

Units

**"If you thought that science was certain - well,
that is just an error on your part."**

Richard Feynman

Question time

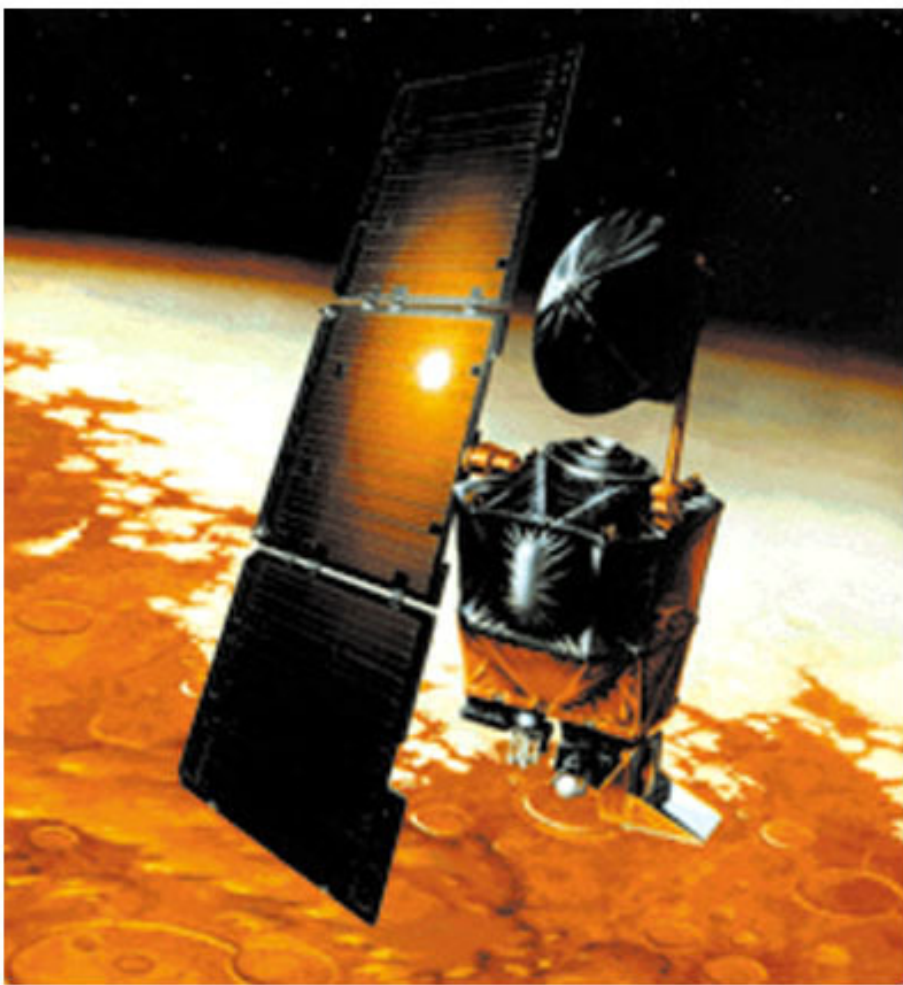
- What do you know about units
- Where did they come from?
- Why do you think we need them
- How do we know if they're accurate? I.e. : is a meter really a meter?

Fundamental Dimensions and Units

- Historically we have two sets of units in use, the Metric and Imperial System.
- In 1960 Most countries in the world adopted the metric system, even the USA, although they are very resistant to change.
- The units were standardized and the “SI” system was born. SI is from the French term “**Systeme international d’unites**”

Physics In Action

On 9/23/99, \$125,000,000 Mars Climate Orbiter entered Mar's atmosphere 100 km lower than planned and was destroyed by heat.



$$1 \text{ lb} \neq 1 \text{ N}$$

$$1 \text{ lb} = 4.45 \text{ N}$$

“This is going to be the cautionary tale that will be embedded into introduction to the metric system in elementary school, high school, and college science courses till the end of time.”

Metric System

- The metric system is based on a **base** unit that corresponds to a certain kind of measurement
 - Length = meter
 - time = second
 - Mass = kilogram

Other units that are defined in terms of these base units are called **derived units**.

Base units in the metric system

Length	metre (m)
Mass	kilogram(kg)
Time	second (s)
Temperature	Kelvin (k)
Amount of a substance	mole (mol)
Electric current	Ampere (A)
Luminous intensity	candela(cd)

Derived Units

- Speed meters per second m/s
- Volume cubic meter m³
- Force kilogram per cubic meter kg.m/s/s

**Historically the metric system was called the
MKS system (metre, kilogram, second)**

Metric & English System equivalents

Length	Mass	Volume
1 in. = 2.54 cm	1 oz = 28.35 g	1 qt = 0.946 L
1 m = 39.37 in.	1 lb = 453.6 g	1 gal = 3.785 L
1 mile = 1.609 km	1 kg = 2.205 lb	1 L = 33.81 fl oz
		1 L = 1.057 qt



Time facts...



- Did you know the world is slowing down?
- Not all days are the same length, they can vary by up to 7 minutes.
- The earth's spin is slowing down and in 1972 a "leap second" was added to each year.
- In 500 million years, each day will be 31 hours long, cant wait...

Metric Prefixes

- Prefixes plus base units make up the metric system
 - Example:
 - Centi + meter = Centimeter
 - Kilo + liter = Kiloliter

Metric System

Prefix	Symbol	Value
giga	G	10^9
mega	M	10^6
kilo	k	10^3
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}

Metric System

- So if you needed to measure length you would choose **meter** as your base unit
 - Length of a tree branch
 - 1.5 meters
 - Length of a room
 - 5 meters
 - Length of a ball of twine stretched out
 - 25 meters

Metric System

- But what if you need to measure a longer distance, like from your house to school?
 - Let's say you live approximately 10 miles from school
 - 10 miles = 16093 meters
 - 16093 is a big number, but what if you could add a **prefix** onto the base unit to make it easier to manage:
 - 16093 meters = 16.093 kilometers (or 16.1 if rounded to 1 decimal place)

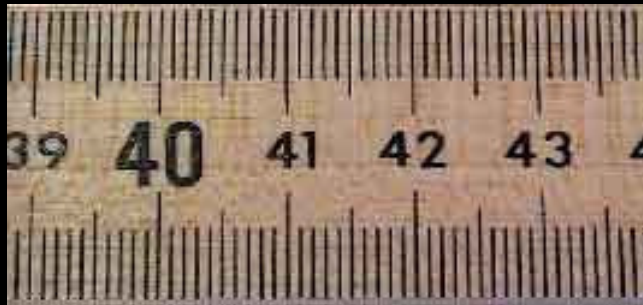
Metric System

- These prefixes are based on powers of 10. What does this mean?
 - From each prefix every “step” is either:
 - 10 times larger
 - or
 - 10 times smaller
 - For example
 - Centimeters are 10 times larger than millimeters
 - 1 centimeter = 10 millimeters

kilo	hecto	deca	<u>Base Units</u> meter gram liter	deci	centi	milli
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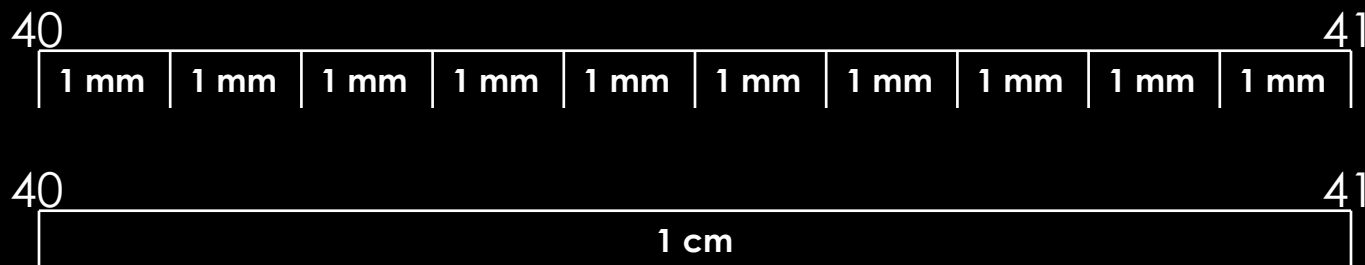
Metric System

- Centimeters are 10 times larger than millimeters so it takes **more** millimeters for the same length



1 centimeter = 10 millimeters

Example not to scale



Metric System

- For each “step” to right,
you are multiplying by 10
- For example, let’s go from a base unit to centi

$$1 \text{ liter} = 10 \text{ deciliters} = 100 \text{ centiliters}$$

$(1 \times 10 = 10) \quad = \quad (10 \times 10 = 100)$

$$2 \text{ grams} = 20 \text{ decigrams} = 200 \text{ centigrams}$$

$(2 \times 10 = 20) \quad = \quad (20 \times 10 = 200)$

kilo	hecto	deca	meter liter gram	deci	centi	milli
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Metric System

- An easy way to move within the metric system is by moving the decimal point one place for each “step” desired

Example: change meters to centimeters

1 meter = 10 decimeters = 100 centimeters

or

1.00 meter = 10.0 decimeters = 100. centimeters

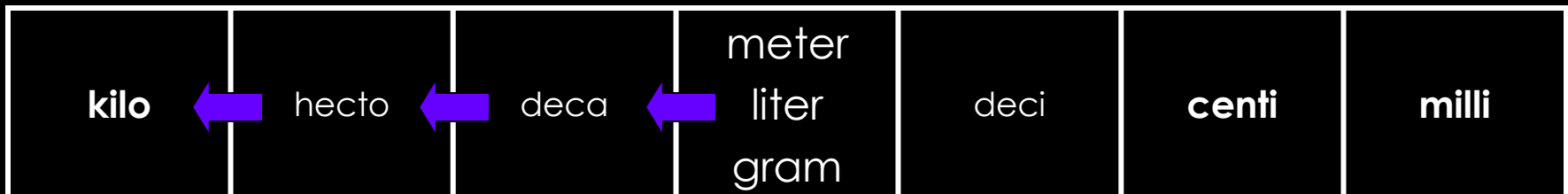


Metric System

- Now let's try our previous example from meters to kilometers:

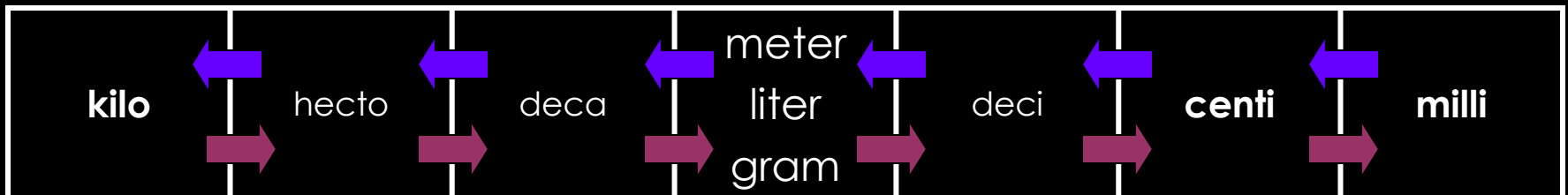
16093 meters = 1609.3 decameters = 160.93 hectometers = 16.093 kilometers

- So for every “step” from the base unit to kilo, we moved the decimal 1 place to the left (the same direction as in the diagram below)



Metric System

- If you move to the **left** in the diagram, move the decimal to the **left**
- If you move to the **right** in the diagram, move the decimal to the **right**

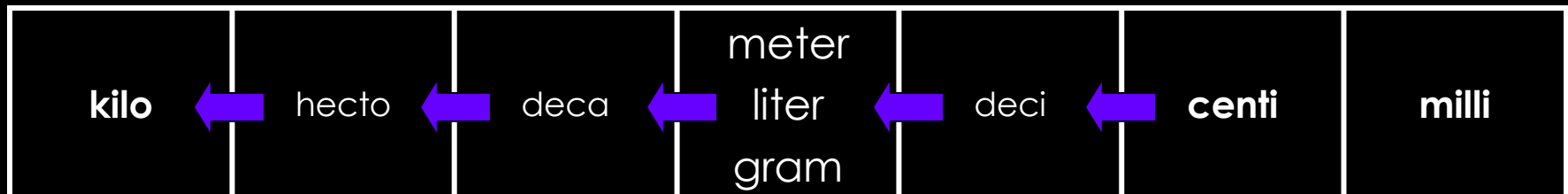


Metric System

- Now let's start from centimeters and convert to kilometers

400000 centimeters = 4 kilometers

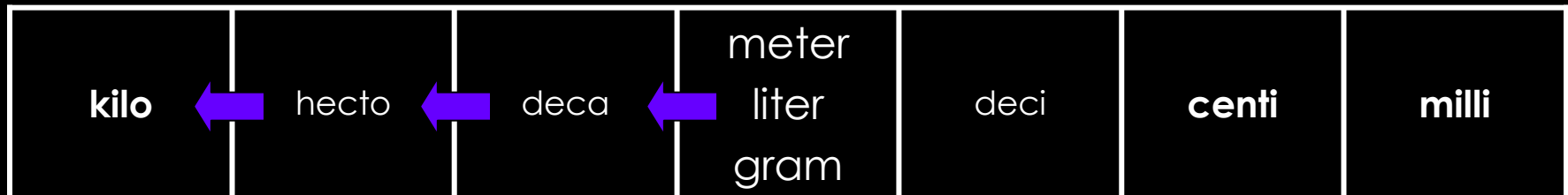
400000 centimeters = 4.00000 kilometers



Metric System

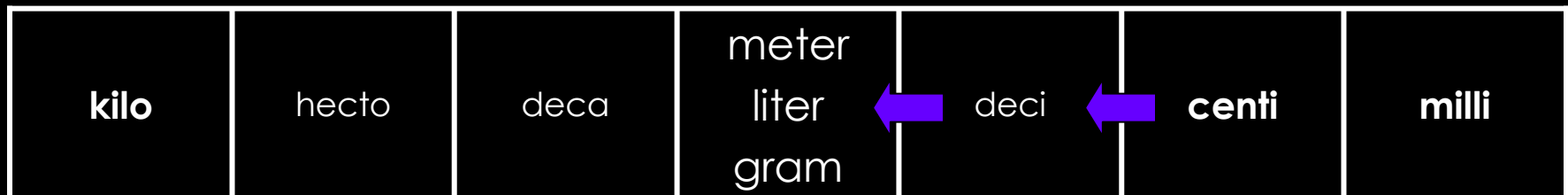
- Now let's start from meters and convert to kilometers

4000 meters = 4 kilometers



- Now let's start from centimeters and convert to meters

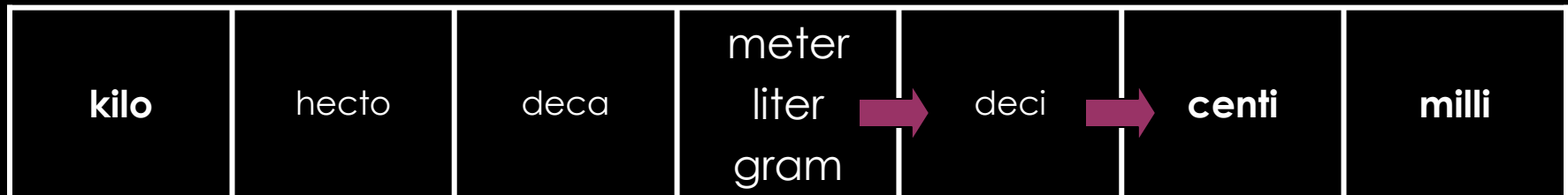
4000 centimeters = 40 meters



Metric System

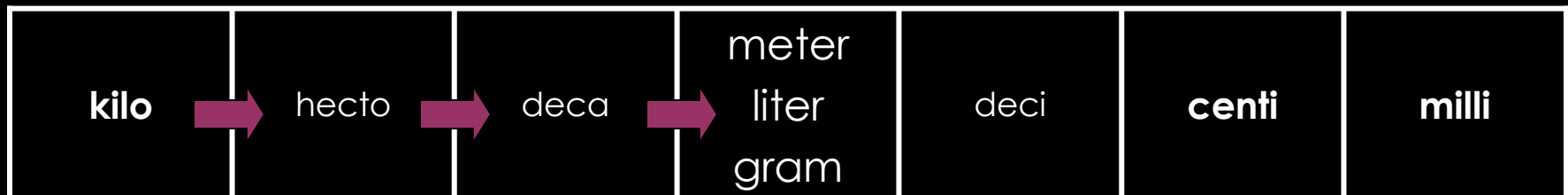
- Now let's start from meters and convert to centimeters

5 meters = 500 centimeters



- Now let's start from kilometers and convert to meters

.3 kilometers = 300 meters



Metric System

- Now let's start from kilometers and convert to millimeters

4 kilometers = 4000000 millimeters

or

4 kilometers = 40 hectometers = 400 decameters
= 4000 meters = 40000 decimeters
= 400000 centimeters = 4000000 millimeters

