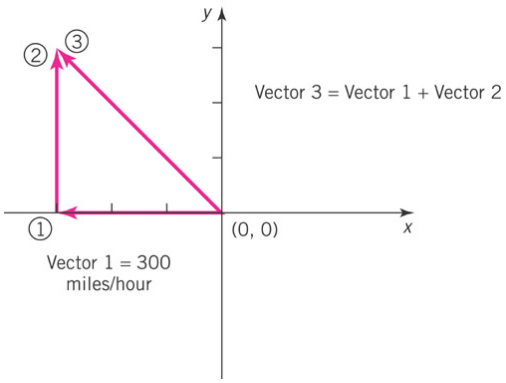
Chap 2 The Language of Science

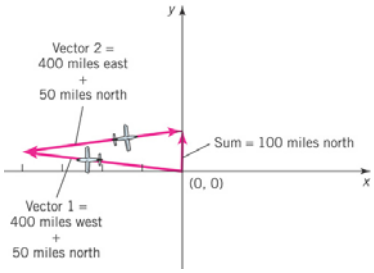
Describing an object: Need specific and quantitative language.

Scalars and Vectors

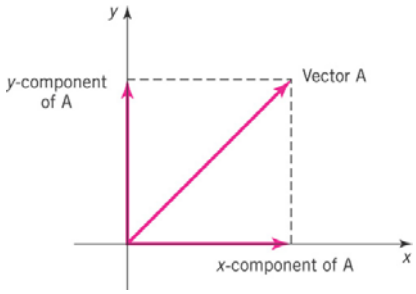


Vector Addition and Decomposition

Vector Addition

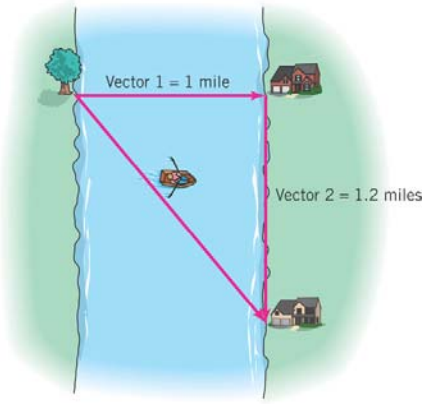


Vector Decomposition



Example 2-3: Vectors on the Water

An inexperienced canoeist sets out straight across a 1-mile wide river, paddling at 5 miles per hour. The average current of the river is 6 miles per hour. Where does she land on the opposite of the river?

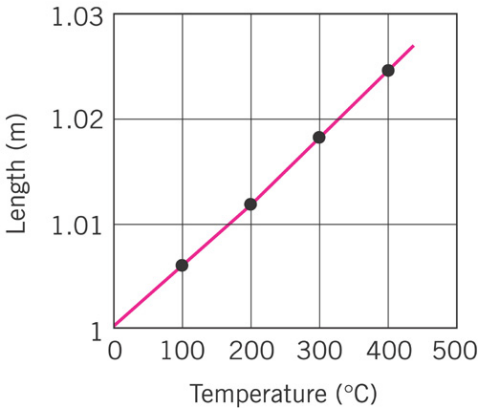


Example on Vector Addition

An airplane makes two stops before arriving at its final destination. During the first leg, it flies 500 miles north and 300 miles east. During the second flight, it flies 400 miles north and 600 miles west. On the final leg, it flies 300 miles south and 500 miles east. Where is the final destination in relationship to its starting location?

Equations: The Dynamics of the Physical World

The length of an iron bar changes with temperature. It is 1.0000 meter long at 0°C. Describe the systematic trend in an equation.



Example from Chap 1

d. While waiting for the gas station attendant to fill up your car's 10-gallon tank, you record the time it takes for the pump to reach every 2 gallons. A table of your findings is given next.

Volume (gallons)	Time (seconds)
0	0.0
2	2.5
4	5.0
6	7.5
8	10.0
10	12.5

How do we write an equation on the volume of gas as a function of time?

Fuel Efficiency

$$Miles\ per\ gallon = \frac{Total\ miles\ driven}{Gallons\ of\ gas}$$

Modeling the World

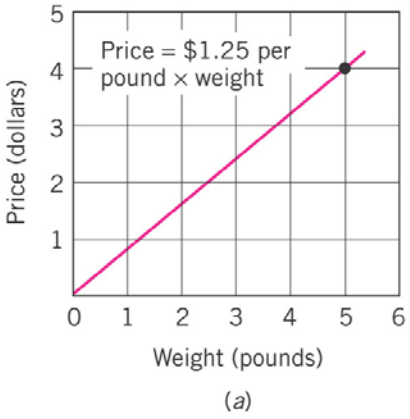
Direct relationship

$$A = k \times B$$

k: constant of proportionality

Example:

Cost = price per pound x weight



(a)

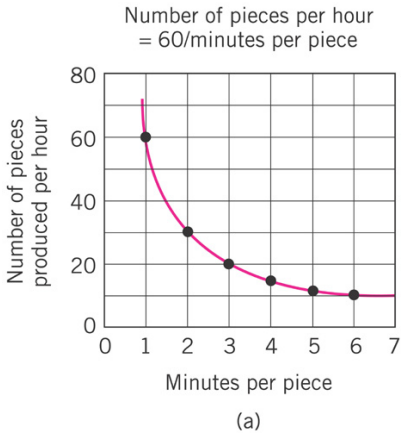
Inverse Relationship

$$A = \frac{k}{B}$$

k: constant

Example:

Car manufacturing

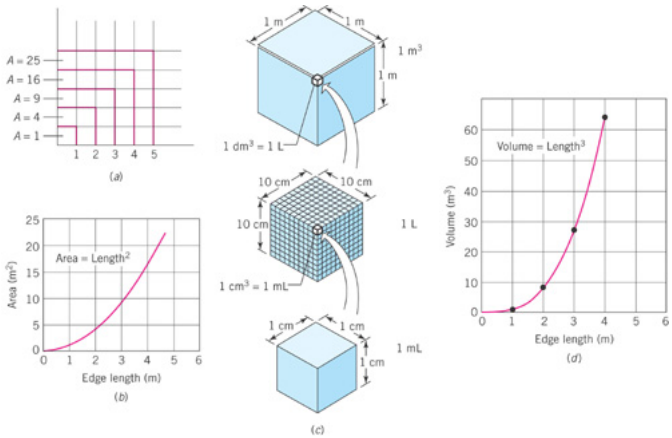


Power Law Relationship

$$A = k \times B^n$$

k: constant

Examples:

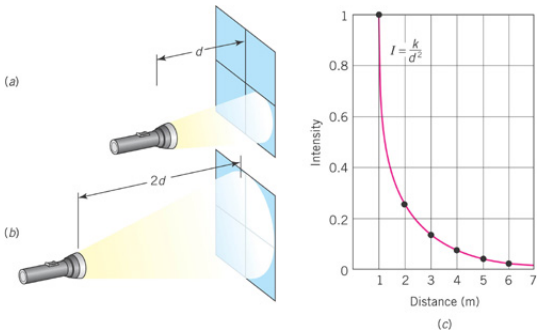


square area and cubic volume

Inverse Square Relationship

$$I = \frac{k}{d^2}$$

k: constant



Example:

Brightness and distance

Units

SI Units:

Length: meter (m)

Mass: kilogram (kg)

Time: second (s)

Energy: joule (J)

Force: newton (N)

Power: watt (w)

Power of Ten

1. **Every number is written as a number between 1 and 10, followed by 10 raised to a power.**
2. **If power of 10 is positive, it means move the decimal point to the right.**
3. **If it is negative, move the decimal point to the left.**

14. Multiply the following.

a. $(4.3 \times 10^{6}) \times (7.4 \times 10^{-7})$
b. $(1.2 \times 10^{-8}) \times (3.4 \times 10^{-5})$
c. $(5.5 \times 10^{3}) \times (6.7 \times 10^{7})$
d. $(6.6 \times 10^{2}) \times 120$
e. $(2.3 \times 10^{12}) \times (4.9 \times 10^{8})$

15. Divide the following.

a. $\dfrac{3.3 \times 10^{12}}{3.0 \times 10^{-4}}$
b. $\dfrac{7.6 \times 10^{-6}}{8.2 \times 10^{8}}$
c. $\dfrac{1.5 \times 10^{2}}{5.0 \times 10^{7}}$
d. $\dfrac{2.2 \times 10^{11}}{4.5 \times 10^{8}}$

Prefixes and Conversion

Common Prefixes:

giga-	**deci-**
mega-	**centi-**
kilo-	**milli-**
hector-	**micro-**
deca-	**nano-**

Conversion factors:

1 ft = 30.48 cm, 1 mile = 1609 m

Exercise: Which is faster, 25 mph or 10 m/s?

Examples

13. Express the following quantities in powers of ten notation.

a. 150 gigadollars
b. 43 hectofeet
c. 23 micrometers
d. 92 nanoseconds
e. 74 milligrams
f. 617 kilobucks
g. 43 microbreweries

Examples

16. Convert the given quantities to the units shown in parentheses.

a. 40 acres (square miles)
b. 23,000 bushels (cubic yards)
c. 50 barrels (liters)
d. 125 bushels (cubic meters)
e. 50 caliber (millimeters)
f. 50,000 carats (grams)
g. 20 fathoms (meters)
h. 600 knots (kilometers per second)
i. 540 knots (meters per second)

acre—used to measure land area in the United States (43,560 square feet, or $\frac{1}{640}$th of a square mile)

barrel—international unit for oil production (42 gallons; although many different specialized definitions of barrel exist for other commodities, including wine, spirits, and cranberries)

bushel—used to measure production of grains in the United States (1.24 cubic feet)

caliber—used to measure diameter of bullets and gun barrels (0.01 inches)

carat—used to measure size of gemstones (0.2 grams)

fathom—used to measure depth of navigable water (6 feet)

knot—used to measure speed of ships (1.85 kilometers per hour)

ounce—used to measure the weight of produce ($\frac{1}{16}$ pound)

Troy ounce—used to measure precious metals ($\frac{1}{12}$ pound)

Problems

8. An industrious student decided that she wanted to prove certain laws about gases and the relationships among pressure, volume, and temperature. In Sarah's science laboratory, she collected the following data.

Temperature (kelvins)	Volume (liters)	Pressure (atmospheres)
100	1000	1.0
100	500	2.0
100	250	4.0
100	125	8.0
200	2000	1.0
200	1000	2.0
200	500	4.0
300	750	4.0
600	1500	4.0

a. Show by using a graph, an equation, or a written statement that the volume is directly proportional to the temperature if the pressure is held constant.
b. Use these data to show Boyle's law, which states that at a constant temperature the pressure and volume vary inversely.

Problems

9. The brightness of a lightbulb can be measured by a light meter in a unit named lumens. Jeremy decided to investigate how the brightness of a certain lightbulb changes with the distance from the lightbulb. Jeremy recorded the following data.

Distance from bulb (feet)	Brightness (lumens)
1	1600
2	400
3	178
4	100
5	64
10	16
20	4

a. Express any trends or patterns in words.
b. Display the data in graphical form.
c. Express any trends or patterns in an equation with words.
d. Express any trends or patterns in an equation with symbols.