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. \( V \) is directly proportional to the square of \( r \). \( V \propto r^2 \)

b) Determine the relationship between volume, \( V \), and height, \( h \). Express the relationship in both words and symbols. \( V \) is directly proportional to \( h \). \( V \propto h \)

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

- c) The height is increased by a factor of four. \( 4 \times \)
- d) The radius is halved. \( \frac{1}{4} \times \)
- e) The radius is decreased by a factor of three and the height is doubled. \( \frac{2}{9} \times \)

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 \( \mu_0 \) represents the permeability of free space (a constant), \( I \) represents 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. \( \frac{1}{2} \times \)
- d) The distance from the wire is decreased by a factor of five. \( 5 \times \)
- e) The current is increased by a factor of ten and the distance from the wire is tripled. \( \frac{10}{3} \times \)

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. 5 nT
- g) The distance from the wire is increased to 5x. 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. \( \frac{1}{2} \times \)
- d) The spring constant is increased by a factor of nine. \( \frac{1}{3} \times \)
- 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