Physics 11
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More Relationships Between Variables - Solutions

1. Consider the equation for the volume of a cylinder

$$V = \pi r^2 h$$

where *r* represents the radius and *h* represents the height.

a) Determine the relationship between volume, *V*, and radius, *r*. Express the relationship in both words and symbols. Volume is directly proportional to the square of radius. $V \propto r^2$
b) Determine the relationship between volume, *V*, and height, *h*. Express the relationship in both words and symbols. Volume is directly proportional to height. $V \propto h$

Determine the change in volume for each of the following changes.
c) The height is increased by a factor of four. 4×
d) The radius is halved. 1/4×
e) The radius is decreased by a factor of three and the height is doubled. 2/9×

A cylindrical glass can hold 400 mL of water. Determine how much water the glass can hold for each of the following changes.
f) The height is tripled. 1200 mL
g) The radius is doubled. 1600 mL
h) The radius is halved and the height is decreased by a factor of four. 25 mL

2. Consider the equation for magnetic field around a current-carrying wire

$$B = \frac{\mu_0 I}{2\pi d}$$

where μ_0 represents the permeability of free space (a constant), *I* represents the the current through the wire and *d* represents distance from the wire.

a) Determine the relationship between magnetic field, B, and current, I. Express the relationship in both words and symbols.
Magnetic field is directly proportional to current. $B \propto I$
b) Determine the relationship between magnetic field, *B*, and distance, *d*. Express the relationship in both words and symbols.
Magnetic field is inversely proportional to distance. $B \propto \frac{1}{d}$

Determine the change in magnetic field for each of the following changes.
c) The current is halved. 1/2×
d) The distance from the wire is decreased by a factor of five. 5×
e) The current is increased by a factor of ten and the distance from the wire is tripled. 10/3×

A long wire carries a current of 100 mA. At a distance *x* from the wire, the magnetic field is found to be 20 nT. Determine the magnetic field for each of the following changes.
f) The current is decreased to 25 mA. 5nT
g) The distance from the wire is increased to 5*x*. 4 nT
h) The current is increased to 300 mA and the distance from the wire is decreased to *x*/4. 240 nT

3. Consider the equation for the period of a mass-spring oscillator

$$T = 2\pi\sqrt{\frac{m}{k}}$$

where m represents the mass and k represents the spring constant.

a) Determine the relationship between period, T, and mass, m. Express the relationship in both words and symbols.
Period is directly proportional to the square root of mass. $T \propto \sqrt{m}$

b) Determine the relationship between period, T, and the spring constant, k. Express the relationship in both words and symbols.
Period is inversely proportional to the square root of the spring constant. $T \propto \frac{1}{\sqrt{k}}$

Determine the change in period for each of the following changes.

c) The mass is decreased by a factor of four. 1/2×
d) The spring constant is increased by a factor of nine. 1/3×
e) The mass and spring constant are both tripled. no change

A mass attached to a spring oscillates with a period of 0.80 seconds. Determine the period for each of the following changes.

f) The spring constant is decreased by a factor of four. 1.6 s
g) The mass is increased by a factor of 25. 4.0 s
h) The mass is halved and the spring constant is increased by a factor of eight. 0.20 s

4. Consider the equation for the electric force between two charges

$$F_e = k\frac{q_1 q_2}{r^2}$$

where k represents the electrostatic constant, q_1 and q_2 represent the charges and r represents the separation distance.

Two charges are separated by a distance of 20 mm. The electric force at this distance is 2 N. Determine the electric force between the charges for the following changes.

a) One charge is halved. 1 N
b) Both charges are increased by a factor of three. 18 N
c) The distance separating the charges is increased to 100 mm. 0.08 N
d) The distance separating the charges is decreased to 10 mm. 8 N
e) The distance separating the charges is decreased to 50 mm. 0.32 N
f) One charge is halved and the distance separating the charges is decreased to 10 mm. 4 N
g) Both charges are increased by a factor of ten and the distance separating the masses is increased to 100 mm. 8 N
h) One charge is doubled, the other is decreased by a factor of five, and the distance separating them is decreased to 4 mm. 20 N