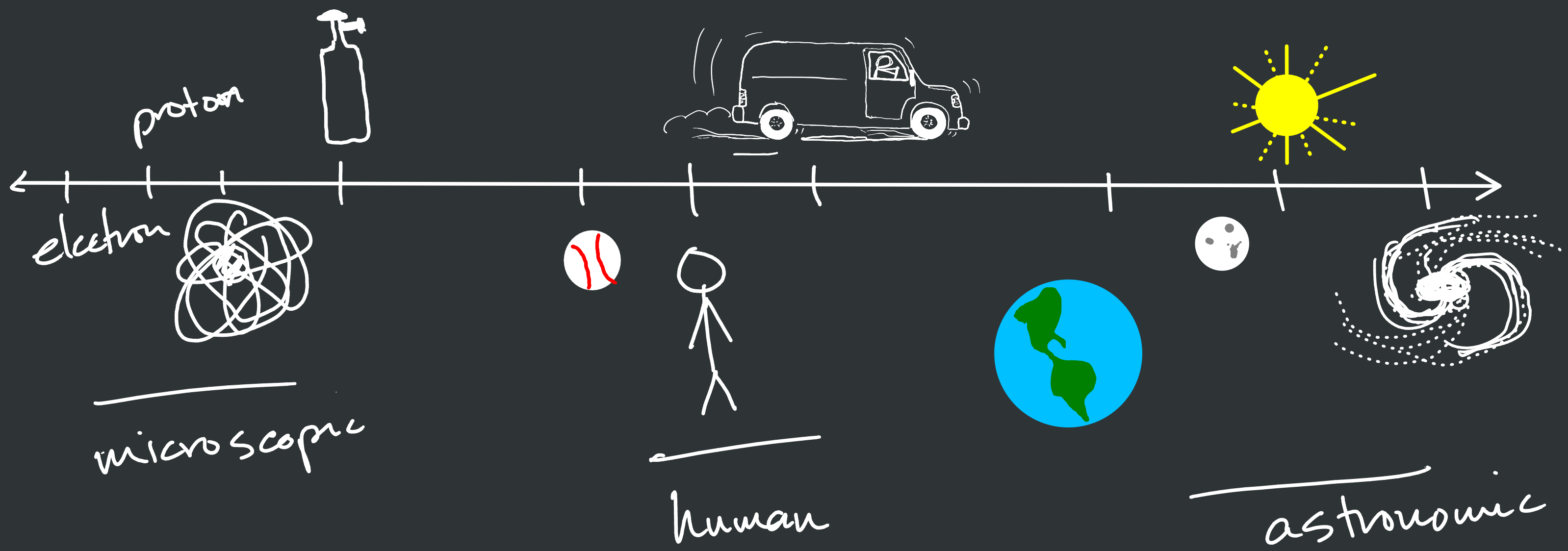
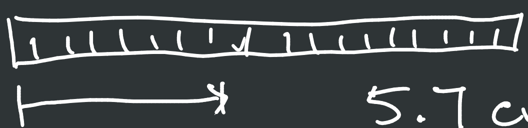
Welcome to Physics 101!

After this video you can
- discuss the scope of studying physics
- discuss the usefulness of the metric system to physicists
- convert within the metric system
- use the units of a measurement to interpret its relationship to other quantities
- connect scientific notation to the metric prefixes



Measurement - quantity that draws an analogy to a unit



5.7 cm

SI Units

→ base units

→ composite units

- length (distance) – meter (m)
- time – second (s)
- mass – kilogram (kg)

$\left.\right\}$ base unit

Composite unit

– mph

miles per hour

$\frac{\text{miles}}{\text{hours}}$

– meters per second

$\frac{m}{s}$

– [Newton]

$\left[\frac{kg\,m}{s^2}\right]$

Table 1.1 SI Base Units

Quantity	Unit Name	Symbol	Present Definition (2017)*
Length	meter	m	The distance traveled by light in vacuum during a time interval of 1/299 792 458 s.
Mass	kilogram	kg	The mass of the international prototype of the kilogram.
Time	second	s	The duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom.
Electric current	ampere	A	The constant current in two long, thin, straight, parallel conductors placed 1 m apart in vacuum that would produce a force on the conductors of 2×10^{-7} newtons per meter of length.
Temperature	kelvin	K	The fraction 1/273.16 of the thermodynamic temperature of the triple point of water.
Amount of substance	mole	mol	The amount of substance that contains as many elementary entities as there are atoms in 0.012 kg of carbon-12.
Luminous intensity	candela†	cd	The luminous intensity, in a given direction, of a source that emits radiation of frequency 540×10^{12} Hz and that has a radiant intensity in that direction of 1/683 watts per steradian.

$\longrightarrow$ larger

$\frac{1}{100}$ m $\quad \frac{1}{10}$ m $\longleftarrow$ 1 meter $\rightarrow$ 10 meters $\rightarrow$ 100 meter $\rightarrow$ 1000 meter

0.01 m $\quad$ 0.1 m

10^{-2} m $\quad 10^{-1}$ m $\quad\quad 10^{1}$ m $\quad 10^{2}$ m $\quad 10^{3}$ m

centimeter decimeter $\quad\quad$ 1 decameter $\quad$ 1 hectometer $\quad$ 1 kilometer

smaller $\longleftarrow$ $\longrightarrow$ larger

milli	centi	deci	base	deca	hecto	kilo
10^{-3}	10^{-2}	10^{-1}	10^{0}	10^{1}	10^{2}	10^{3}
mm	cm		meter			km
ms			second			
mg			gram			kg

$1243 \text{ m} \rightarrow 1.243 \cdot 10^{3} \text{ m} \rightarrow 1.243 \text{ km}$

$15000000000 \text{ m} \rightarrow 1.5 \cdot 10^{10} \text{ m}$

mantissa $\quad 15 \cdot 10^{9} \text{ m} \rightarrow 15 \text{ Gm}$

Table 1.2 SI Prefixes

Prefix (abbreviation)	Power of Ten
peta- (P)	10^{15}
tera- (T)	10^{12}
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}
pico- (p)	10^{-12}
femto- (f)	10^{-15}

Topics/Learning Outcomes:
After this video you can use the chain method to
- convert in two or more steps within the metrics system
- convert between the metric and imperial system

1.2 km to m

$$\frac{1.2\cancel{km}}{1} \cdot \underbrace{\frac{1000\ m}{1\ \cancel{km}}}_{\text{conversion factor}} = 1200\ m$$

1.2 km to cm

$$1.2\cancel{km} \cdot \frac{1000\ \cancel{m}}{1\ \cancel{km}} \cdot \frac{100 cm}{1\ \cancel{m}} = 120{,}000\ cm$$

$$1.2\cancel{km} \cdot \frac{10^3\ \cancel{m}}{1\ \cancel{km}} \cdot \frac{10^2\ cm}{1\ \cancel{m}} = 1.2 \cdot 10^5\ cm$$

$$60 \frac{miles}{hr} \to \frac{miles}{sec}$$

$$\cancel{60}^{\,1} \frac{miles}{\cancel{hr}} \cdot \frac{1\ \cancel{hr}}{\cancel{60}_{\,1}\ \cancel{min}} \cdot \frac{1\ \cancel{min}}{60\ sec} = 1/60\ \frac{miles}{sec}$$

What about?

$$60 \frac{miles}{hour} \to \frac{m}{s}$$

Topics/Learning Objectives:
After this you can
- discuss the uses of ratios
- transform English statements comparing quantities to mathematical ones
- apply the meaning of percent change
- transform from a ratio comparison to a percent change comparison and vice versa

ratio - comparison between measurements of the same type by division

- $\underbrace{\text{you pick}}_{a_1}$ twice as many apples as $\underbrace{\text{me}}_{a_2}$

a_1 is $\underset{(\times 2)}{\text{twice}}$ a_2

$\rightarrow a_1 = 2 \cdot a_2$

$\Downarrow$

$$\frac{a_1}{a_2} = 2$$

ratio

ratio, constant, factor

$\Downarrow$

$$\frac{a_2}{a_1} = \frac{1}{2}$$

different ratio

$\Downarrow$

$a_2 = \frac{1}{2} \cdot a_1 \rightarrow$ $\underbrace{\text{I picked}}_{a_2}$ half as many apples as you

a_2 is half a_1

percent change

$\underbrace{\text{I picked}}_{a_2}$ $\underline{\underline{300\%}}$ $\underline{\underline{\text{more}}}$ apples than $\underbrace{\text{I started with}}_{a_1}$. What is the $\underline{\underline{\text{ratio}}}$ of final apples to initial apples

not a ratio

$\rightarrow \dfrac{a_2}{a_1}$

$$\text{percent change} = \frac{\text{final value} - \text{initial value}}{\text{initial value}} \times 100$$

$$n\% = \frac{a_2 - a_1}{a_1} \times 100 \iff \frac{n\%}{100} = \frac{a_2 - a_1}{a_1}$$

$$\frac{n\%}{100} = \frac{a_2}{a_1} - \underbrace{\frac{a_1}{a_1}}_{1}$$

ratio

what I solve for

$$\boxed{\frac{n\%}{100} = \frac{a_2}{a_1} - 1}$$

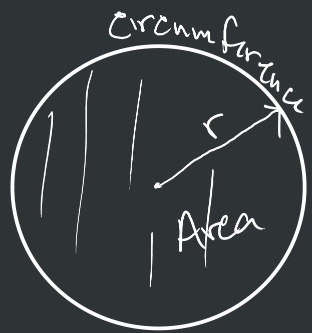
$$\frac{300}{100} = \frac{a_2}{a_1} - 1$$

$$3 = \frac{a_2}{a_1} - 1$$

$$4 = \frac{a_2}{a_1} \leftarrow \text{ratio}$$

Topics/Learning Objectives
After this video I can
- discuss the usefullness of proportionality statements
- translate useful equations out of proportionality statements
- predict how changes in one quantity will effect another dependent quantity

proportionality → relationship between different types of quantities



- circumference is directly proportional to the radius
- area is proportional to the square of the radius

First approach

direct prop → exponent of 1

→ $C = \underbrace{\text{constant}} \cdot r^1$ $\qquad$ $C = 2\pi r$

constant of proportionality – physically significant or famous "constant"

→ $A = \overbrace{\text{constant}} \cdot r^2$ $\qquad$ $A = \pi r^2$

$$\frac{A}{r^2} = \text{constant}$$

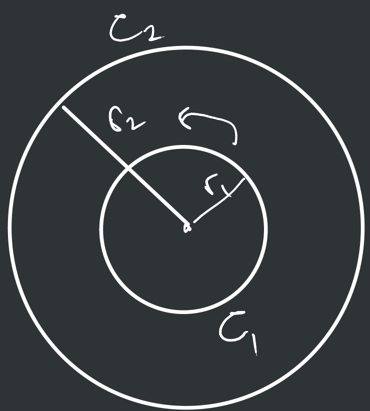
Travel time is inversely proportional to your speed.

$$\text{time} = \text{constant} \cdot (\text{speed})^{-1}$$

$$\text{time} = \frac{\text{constant}}{\text{speed}} \Rightarrow \underbrace{\text{constant}}_{\text{travel distance}} = \text{speed} \cdot \text{time}$$

Second approach

- do not need to know the constant of proportionality
- Comparing the change of one quantity and how that changes the other quantity
  - initial condition $\longrightarrow$ final condition
- compares the ratios of quantities together

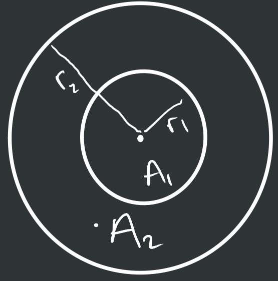


$$\rightarrow C \underset{\text{is proportional to}}{\propto} r^1 \longrightarrow \frac{C_2}{C_1} = \left(\frac{r_2}{r_1}\right)^1$$

if $r_2 = 2r_1$

$$\frac{C_2}{C_1} = \frac{r_2}{r_1} \qquad \frac{r_2}{r_1} = 2$$

$$\frac{C_2}{C_1} = 2 \longrightarrow C_2 \text{ is twice } C_1$$



$$A \propto r^2 \rightarrow \frac{A_2}{A_1} = \left(\frac{r_2}{r_1}\right)^2$$

$r_2 = 2 \cdot r_1 \leftarrow$ given

$$\frac{r_2}{r_1} = 2$$

$$\frac{A_2}{A_1} = (2)^2 = 4$$

$$\frac{A_2}{A_1} = 4 \Rightarrow A_2 = 4 \cdot A_1$$

A_2 is 4 times bigger than A_1

$$R \propto A^{-1} \rightarrow \frac{R_2}{R_1} = \left(\frac{A_2}{A_1}\right)^{-1}$$

$$\boxed{\frac{R_2}{R_1} = \frac{A_1}{A_2}}$$