Physics 11
M. Lam

Relationships Between Variables - Solutions

1. For each pair of variables, write the equation (rearrange the equation if necessary) and determine the relationship. The relationships should be a description of how the first variable depends on the second.

   a) $A = \pi r^2$

   $A \propto r^2$

   Area is directly proportional to the square of radius.

   b) $V = \frac{4}{3}\pi r^3$

   $V \propto r^3$

   Volume is directly proportional to the cube of radius.

   c) $d = vt$

   $d \propto v$

   Displacement is directly proportional to velocity.

   d) $d = \frac{1}{2}at^2$

   $d \propto t^2$

   Displacement is directly proportional to the square of time.

   e) $a = \frac{F_{\text{NET}}}{m}$

   $a \propto F_{\text{NET}}$

   Acceleration is directly proportional to net force.

   f) $a = \frac{F_{\text{NET}}}{m}$

   $a \propto \frac{1}{m}$

   Acceleration is inversely proportional to mass.

   g) $F_{\text{f}} = \mu F_{\text{N}}$

   $F_{\text{f}} \propto F_{\text{N}}$

   Force of friction is directly proportional to the normal force.

   h) $\Delta x = \frac{F_{\text{s}}}{k}$

   $\Delta x \propto \frac{1}{k}$

   Displacement from equilibrium position is inversely proportional to the spring constant.

i) $g = G\frac{M}{r^2}$

$g \propto M$

Gravitational field strength is directly proportional to the mass.

j) $F_g = G\frac{m_1 m_2}{r^2}$

$F_g \propto \frac{1}{r^2}$

Gravitational force is inversely proportional to the square of separation distance.

k) $p = mv$

$p \propto v$

Momentum is directly proportional to velocity.

l) $E_p = mgh$

$E_p \propto h$

Gravitational potential energy is directly proportional to height.

m) $E_k = \frac{1}{2}mv^2$

$E_k \propto m$

Kinetic energy is directly proportional to mass.

n) $E_k = \frac{1}{2}mv^2$

$E_k \propto v^2$

Kinetic energy is directly proportional to the square of velocity.

o) $P = \frac{W}{t}$

$P \propto \frac{1}{t}$

Power is inversely proportional to time.

p) $I = \frac{V}{R}$

$I \propto \frac{1}{R}$

Current is inversely proportional to resistance.

2. Determine how the following variables change.
   a) 4×
   b) 1/8×
   c) 5×
   d) 1/16×
   e) 3×
   f) 1/2×
   g) 1/3×
   h) 2×
   i) 4×
   j) 1/36×
   k) 2.5×
   l) 1/10×
   m) 1/2×
   n) 1/4×
   o) 1/2×
   p) 5/4×

3. Consider the equation for kinetic energy

$$E_{\mathrm{k}} = \frac{1}{2}mv^2$$

   where m represents the mass and v represents the velocity.
   Determine the change in the kinetic energy for each of the following changes.
   a) 2×
   b) 4×
   c) 1/2×
   d) 1/4×
   e) 27×
   f) 1/27×
   g) 1/2×
   h) 1× (no change)

4. Consider the equation for resistance

$$R = \frac{\rho \ell}{A}$$

   where ρ represents the resistivity, l represents the length of the wire, and A represents the cross-sectional area.
   Determine the change in the resistance for each of the following changes.
   a) 3×
   b) 2×
   c) 1/4×
   d) 1/4×
   e) 1× (no change)
   f) 3/2×
   g) 1/12×
   h) 2/3×

5. Consider the equation for the gravitational force between two masses

$$F_g = G\frac{m_1 m_2}{r^2}$$

where G represents the gravitation constant, m_1 and m_2 represent the masses and r represents the separation distance.
Two objects are separated by a distance of 1000 km (from their centres). The gravitational force at this distance is 500 N. Determine the gravitational force between the masses for the following changes.

a) 1000 N
b) 4500 N
c) 20 N
d) 8000 N
e) 320 N
f) 625 N
g) 500 N
h) 1172 N