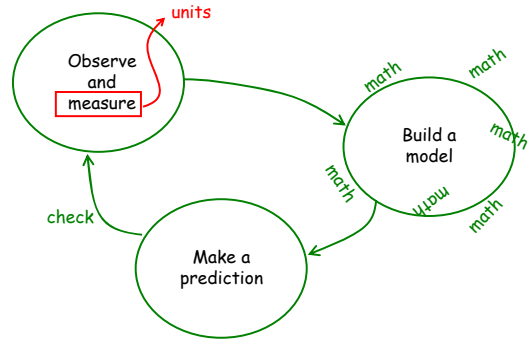


Welcome to Physics 221

How does Physics work?



SI Units

Used by scientific and engineering communities and almost everywhere in the world.

Length: The meter (1 m = 3.281 ft)

Mass: The kilogram (1 kg = 0.06585 slug)
 Not the same as weight!
 on Earth 1 kg weighs 2.205 lb
 on the Moon 1 kg weighs 0.368 lb

Time: The second (s)

Combinations:
 Unit of speed m/s
 Unit of force (Newton) is 1 N = 1 kg m/s²

10 ⁻²⁴	yocto-	y
10 ⁻²¹	zepto-	z
10 ⁻¹⁸	atto-	a
10 ⁻¹⁵	femto-	f
10 ⁻¹²	pico-	p
10 ⁻⁹	nano-	n
10 ⁻⁶	micro-	μ
10 ⁻³	milli-	m
10 ⁻²	centi-	c
10 ³	kilo-	k
10 ⁶	mega-	M
10 ⁹	giga-	G
10 ¹²	tera-	T
10 ¹⁵	peta-	P
10 ¹⁸	exa-	E
10 ²¹	zetta-	Z
10 ²⁴	yotta-	Y

Multiples of Units

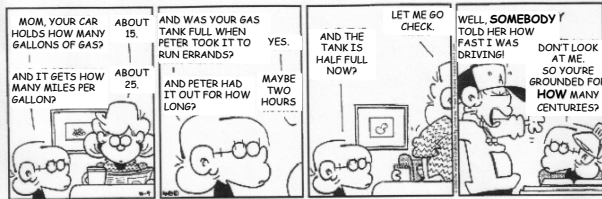
Formal conversion of units:

• Multiply by the appropriate representation of 1 to cancel the unwanted units away:

• eg. convert 10 mph into m/s

$$10 \frac{\text{mile}}{\text{h}} = 10 \frac{\cancel{\text{mile}}}{\cancel{\text{h}}} \times \frac{1 \cancel{\text{h}}}{3600 \text{ s}} \times \frac{1609 \text{ m}}{1 \cancel{\text{mile}}} = 4.47 \text{ m/s}$$

Example



What tank level would indicate an average speed of 90 mph?

- a. 3/4 full
- b. 1/2 full**
- c. 1/4 full
- d. 1/8 full
- e. empty

$$2 \text{ hours} \frac{90 \text{ miles}}{1 \text{ h}} \frac{1 \text{ gallon}}{25 \text{ miles}} = 7.2 \text{ gallons (used)}$$

$$\text{gas left} = 15 - 7.2 = 7.8 \text{ gallons (left)}$$

Consistency of Equations

If $A=B$ then A and B must have the same combination of units (dimensionality).

- For example
 $(\text{distance}) = (\text{speed})(\text{time})$
 $[m] = ([m]/[s])[s]$ ✓

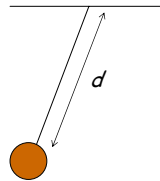
ACT: Dimensional Analysis

The period T of a swinging pendulum depends only on the length of the pendulum d and the acceleration of gravity, g . Which of the following formulas could be correct?

A. $T = 2\pi(dg)^2$

B. $T = 2\pi \frac{d}{g}$

C. $T = 2\pi \sqrt{\frac{d}{g}}$



Note: [Acceleration] = m/s^2

Significant figures

Measurement tools and human perception have limitations.

Eg. A distance measured with a ruler with millimeter markings cannot be 1.047543 m

The last three digits are meaningless. Correct value is 1.047 m (4 significant figures)

Keep track of that in calculations

Eg. Find the distance covered by a car moving at 31.6 mph for 35 minutes.

$$35 \text{ min} \frac{1 \text{ h}}{60 \text{ min}} = 0.58\bar{3} \text{ h}$$

Last digit is meaningless, but you can keep it...

$$\text{distance} = 31.6 \frac{\text{miles}}{\text{h}} \times 0.583 \text{ h} = 18.4 \text{ miles}$$

Correct answer is 18 miles (only 2 significant figures given for time)

Scientific notation and significant figures

Number	Significant figures
3.4	2
3.40 / 3.45	3
0.3 / 3 / 0.0003	1
30	1 or 2?
3×10^1	1
3.0×10^1	2
3.00×10^1	3

Order of magnitude

- **Intuition:**

A coin is dropped from 2 m. How long does it take to reach the ground?

→ About 1 s. (not 10 s, not 0.1 s)

- **Estimation:**

How "strong" should a roof be?

Example: The roof in room 5 is a 10 m x 20 m flat surface. If the drains get clogged and 1 cm of water accumulates on it, this is an extra

$$200 \text{ m}^2 \times 0.01 \text{ m} \times \left(\frac{10 \text{ dm}}{1 \text{ m}} \right)^3 \frac{1 \text{ kg}}{1 \text{ dm}^3 \text{ water}} = 2000 \text{ kg} \quad (4410 \text{ lb!!!})$$

Not 200 kg, not 20,000 kg