The Art of Guessing

•••

Rainstorm, Spring 2021

The original "Fermi question"

"Trinity"

New Mexico (1945)

0.025 SEC.
N

100 METERS

What's an order of magnitude (OOM)?

Which of these numbers are farther apart?

0.001   1   3

What's an order of magnitude (OOM) ?

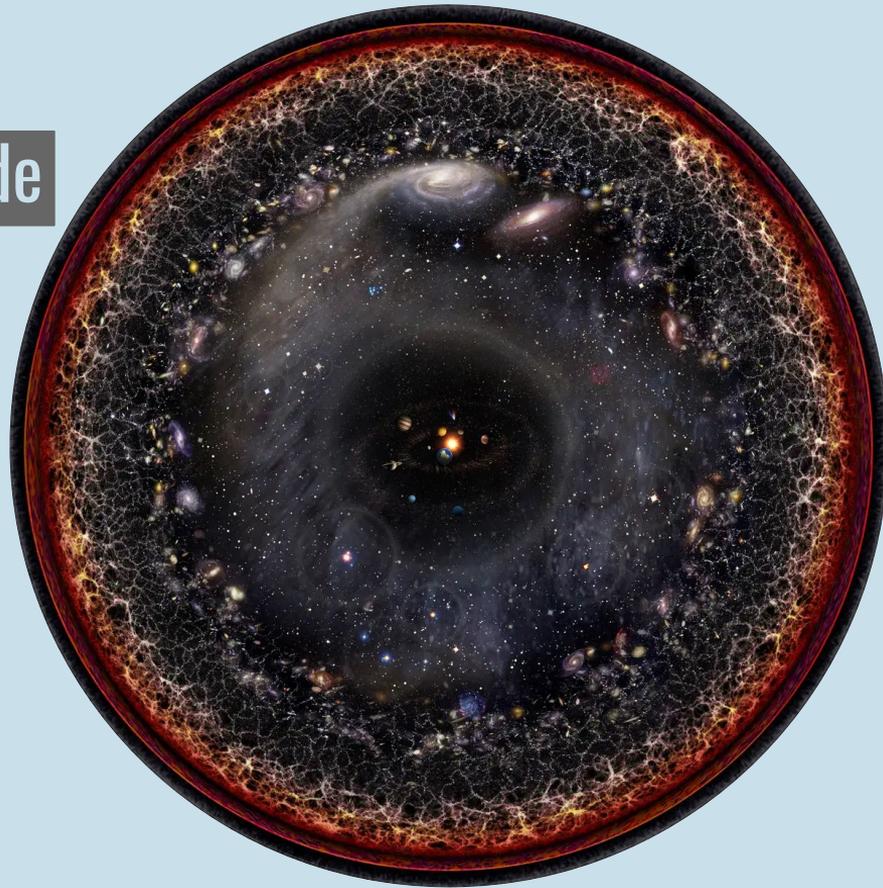Which of these numbers are farther apart?

0.001   1   3

➜ Think not **linearly**, but **logarithmically**—the natural choice

➜ The **exponent** in "scientific notation"

Hundred 10^2 Thousand 10^3 Million 10^6 Billion 10^9 Trillion 10^{12}

➜ Examples: Richter scale, decibels (sound), pH, entropy

What's an Order of Magnitude (OOM)?

Hundred	Thousand	Million	Billion	Trillion
10^2	10^3	10^6	10^9	10^{12}
100	1,000	1,000,000	1,000,000,000	1,000,000,000,000

How many dentists are there in the US?

• • •

Practice Question

One approach:

How many people in the United States?	~300 million people = $\mathbf{3 \times 10^8}$
How many people visit dentists?	75% of the population = 0.75 = **3/4**
How often do people visit dentists?	twice a year = 2 visits per person = **2**
How many customers does one dentist have in one work day?	6 patients per day (8 hour work day) = **6**
How often do people visit dentists?	50 weeks per year * 5 days a week = **250 days**

(300 million people) * (3/4) * (2 times a yr) / (250 days * 6 patients/day) = **300,000 dentists**

201,117
dentists

Number of dentists using their dental degree in some fashion as of 2020, according to the American Dental Association

Helpful tips for solving OOM Fermi Questions

- Familiarize yourself with units; build a library of numbers

Lengths	Metric	American
Length	mm, cm, m, km	inch = 2.54 cm, mile
Weight	mg, g, kg	lb, ton
Time	sec, min, hour day, year	

- If uncertain, figure out what's a reasonable max and min, and go between
- In the final computation, make sure the multiplication/division makes sense

Now it's your turn!

Rules:

- Work as a team (breakout room), and hear everyone out!
- Don't Google anything! Let your gut tell you the information you need.
- You can use a calculator for the final computation

How many seconds does the average person live?

• • •

Around 2.1 billion seconds
or 2.1 x 10^9 seconds

* For average lifespan of ~70 yrs

How many tons of food are consumed in one lifetime (in US)?

•••

Level 1 Question (B)

Around 35 tons*

* This number greatly depends on gender, diet, lifestyle, lifespan.

How many dairy cows are there in the US?

• • •

Level 2 Question (B)

Around 9 million dairy cows

What is the weight of a battleship in tons?

• • •

Level 2 Question (A)

48,592 tons for the
Iowa-class battleship

How many intelligent civilizations are there in our galaxy?

...

Level 3 Question

The Drake Equation

$$N = R_* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

N   The number of civilizations in the Milky Way galaxy whose electromagnetic emissions are detectable

R_* The rate of formation of stars suitable for the development of intelligent life (number per year)

f_p The fraction of those stars with planetary systems

n_e The number of planets, per solar system, with an environment suitable for life

f_l The fraction of suitable planets on which life actually appears

f_i The fraction of life bearing planets on which intelligent life emerges

f_c The fraction of civilizations that develop a technology that produces detectable signs of their existence

L   The average length of time such civilizations produce such signs (years)

At least one.