

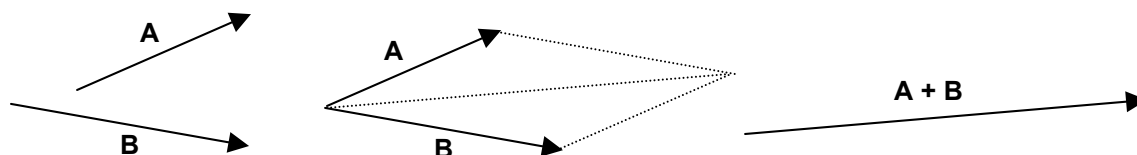


## The Big Idea

Units identify what a specific number represents. For example, the number 42 can be used to represent 42 miles, 42 pounds, or 42 elephants! Without the units attached, the number is meaningless. Also, correct unit cancellation can help you find mistakes when you work out problems.

## Key Concepts

- Every answer to a physics problem must include units. Even if a problem explicitly asks for a speed in meters per second (m/s), the answer is 5 m/s, not 5.
- When you're not sure how to attack a problem, you can often find the appropriate equation by thinking about which equation will provide an answer with the correct units. For instance, if you are looking to predict or calculate a distance, use the equation where all the units cancel out, with only a unit of distance remaining.
- This textbook uses *SI units* (Le Système International d'Unités).
- When converting speeds from one set of units to another, remember the following rule of thumb: a speed measured in *mi/hr* is about double the value measured in *m/s* (i.e., 10 m/s is equal to about 20 MPH). Remember that the speed itself hasn't changed, just our representation of the speed in a certain set of units.
- If a unit is named after a person, it is capitalized. So you write "10 Newtons," or "10 N," but "10 meters," or "10 m."
- Vectors are arrows that represent quantities with direction. In this textbook, vectors will be written in bold. For instance, the force vector will be written as **F** in this textbook. Your teacher will likely use  $\vec{F}$  to represent vectors. Don't let this confuse you:  $\vec{F}$  represents the same concept as **F**.
- Vectors can be added together in a simple way. Two vectors can be moved (without changing their directions) to become two legs of a parallelogram. The sum of two vectors is simply the diagonal of the parallelogram:



## Key Equations

- 1 meter = 3.28 feet
- 1 mile = 1.61 kilometers
- 1 lb. (1 pound) = 4.45 Newtons

## Key Applications

The late, great physicist Enrico Fermi used to solve problems by making educated guesses. For instance, say you want to *guesstimate* the number of cans of soda drank by everybody in San Francisco in one year. You'll come pretty close if you guess that there are about 800,000 people in S.F., and that each person drinks on average about 100 cans per year. So, 80,000,000 cans are consumed every year. Sure, this answer is wrong, but it is likely not off by more than a factor of 10 (i.e., an "order of magnitude"). That is, even if we guess, we're going to be in the *ballpark* of the right answer. That is always the first step in working out a physics problem.

<i>Type of measurement</i>	<i>Commonly used symbols</i>	<i>Fundamental units</i>
length or position	d, x, L	meters (m)
time	t	seconds (s)
velocity or speed	v, u	meters per second (m/s)
mass	m	kilograms (kg)
force	<b>F</b>	Newton's (N)
energy	E, K, U, Q	Joules (J)
power	P	Watts (W)
electric charge	q, e	Coulombs (C)
temperature	T	Kelvin (K)
electric current	I	Amperes (A)
electric field	<b>E</b>	Newton's per Coulomb (N/C)
magnetic field	<b>B</b>	Tesla (T)
magnetic flux	$\Phi$	Webers (Wb)

### *Pronunciation table for commonly used Greek letters*

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$\mu$ "mu"	$\tau$ "tau"	$\Phi$ "phi"*	$\omega$ "omega"	$\rho$ "rho"
$\theta$ "theta"	$\pi$ "pi"	$\Omega$ "omega"*	$\lambda$ "lambda"	$\Sigma$ "sigma"*
$\alpha$ "alpha"	$\beta$ "beta"	$\gamma$ "gamma"	$\Delta$ "delta"*	$\epsilon$ "epsilon"

\* upper case

(a subscript zero, such as that found in " $X_0$ " is often pronounced "naught" or "not")

## Units and Problem Solving Problem Set

1. Estimate or measure your height.
  - a. Convert your height from feet and inches to meters
  - b. Convert your height from feet and inches to centimeters ( $100\text{ cm} = 1\text{ m}$ )
2. Estimate or measure the amount of time that passes between breaths when you are sitting at rest.
  - a. Convert the time from seconds into hours
  - b. Convert the time from seconds into milliseconds (ms)
3. Convert the French speed limit of  $140\text{ km/hr}$  into  $\text{mi/hr}$ .
4. Estimate or measure your weight.
  - a. Convert your weight in pounds into a mass in kg
  - b. Convert your mass from kg into  $\mu\text{g}$
  - c. Convert your weight into Newtons

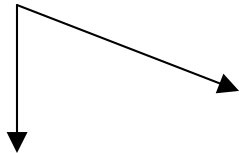
Note: Your weight is simply the force of gravity on you, so pounds are just the English version of Newtons. (The English version of kilograms is slugs!)

5. Find the *SI* unit for pressure.
6. An English lord says he weighs 12 stone.
  - a. Convert his weight into pounds (you may have to do some research online)
  - b. Convert his weight in stones into a mass in kilograms
7. If the speed of your car increases by  $10\text{ mi/hr}$  every 2 seconds, how many  $\text{mi/hr}$  is the speed increasing every second? State your answer with the units  $\text{mi/hr/s}$ .
8. A tortoise travels 15 meters (m) west, then another 13 centimeters (cm) west. How many meters total has she walked?

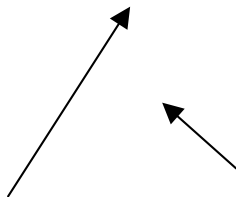


9. A tortoise, Bernard, starting at point A travels 12 m west and then 150 millimeters (mm) east. How far west of point A is Bernard after completing these two motions?
10.  $80\text{ m} + 145\text{ cm} + 7850\text{ mm} = X\text{ mm}$ . What is  $X$ ?
11. A square has sides of length 45 mm. What is the area of the square in  $\text{mm}^2$ ?
12. A square with area  $49\text{ cm}^2$  is stretched so that each side is now twice as long. What is the area of the square now? Include a sketch.
13. A rectangular solid has a square face with sides 5 cm in length, and a length of 10 cm. What is the volume of the solid in  $\text{cm}^3$ ? Sketch the object, including the dimensions in your sketch.
14. As you know, a cube with each side 4 m in length has a volume of  $64\text{ m}^3$ . Each side of the cube is now doubled in length. What is the *ratio* of the new volume to the old volume? Why is this ratio **not** simply 2? Include a sketch with dimensions.
15. What is the ratio of the mass of the Earth to the mass of a single proton? (See equation sheet.)
16. A spacecraft can travel 20 km/s. How many km can this spacecraft travel in 1 hour (h)?
17. A dump truck unloads 30 kilograms (kg) of garbage in 40 s. How many kg/s are being unloaded?
18. The lengths of the sides of a cube are doubling each second. At what rate is the volume increasing?
19. Estimate the number of visitors to Golden Gate Park in San Francisco in one year. Do your best to get an answer that is right within a factor of 10.
20. Estimate the number of water drops that fall on San Francisco during a typical rainstorm.
21. What does the formula  $\mathbf{a} = \mathbf{F} / m$  tell you about the units of the quantity **a** (whatever it is)?
22. Add the following vectors using the parallelogram method.

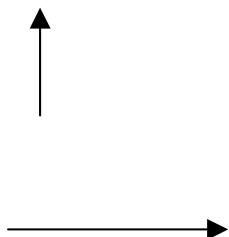
a.



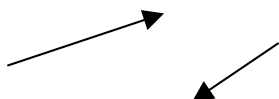
b.



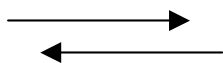
c.



d.



e.



- f. For adding more than two vectors, simply add any two then add the third. Order is not important.

