Physics 11

**Solving Equations – Substitution Physics Style**

In Physics we use some simple formula to describe or explain our world. Physicists must be able to manipulate these equations to solve for what they are looking for. You already have these skills if you have passed a lower level math course. You will simply need to brush up on the knowledge you already have.

An equation just shows the relationship between some variables. For example $X + 5 = Y$, shows how the variable $x$ and $Y$ are related. If we substitute a number for $X$ (such as 3) than we can find $Y$.

\[ X + 5 = Y \]

**Let $X = 3$**

Then \[ (3) + 5 = Y \]

And \[ 8 = Y \]

**Now Try These:**

a) \[ 3X + 7 = Y \] Solve for $Y$ if $X = 2$  
   *(Ans: $Y = 13$)*

b) \[ 4a + 2c + d = Z \] Solve for $Z$ if $a = 2$, $c = 5$, & $d = -6$  
   *(Ans: $Z = 12$)*

c) \[ s/2 + t/3 = P \] Solve for $P$ if $s = 24$, & $t = -12$  
   *(Ans: $P = 8$)*

You must be able to use all your math skills such as adding opposites, multiplying or dividing by a number to rearrange your equation to solve for the unknown in question.

For example if $D = V \times T$, then solve for $V$ if $D = 25$ and $T = 14$

\[ D = V \times T \]

**Divide both side by $T$**

\[ D/T = (V \times T)/T \]

(The T's on the left side cancel)

\[ D/T = V \]

(Substitute in 25 for $D$ and 14 for $T$)

\[ 25/14 = V \]

(Give the decimal equivalent as your final answer.)

\[ 1.8 = V \]

**Now Try these:**

(a) \[ F = m \times a \] solve for $m$, if $a = 4.6$ and $F = 650$  
   *(Ans: 141)*

(b) \[ D = \frac{1}{2} \times a \times t^2 \] solve for $a$, if $D = 50$ and $t = 3$  
   *(Ans: 11.1)*

c) \[ T^2 = 4\pi L/g \] solve for $g$, if $T = 2.53$, $L = 5.0$ and $\pi = 3.14$  
   *(Ans: 9.8)*

d) \[ V^2 = 2d/a \] solve for $a$, if $d = 1680$ and $V = 25$  
   *(Ans: 5.4)*
Sometimes simply re-arranging the equations to find a variable (without actually solving for the variable) is an important skill.

For example 1: \[ v^2 = \frac{2d}{a} \] solve for \( d \)

\[ av^2 = 2d \] (multiply both side by a to move the a to the other side)

\[ av^2/2 = d \] (divide both sides by 2)

For example 2: \[ F = \frac{GM^2}{R^2} \] solve for \( R \)

\[ FR^2 = GM^2 \] (Multiple both side by \( R^2 \))

\[ R^2 = \frac{GM^2}{F} \] (Divide both sides by \( F \))

\[ R = \sqrt{\frac{GM^2}{F}} \] (Take square root of both sides)

Now try these:

- a) \( y = mx + b \) Solve for \( b \)
- b) \( a = \frac{v^2}{2d} \) Solve for \( v \)
- c) \( E = mc^2 \) Solve for \( c \)
- d) \( d = vt + \frac{1}{2}at^2 \) Solve for \( a \)

In Physics units play an important role in defining what the number means. Keep track of your units and always include them in your final answer.

For example 1: Use the formula \( v = \frac{d}{t} \) to solve for \( v \) if \( d = 120 \) m and \( t = 2.0 \) s

\[ v = \frac{120}{2.0} = 60 \] but the units: “m” for \( d \) and “s” for \( t \) leave you with “m/s”

Final answer would be 60 m/s

For example 2: The surface area of a sphere is given by the equation \( A = 4\pi R^2 \). Find the surface of sphere that has a radius of 12 cm.

\[ A = 4\pi R^2 = 4\pi (12 \text{ cm})^2 = 1808 \text{ cm}^2 \]

Now Try These:

- a) \( v = \frac{2\pi R}{T} \) solve for \( v \), if \( R = 250 \) m and \( T = 5.6 \) s
- b) \( V = \frac{4}{3} \pi R^3 \) Solve for \( V \) if \( R = 1.56 \) m
- c) \( T = \frac{2\pi(L/g)\sqrt{2}}{\sqrt{2}} \) solve for \( L \) if \( T = 6.5 \) s and \( g = 1.63 \) m/s²