**Problem 1:** When converting units, the presentation of a number is altered, but its value is unchanged. Conversion of units is achieved upon multiplication by a conversion factor which is a ratio equivalent to 1 but involving both types of units. For example, because

$$100\ \text{cm} = 1\ \text{m}$$

the following expressions all suggest candidate conversion factors:

$$1 = \frac{100\ \text{cm}}{1\ \text{m}} \qquad 1 = \frac{1\ \text{cm}}{10^{-2}\ \text{m}} \qquad 1 = \frac{1\ \text{m}}{100\ \text{cm}} \qquad 1 = \frac{10^{-2}\ \text{m}}{1\ \text{cm}}$$

Choose any valid conversion factor that cancels the old units while leaving the desired units in place.

**Part (a)** Select *all* expressions that could be used to convert a distance $x = 5.97$ m to centimeters.
**MultipleSelect** :

1) $x = 5.97\ \text{m} \times \left(\frac{100\ \text{cm}}{1\ \text{m}}\right)$
2) $x = 5.97\ \text{m} \times \left(\frac{100\ \text{m}}{1\ \text{cm}}\right)$
3) $x = 5.97\ \text{m} \times \left(\frac{1\ \text{m}}{100\ \text{cm}}\right)$
4) $x = 5.97\ \text{m} \times \left(\frac{1\ \text{m}}{10^{-2}\ \text{cm}}\right)$
5) $x = 5.97\ \text{m} \times \left(\frac{1\ \text{cm}}{10^{-2}\ \text{m}}\right)$
6) $x = 5.97\ \text{m} \times \left(\frac{10^{-2}\ \text{cm}}{1\ \text{m}}\right)$
7) $x = 5.97\ \text{m} \times \left(\frac{1\ \text{cm}}{100\ \text{m}}\right)$
8) $x = 5.97\ \text{m} \times \left(\frac{10^{-2}\ \text{m}}{1\ \text{cm}}\right)$

**Part (b)** Use an expression of the type determined in step (a) to convert the distance $x =$*4.65* m to centimeters.
**Numeric** : A numeric value is expected and not an expression.
$x =$ _____ cm

**Part (c)** Select *all* expressions that could be used to convert a length $L = 23.7$ cm to meters.
**MultipleSelect** :

1) $L = 23.7\ \text{cm} \times \left(\frac{1\ \text{cm}}{10^{-2}\ \text{m}}\right)$
2) $L = 23.7\ \text{cm} \times \left(\frac{10^{-2}\ \text{m}}{1\ \text{cm}}\right)$
3) $L = 23.7\ \text{cm} \times \left(\frac{1\ \text{m}}{10^{-2}\ \text{cm}}\right)$
4) $L = 23.7\ \text{cm} \times \left(\frac{1\ \text{cm}}{100\ \text{m}}\right)$
5) $L = 23.7\ \text{cm} \times \left(\frac{100\ \text{m}}{1\ \text{cm}}\right)$
6) $L = 23.7\ \text{cm} \times \left(\frac{1\ \text{m}}{100\ \text{cm}}\right)$
7) $L = 23.7\ \text{cm} \times \left(\frac{100\ \text{cm}}{1\ \text{m}}\right)$
8) $L = 23.7\ \text{cm} \times \left(\frac{10^{-2}\ \text{cm}}{1\ \text{m}}\right)$

**Part (d)** Use an expression of the type determined in step (c) to convert the length $L =$*256.8* cm to meters.
**Numeric** : A numeric value is expected and not an expression.
$L =$ _____ m

**Problem 2:** When converting units, the presentation of a number is altered, but its value is unchanged. Conversion of units is achieved upon multiplication by a conversion factor which is a ratio equivalent to 1 but involving both types of units. The exponent on a conversion factor must match the exponent on the units. When converting more than one type of unit, include a separate conversion factor for each type.

**Part (a)** Select *all* expressions that could be used to convert a density of $\rho = 2.47\ \mathrm{g/cm^3}$ to kilograms per cubed meter.
**MultipleSelect** :

1) $\rho = (2.47\ \mathrm{g/cm^3})\left(\frac{1\ \mathrm{cm}}{10^{-2}\ \mathrm{m}}\right)^3\left(\frac{1\ \mathrm{g}}{10^{-3}\ \mathrm{kg}}\right)$
2) $\rho = (2.47\ \mathrm{g/cm^3})\left(\frac{1\ \mathrm{cm}}{10^{-2}\ \mathrm{m}}\right)^3\left(\frac{10^{-3}\ \mathrm{kg}}{1\ \mathrm{g}}\right)$
3) $\rho = (2.47\ \mathrm{g/cm^3})\left(\frac{1\ \mathrm{m}}{100\ \mathrm{cm}}\right)^3\left(\frac{1\ \mathrm{kg}}{10^3\ \mathrm{g}}\right)$
4) $\rho = (2.47\ \mathrm{g/cm^3})\left(\frac{10^{-2}\ \mathrm{cm}}{1\ \mathrm{m}}\right)^3\left(\frac{10^{-3}\ \mathrm{kg}}{1\ \mathrm{g}}\right)$
5) $\rho = (2.47\ \mathrm{g/cm^3})\left(\frac{100\ \mathrm{cm}}{1\ \mathrm{m}}\right)\left(\frac{1\ \mathrm{kg}}{10^3\ \mathrm{g}}\right)$
6) $\rho = (2.47\ \mathrm{g/cm^3})\left(\frac{100\ \mathrm{cm}}{1\ \mathrm{m}}\right)^3\left(\frac{10^3\ \mathrm{g}}{1\ \mathrm{kg}}\right)$
7) $\rho = (2.47\ \mathrm{g/cm^3})\left(\frac{100\ \mathrm{cm}}{1\ \mathrm{m}}\right)^3\left(\frac{1\ \mathrm{kg}}{10^3\ \mathrm{g}}\right)$
8) $\rho = (2.47\ \mathrm{g/cm^3})\left(\frac{1\ \mathrm{cm}}{10^{-2}\ \mathrm{m}}\right)^3\left(\frac{1000\ \mathrm{kg}}{1\ \mathrm{g}}\right)$

**Part (b)** Use an expression of the type determined in step (a) to convert the density of $\rho = 13.08\ \mathrm{g/cm^3}$ to kilograms per cubed meter.
**Numeric** : A numeric value is expected and not an expression.
$\rho$ = _____ $\mathrm{kg/m^3}$

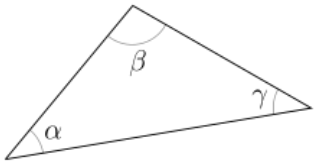
**Problem 3:** Convert the angle, specified in radians, to an angle specified in degrees.

Which angle is the same as an angle of $\frac{2\pi}{3}$ radians?
**MultipleChoice** :

1) $0^\circ$
2) $120^\circ$
3) $330^\circ$
4) $90^\circ$
5) $180^\circ$
6) $150^\circ$
7) $300^\circ$

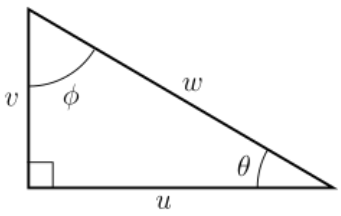
8) $30^\circ$
9) $210^\circ$
10) $240^\circ$
11) $60^\circ$
12) $270^\circ$

**Problem 4:** The angles of a scalene triangle are labeled, as shown. The relative sizes of the angles may be different than those in the image.




Given that $\alpha = 53.3^\circ$ and $\beta = 70.4^\circ$, enter the value, in degrees, of the angle measure of $\gamma$.
**Numeric** : A numeric value is expected and not an expression.
$\gamma$ = _____ $^\circ$

**Problem 5:** The sides and angles of a right-triangle are labeled in the drawing. While it is definitely a right triangle, do *not* assume that the side lengths and the angles are drawn to scale. Side lengths $v$ and $w$ are the only given parameters, and the rest are unknowns.




**Part (a)** Which of the following provides a simple relationship between $v$, $w$, and the unknown $u$?
**MultipleChoice** :

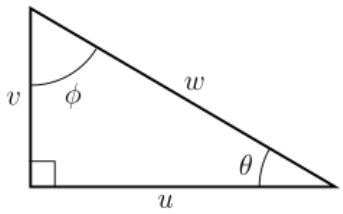
1) The tangent function.
2) The Pythagorean theorem.
3) The sine function.
4) The cosine function.

**Part (b)** Enter a simple expression that uses the relationship chosen in the previous step to solve for the unknown $u$ in terms of the parameters given in the problem statement.
**Expression** :
$u$ = _____

Select from the variables below to write your expression. Note that all variables may not be required.
**cos(φ)**, **cos(θ)**, **sin(φ)**, **sin(θ)**, **tan(φ)**, **tan(θ)**, **π**, **v**, **w**

**Part (c)** Given $v = 15.2$ and $w = 61.2$, enter a numeric value for $u$.
**Numeric** : A numeric value is expected and not an expression.
$u$ = _____

**Problem 6:** The sides and angles of a right-triangle are labeled in the drawing. While it is definitely a right triangle, do *not* assume that the side lengths and the angles are drawn to scale. Side lengths $v$ and $w$ are the only given parameters, and the rest are unknowns.




**Part (a)** Which of the following provides a simple relationship between $v$, $w$, and the unknown $\phi$?
**MultipleChoice** :

1) The tangent function.
2) The Pythagorean theorem.
3) The sine function.
4) The cosine function.

**Part (b)** Given $v = 14.7$ and $w = 37.7$, enter a numeric value, in degrees, for $\phi$.
**Numeric** : A numeric value is expected and not an expression.
$\phi$ = _____ $^\circ$

**Problem 7:** In this problem, the symbols $x$ and $y$ are lengths, and $n$ is an integer.

**Part (a)** What should be the value of the exponent $n$ so that the formula $\pi x^n y^1$ represents a volume?
**Numeric** : A numeric value is expected and not an expression.
***n*** = _____

**Part (b)** What should be the value of the exponent $n$ so that the formula $4\pi x^n$ represents an area?
**Numeric** : A numeric value is expected and not an expression.
***n*** = _____

**Problem 8:** The units on each side of an equation should be the same, or the equation is wrong. You will determine which units belong on each side of an equation.

| Quantity | Symbol | Unit | Abbreviation |
|---|---|---|---|
| mass | $m$ | kilogram | kg |
| distance | $x$ | meter | m |
| height | $h$ | meter | m |
| time | $t$ | second | s |
| velocity | $v$ | meter/second | m/s |
| acceleration | $a$ | meter/second$^2$ | m/s$^2$ |
| acceleration due to gravity | $g$ | meter/second$^2$ | m/s$^2$ |
| Newton's gravitational constant | $G$ | meter$^3$/ kilogram*second$^2$ | m$^3$/kg$\cdot$s$^2$ |



**Part (a)** What are the units on both sides of the equation: $v^2 = 2ax$?
**MultipleChoice** :

1) m•s/kg
2) kg$^2$/m$^3$.
3) m/s
4) kg•m/s$^2$.
5) m$^3$/s$^2$.
6) m$^2$/s$^2$

**Part (b)** What units are on both sides of the equation: $x = vt + 1/2at^2$?
**MultipleChoice** :

1) m/s
2) kg•m
3) m$^2$/s
4) s•m
5) m
6) s$^2$/m

**Part (c)** What are the units on both sides of the equation $mv^2 = mgh$?
**MultipleChoice** :

1) m/s
2) m•kg$^2$
3) s$^2$/m$^2$
4) kg•m$^2$/s$^2$
5) s•kg/m
6) kg•m/s

**Part (d)** What are the units on each side of the equation $GMm/x^2 = mv^2/x$? ($M$ and $m$ are two different masses.)
**MultipleChoice** :

1) kg•m/s$^2$
2) m•s$^2$/kg
3) kg•m/s
4) s•m/kg
5) kg•m$^2$/s
6) kg•m$^2$/s$^3$

**Problem 9:** The density of a particular alloy is *7.8* g/cm$^3$.

What is this density in kg/m$^3$?
**Numeric** : A numeric value is expected and not an expression.
$\rho$ = _____ $\mathrm{kg/m^3}$

**Problem 10:** A light-nanosecond is the distance light travels in 1 ns. A tomato plant has a height of *5.6* feet.

What is this height in light-nanoseconds? (Light travels at a speed of about $3.00 \times 10^8$ m/s.)
**Numeric** : A numeric value is expected and not an expression.
$h$ = _____ light-nanoseconds

**Problem 11:** There is relatively little empty space between atoms in solids and liquids, so that the average density of an atom is about the same as matter on a macroscopic scale—approximately $10^3$ kg/m$^3$. The nucleus of an atom has a radius about $10^{-5}$ times that of the entire atom, and contains nearly all the mass of the atom.

**Part (a)** What is the approximate density, in kilograms per cubic meter, of a nucleus?
**Numeric** : A numeric value is expected and not an expression.
$\rho$ = _____

**Part (b)** One possible remnant of a supernova, called a neutron star, can have the density of a nucleus, while being the size of a small city. What would be the radius, in kilometers, of a neutron star with a mass 10 times that of the Sun? The radius of the Sun is $7 \times 10^8$ m and its mass is $1.99 \times 10^{30}$ kg.
**Numeric** : A numeric value is expected and not an expression.
$R$ = _____

**Problem 12:** Consider these points:

$$A = (-8, 9)$$
$$B = (1, -1)$$
$$C = (-1, -5)$$

which are placed in three different quadrants of a Cartesian coordinate system. Convert each set of Cartesian coordinates to polar coordinates of the form $(r, \theta)$ where the angle is measured counterclockwise, in degrees, from the positive $x$ axis.

$$0^\circ \leq \theta < 360^\circ$$

**Part (a)** What quadrant does point $A$ occupy?
**MultipleChoice** :

1) Quadrant III
2) Quadrant I
3) Quadrant II
4) Quadrant IV

**Part (b)** What is the radial coordinate, $r_A$, for point $A$?
**Numeric** : A numeric value is expected and not an expression.
$r_A$ = _____

**Part (c)** What is the angular coordinate, $\theta_A$, for point $A$, expressed in degrees measured counterclockwise from positive $x$?
**Numeric** : A numeric value is expected and not an expression.
$\theta_A$ = _____ $^\circ$

**Part (d)** What quadrant does point $B$ occupy?
**MultipleChoice** :

1) Quadrant IV
2) Quadrant III
3) Quadrant I
4) Quadrant II

**Part (e)** What is the radial coordinate, $r_B$, for point $B$?
**Numeric** : A numeric value is expected and not an expression.
$r_B$ = _____

**Part (f)** What is the angular coordinate, $\theta_B$, for point $B$, expressed in degrees measured counterclockwise from positive $x$?
**Numeric** : A numeric value is expected and not an expression.
$\theta_B$ = _____ $^\circ$

**Part (g)** What Quadrant does point C occupy?
**MultipleChoice** :

1) Quadrant I
2) Quadrant III
3) Quadrant IV
4) Quadrant II

**Part (h)** What is the radial coordinate, $r_C$, for point $C$?
**Numeric** : A numeric value is expected and not an expression.
$r_C$ = _____

**Part (i)** What is the angular coordinate, $\theta_C$, for point $C$, expressed in degrees measured counterclockwise from positive $x$?
**Numeric** : A numeric value is expected and not an expression.
$\theta_C$ = _____ °

**Problem 13:** A fly enters through an open window and zooms around the room. In a Cartesian coordinate system with three axes along three edges of the room, the fly changes its position from point (4.00 m, 1.50 m, 2.50 m) to (*2.5* m, *3.35* m, *1.44* m).

What is the magnitude of the fly's displacement?
**Numeric** : A numeric value is expected and not an expression.
***d*** = _____

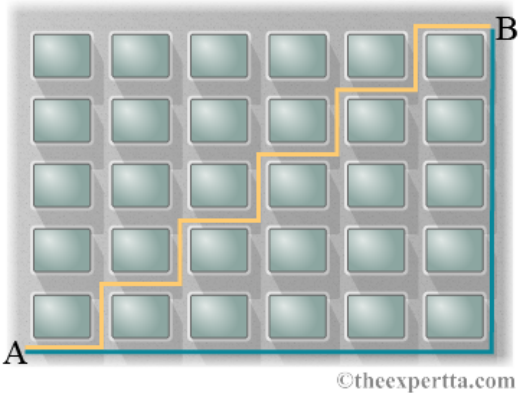
**Problem 14:** The distance from San Francisco to Sacramento is shown in the figure.




**Part (a)** Find the component in the northern direction of the displacement from San Francisco to Sacramento in kilometers.
**Numeric** : A numeric value is expected and not an expression.
$s_x$ = _____

**Part (b)** Find the component in the eastern direction of the displacement from San Francisco to Sacramento in kilometers.
**Numeric** : A numeric value is expected and not an expression.
$s_y$ = _____

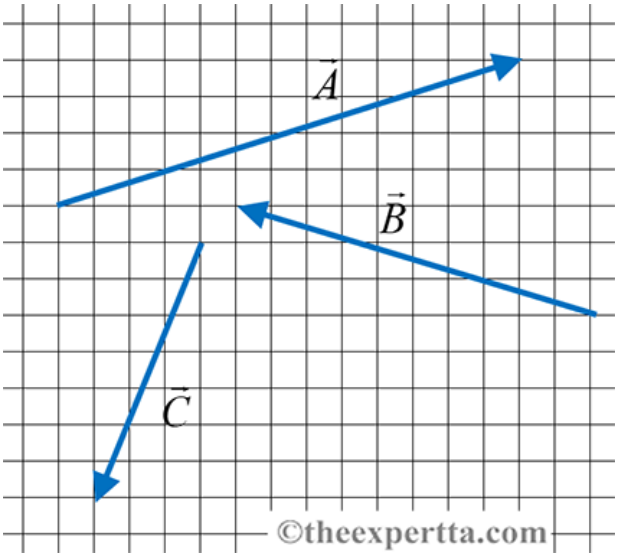
**Problem 15:** You are in Manhattan and need to walk from point A to point B. The person you are with suggests that you will get there quicker if you walk directly towards your destination. Given that buildings are in the way, the most "direct" route results in zig-zagging as shown in the figure, since you are only able to travel exactly east or exactly north. Consider the figure and compare the yellow zig-zag path with the blue-green single-turn path.




Which is the true statement?
**MultipleChoice** :

1) It depends on the lengths of the city blocks.
2) The two paths involve walking the same distance.
3) The zig-zag path is shorter.
4) The zig-zag path is longer.

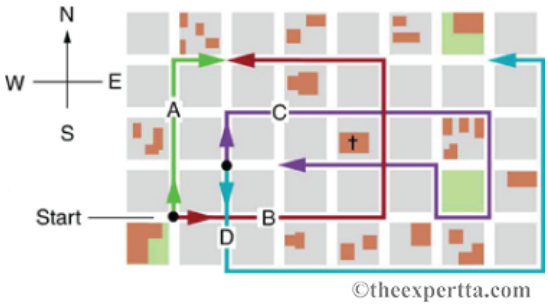
**Problem 16:** When two vectors are added together graphically, one can draw the vectors so that the tail of one vector touches the tip of the other. Consider the three vectors shown in the figure labeled $\vec{A}, \vec{B},$ and $\vec{C}$.




If the three vectors in the figure are added together $\vec{A} + \vec{B} + \vec{C}$ using the graphical method, in approximately what direction will the resultant be?
**MultipleChoice** :

1) Right
2) Up
3) Down
4) They add to zero, so there is no direction.
5) Left

**Problem 17:** The various lines represent routes taken by different families walking in a neighborhood. All blocks are square and 120 m on a side.




**Part (a)** Find the total distance traveled for path D in kilometers.
**Numeric** : A numeric value is expected and not an expression.
$d$ = _____ km

**Part (b)** Find the magnitude of the displacement on path D from start to finish in meters.
**Numeric** : A numeric value is expected and not an expression.
$D$ = _____ m

**Part (c)** Find the angle, in degrees, of the direction of the displacement measured north of east.
**Numeric** : A numeric value is expected and not an expression.
$\theta$ = _____ deg

**Problem 18:** A delivery man starts at the post office, drives 40.0 km north, then ***21*** km west, then ***73*** km northeast, and finally ***34*** km north to stop for lunch. (The direction "northeast" is 45 degrees east of north.)

**Part (a)** What is the magnitude of his net displacement vector, in units of km?
**Numeric** : A numeric value is expected and not an expression.
$\boldsymbol{d}$ = _____

**Part (b)** What is the direction of his net displacement? Express your answer an angle measured in degrees east of north.
**Numeric** : A numeric value is expected and not an expression.
$\boldsymbol{\theta}$ = _____