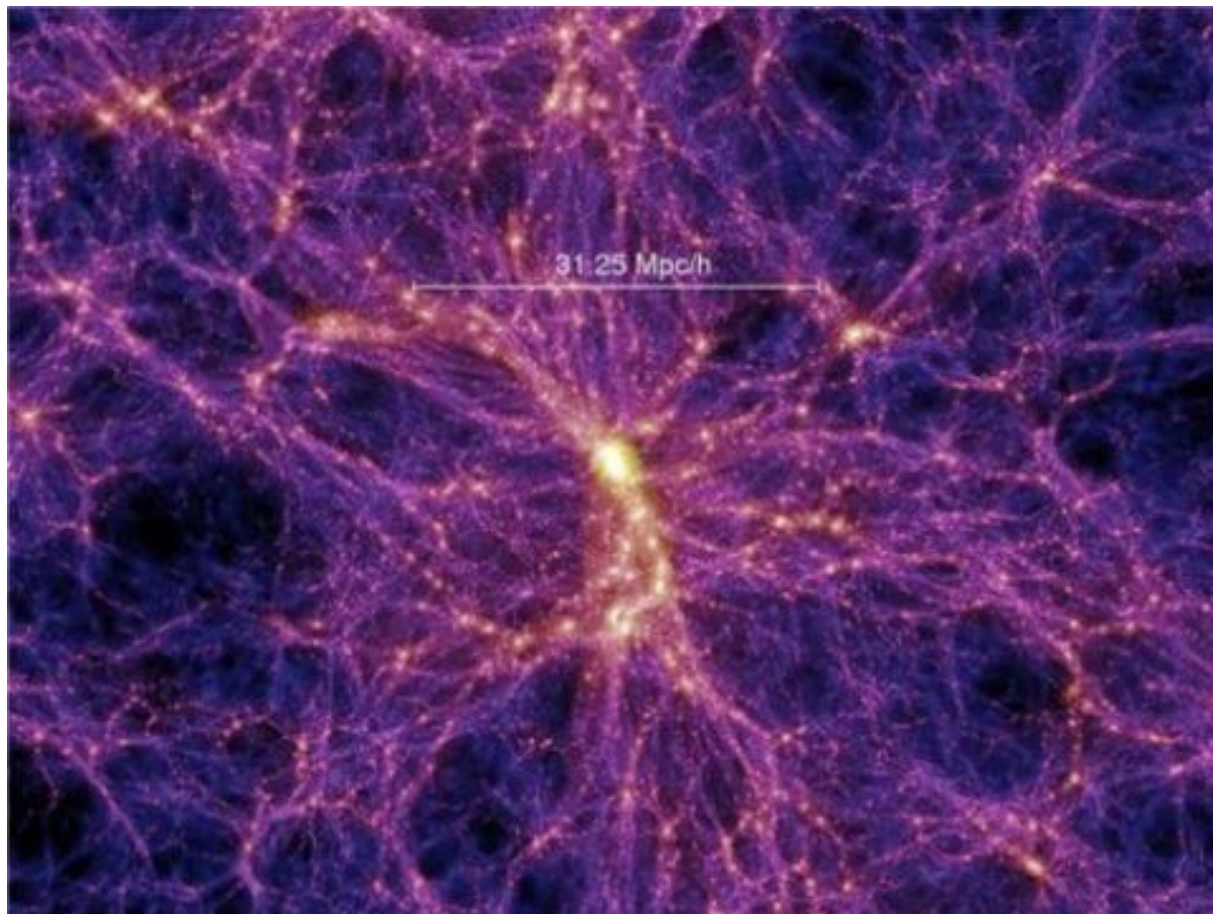
# Course topics overview

- The history of the universe



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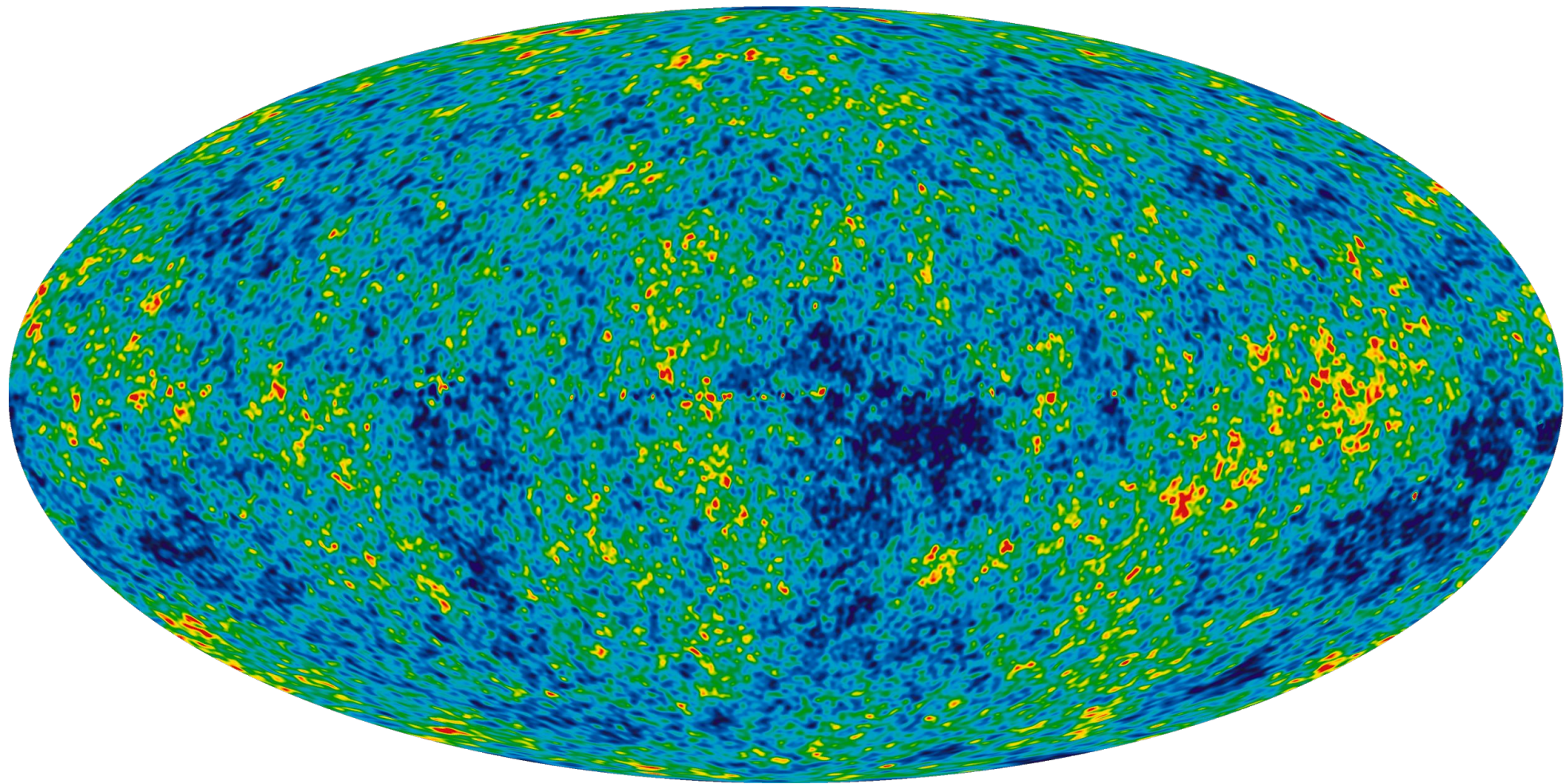
- Large-scale structure and galaxy formation





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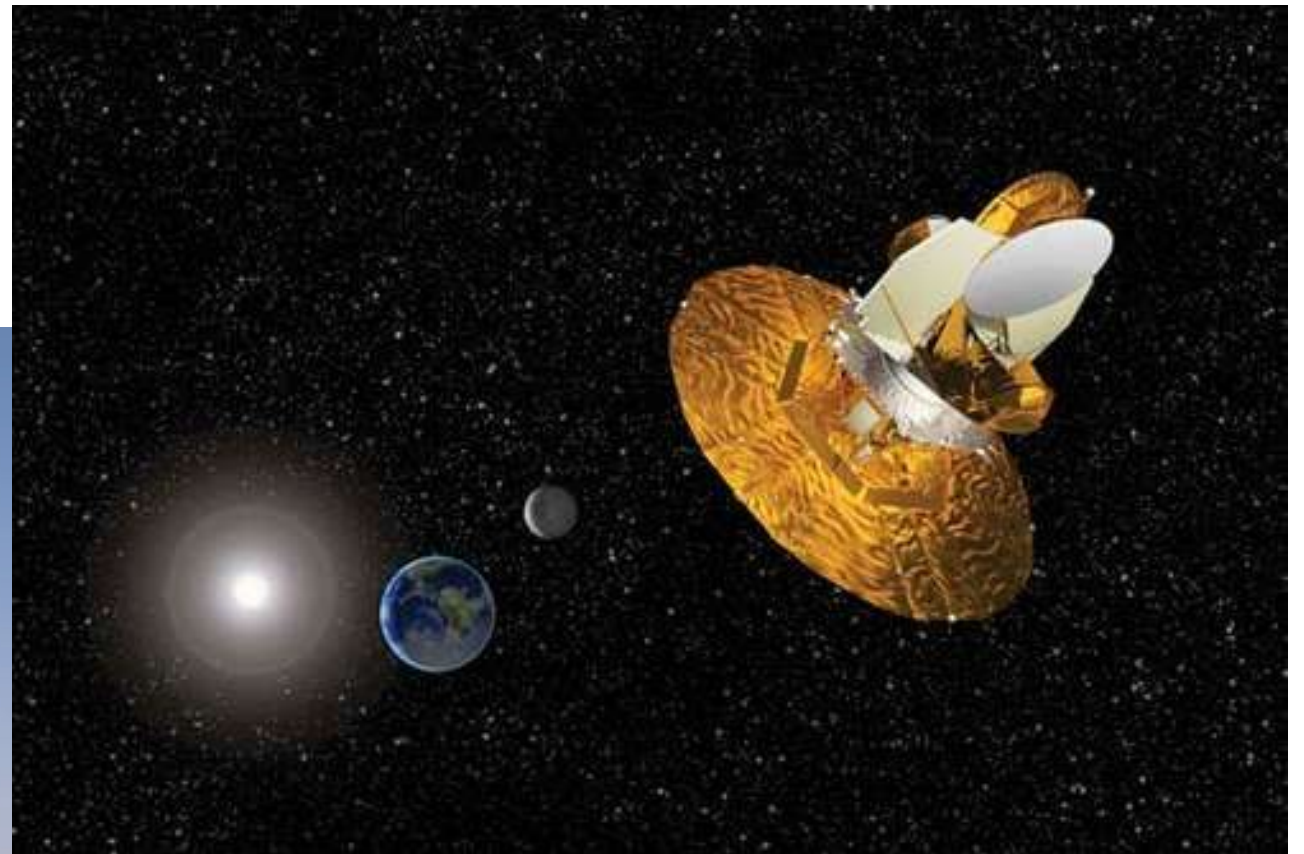
- The “first light” of the universe





# Course topics overview

- Modern methods of observation



# Field trips and special events

- Guest lecture by Professor Risa Wechshler
- Field trip to SLAC with tour of VizLab
- Liquid nitrogen ice cream party with Stanford physics majors

## **Powers of Ten (1977 film)**

<https://www.youtube.com/watch?v=0fKBhvDjuy0>

# Orders of magnitude

An order of magnitude is an approximate measure of the number of digits that a number has in the base-ten number system.



# Orders of magnitude

<b>Earth</b>	$\sim 10^7$ m
<b>Solar System</b>	$\sim 10^{13}$ m
<b>Milky Way galaxy</b>	$\sim 10^{16}$ m
<b>Visible universe</b>	$\sim 10^{26}$ m

How many orders of magnitude bigger than Earth is our Solar System?

How many “times” bigger is it?

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How many orders of magnitude bigger than Earth is our Solar System? **Answer: 6**

How many “times” bigger is it?

**Answer: 1,000,000x**

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How many orders of magnitude bigger than our solar system is our galaxy? **Answer: 3**

How many “times” bigger is it?

**Answer: 1,000x**

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How many orders of magnitude bigger than the visible universe is our galaxy? **Answer: 10**

How many “times” bigger is it?

**Answer: 10,000,000,000x**

# Orders of magnitude

**Earth diameter**  $\sim 1.5 \times 10^7 \text{ m}$

**Speed of light**  $\sim 3 \times 10^5 \text{ km/s}$

How many Earths, side by side, would light travel past in one second?

**No calculators. Watch the units!**

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Answer: about 20



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Hint: There are  $60 \times 60 = 3600$  seconds in an hour.

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Answer: about 1,000,000,000.

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Mount Everest is 29,029 feet tall. Estimate Mount Everest's height by rewriting it as a number in the form  $x \times 10^y$ , where  $x$  and  $y$  are single digit numbers.

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Answer:  $3 \times 10^4$

# Dimensional Analysis

Dimensional Analysis is a problem-solving method that uses the fact that any number or expression can be multiplied by one without changing its value.

# Dimensional Analysis

A physics teacher spends 5 minutes grading 1 student's lab. She has 150 students who turn in lab papers for each lab.

If we do 25 labs in class, how many minutes will she spend grading lab papers?

# Dimensional Analysis

Eggs are shipped from a poultry farm in trucks. Each carton of eggs holds 12 eggs. The cartons of eggs are then placed in a crate that holds 20 cartons. The cartons are packed in trucks that carry 3125 crates of eggs.

How many truckloads will it take to carry  $3.75 \times 10^6$  eggs?

# Dimensional Analysis

In the average US household, the television is on 6.75 hours a day. How many hours will have passed after 77.7 years (the average life expectancy of an American)?



# Dimensional Analysis

Jonathan raised 60 goats, then entered into a series of business transactions. He traded all the goats for sheep at an exchange rate of 5 goats for 7 sheep. Next, he exchanged all the sheep for hogs at a rate of 4 sheep for 2 hogs. How many hogs did he get?

# Dimensional Analysis

On average, there are 3 pages in every chapter of a James Patterson novel. Each book has approximately 79 chapters. James Patterson has published 58 books. Approximately how many pages has James Patterson written?

# Units of Cosmology

## Distance:

-  
$$\text{Mpc} = 10^6 \text{ pc}$$

Where 1 pc (“parsec”) = 20 trillion miles !!!

[Why Mpc? Typical scale of galaxy clusters]

Ly (light year)

Distance light travels in a year  $\sim 6 \times 10^{12}$  mi

## Masses:

Solar Mass ( $> 300,000$  x Earth mass)

# Math Survey

<https://forms.gle/NY7qFwDuooVTFhKG9>