AP Physics Course 1 Summer Assignment

On the following pages, there are six sections that use the basic skills that will be used throughout the course. We expect that the students will be proficient with these skills at the start of the course. We recommend you complete as many problems as necessary from each section to gain confidence with that skill. The solutions are given on the last pages.

If you are also interested in getting a jump on learning the physics in the curriculum, check out and explore these websites:

Physicsclassroom.com

Learnapphysics.com

Aplusphysics.com

See you in September.

1. Compute the following physics expressions. If the expression has units, then apply the same mathematical operations to the units that were applied to the numbers. Simplify the units if possible. The units are just as important as the numbers.

Sample: $T = 2\pi\sqrt{\frac{4.5\times10^{-2}kg}{2.0\times10^{3}\ kg/s^{2}}}$ = ______________

$$T = 2\pi\sqrt{\frac{4.5\times10^{-2}}{2.0\times10^{3}}}\ \sqrt{\frac{kg}{kg/s^{2}}}$$

$$T = 2\pi\sqrt{2.25\times10^{-5}}\ \sqrt{kg \div (kg/s^{2})}$$

$$T = 2\pi(4.74\times10^{-3})\ \sqrt{\cancel{kg}\times(s^{2}/\cancel{kg})}$$

$$T = 3.0\times10^{-2}\ s$$

a. $K = \frac{1}{2}\left(6.6\times10^{2}\ kg\right)\left(2.11\times10^{4}\ m/s\right)^{2} =$ ______________

b. $F = \left(9.0\times10^{9}\ \frac{N\cdot m^{2}}{C^{2}}\right)\frac{\left(3.2\times10^{-9}C\right)\left(9.6\times10^{-9}C\right)}{\left(0.32m\right)^{2}} =$ ______________

c. $e = \frac{1.7\times10^{3}\ J - 3.3\times10^{2}\ J}{1.7\times10^{3}\ J} =$ ______________

d. $K_{max} = \left(6.63\times10^{-34} J\cdot s\right)\left(7.09\times10^{14} s^{-1}\right) - 2.17\times10^{-19} J =$ ______________

2. Often problems on the AP exam are done with variables only. Solve for the variable indicated. Don't let the different letters confuse you. Manipulate the letters algebraically as though they were numbers.

Sample $v^2 = v_o{}^2 + 2a(x - x_o),$ $a = ?$

$$v^2 - v_o{}^2 = 2a(x - x_o)$$

$$\frac{1}{2}(v^2 - v_o{}^2) = a(x - x_0)$$

$$\frac{\frac{1}{2}(v^2 - v_o{}^2)}{(x - x_o)} = a$$

$$a = \frac{\frac{1}{2}(v^2 - v_o{}^2)}{(x - x_o)}$$

a. $U = \frac{1}{2}kx^2$, $x =$ ______________

b. $T_p = 2\pi\sqrt{\frac{\ell}{g}}$, $g =$ ______________

c. $F_g = G\frac{m_1 m_2}{r^2}$, $r =$ ______________

d. $mgh = \frac{1}{2}mv^2$, $v =$ ______________

e. $x = x_o + v_o t + \frac{1}{2}at^2$, $t =$ ______________

f. $B = \frac{\mu_o}{2\pi}\frac{I}{r}$, $r =$ ______________

g. $x_m = \frac{m\lambda L}{d}$, $d =$ ______________

h. $pV = nRT$, $T =$ ______________

i. $\sin\theta_c = \frac{n_1}{n_2}$, $\theta_c =$ ______________

j. $\frac{1}{f} = \frac{1}{s_o} + \frac{1}{s_i}$, $s_i =$ ______________

3. Physicists usually use the MKS System of measurement. MKS stands for meter, kilogram, and second. This is also known as the SI System of measurement. SI stands for System International. It is often necessary to convert measurements to MKS units. Use the factor-label method (some teachers call it dimensional analysis or the multiplying by one method) to convert the below measurements. Be sure to use this method as shown in the sample. The following conversion factors may be needed.

Kelvin temp. = $^{o}C + 273$
1 atm = 1.013×10^5 Pa
1 m^3 = 1×10^3 L

Factor	Prefix	Symbol
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

Sample: 4008 km/h = ? m/s

$$4008\frac{\cancel{km}}{\cancel{h}}\left(\frac{1\times 10^3 m}{1\ \cancel{km}}\right)\left(\frac{1\ \cancel{h}}{60\ \cancel{min}}\right)\left(\frac{1\ \cancel{min}}{60\ s}\right) = 1113\,\frac{m}{s}$$

a. 1.2 *km* = _______________ *m*

b. 823 *nm* = _______________ *m*

c. 298 *K* = _______________ *°C*

d. 0.77 *m* = _______________ *cm*

e. $8.8\text{x}10^{-8}$ *m* = _______________ *mm*

f. 1.2 *atm* = _______________ *Pa*

g. 25.0 *μm* = _______________ *m*

h. 2.65 *mm* = _______________ *m*

i. 8.23 *m* = _______________ *km*

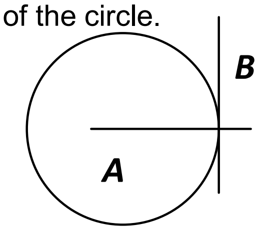
j. 5.4 *L* = _______________ m^3

k. 40.0 *cm* = _______________ *m*

l. $6.23\text{x}10^{-7}$ *m* = _______________ *nm*

4. Solve the following geometric problems.

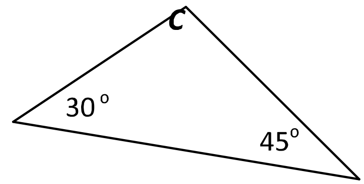
a. Line ***B*** touches the circle at a single point. Line ***A*** extends through the center of the circle.



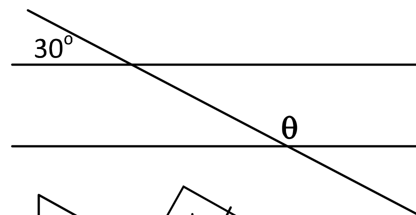
i. What is line ***B*** in reference to the circle? ____________________

ii. How large is the angle between lines ***A*** and ***B***? ______________

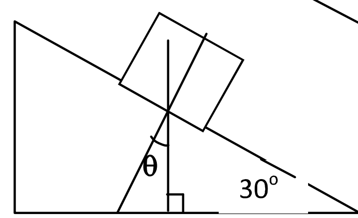
b. What is angle ***C***? ______________



c. What is angle θ ? ______________



d. How large is *θ*? ______________



5. Calculate the following. Be sure to use the factor-label method when converting. Be sure to write down the formula used, the substitution of the values with units, and the final answer with units.

Sample The radius of a circle is 5.5 *cm*. What is the circumference of this circle in meters?

$$5.5\ cm\left(\frac{1\ m}{100\ cm}\right) = 0.055\ m$$

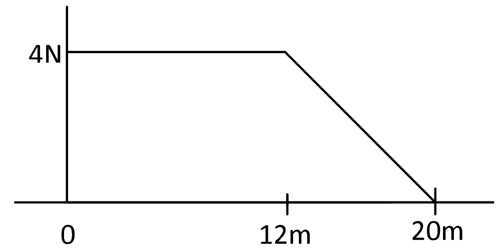
$$C = 2\pi r$$
$$C = 2\ \pi\,(0.055\text{ m})$$
$$C = .35\ m$$

a. The radius of a circle is 57.4 mm. What is its area of this circle in square meters?

b. The base and height of a right triangle are 9.4 nm & 4.5 nm respectively. What is the area of this triangle in square meters?

Parts c, d, and e refer to the graph on the right:
(Remember to write down the formula used, the substitution of the values with units, and the final answer with units)

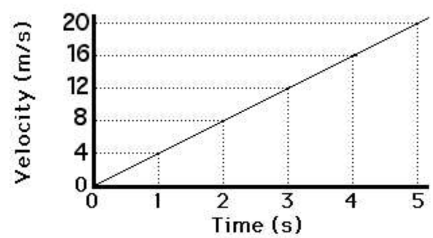
c. What is the slope of the line between 0 and 12 meters?



d. What is the slope of the line between 12 and 20 meters?

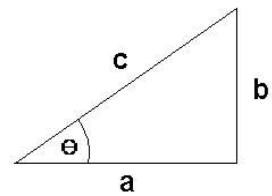
e. What is the area under the curve between 0 and 12 meters?

Parts f and g refer to the graph on the right:
(Remember to write down the formula used, the substitution of the values with units, and the final answer with units)



f. What is the slope of the line?

g. What is the area under the curve between 0 and 5 seconds?



6. Using the generic triangle shown above and right triangle trigonometry, solve the following. Be sure to write down the equation used, the substitution of values with units, and the final answer with units. ***<u>Your calculator must be in degree mode.</u>***

<u>Sample</u>

$\theta = 55^\circ$ and ***c*** = 32 *m*, solve for ***a*** and ***b***. ____18 m____ ____26 m____

$$\sin\theta = \frac{\text{Opposite}}{\text{Hypotenuse}} \qquad \cos\theta = \frac{Adjacent}{\text{Hypotenuse}}$$

$$\sin 55^\circ = \frac{b}{32m} \qquad \cos 55^\circ = \frac{a}{32m}$$

$$b = \left(\sin 55^\circ\right)\left(32m\right) = 26m \qquad a = \left(\cos 55^\circ\right)\left(32m\right) = 18m$$

b. $\theta = 45^\circ$ and ***a*** = 15 *m/s*, solve for ***b*** and ***c***. ________ ________
b **c**

c. ***b*** = 17.8 *m* and $\theta = 65^\circ$, solve for ***a*** and ***c***. ________ ________
a **c**

d. ***a*** = 250 *m* and ***b*** = 180 *m*, solve for θ and ***c***. ________ ________
θ **c**

e. ***a*** =25 *cm* and ***c*** = 32 *cm*, solve for ***b*** and θ. ________ ________
b **θ**

7.

Answer the questions using complete sentences, and answer the problems by writing down the formula used, the substitution of values with units, and the final answer with units. Be sure to use the factor-label method when converting. Keep the following in mind when using the ideal gas equations:

T must be in Kelvins
$R = 8.31\ J/(mol{\cdot}K) = 0.0821\ (L{\cdot}atm)/(mol{\cdot}K)$

<u>Sample</u>

A Goodyear blimp typically contains 5400 m^3 of helium (He) at an absolute pressure of 1.1×10^5 Pa. The temperature of the helium is 280 K. What is the mass (in kilograms) of the helium (4 g/mol) in the blimp?

$V = 5400\ m^3$ $P = 1.1 \times 10^5\ Pa$ $T = 280\ K$ $R = 8.31\ J/(mol{\cdot}K)$ $n = ?$

$$PV = nRT$$
$$(1.1 \times 10^5\ Pa)(5400\ m^3) = n(8.31\ J/(mol{\cdot}K))(280\ K)$$
$$n = 2.6 \times 10^5\ mol$$

$$\mathbf{2.6 \times 10^5 mol} \left(\frac{\mathbf{4\ g}}{\mathbf{1\ mol}}\right)\left(\frac{\mathbf{1\ kg}}{\mathbf{1000\ g}}\right) = \underline{1.0 \times 10^3\ kg}$$

a. Above the liquid in a can of hair spray is a gas at relatively high pressure. The label on the can includes the warning "Do not store at high temperatures." Use the ideal gas law and explain why the warning is given.

b. Assuming that air behaves like an ideal gas, explain what happens to the pressure in a tightly sealed house when the electric furnace turns on for a while.

c. Atmospheric pressure decreases with increasing altitude. With this fact in mind, explain why helium-filled weather balloons are underinflated when they are launched from earth.

d. A commonly used packing material consists of "bubbles" of air trapped between bonded layers of plastic, known as bubble wrap. Using the ideal gas law, explain why this packing material offers less protection on cold days than on warm days.

e. At the start of a trip, a driver adjusts the absolute pressure in her tires to be 2.81×10^5 Pa when the outdoor temperature is 284 K. At the end of the trip she measures the pressure to be 3.01×10^5 Pa. Ignoring the expansion of the tires, find the air temperature inside the tires at the end of the trip.

f. A 50 mL glass vial of xenon gas at 23 °C and 130 kPa was placed in the refrigerator, where the temperature was 3.6 °C. What is the pressure of the chilled xenon gas in the vial?

g. A lung-full of air (350 cm^3) is exhaled into a machine that measures lung capacity. If the air is exhaled from the lungs at a pressure of 1.08 atm at 37 °C, but the machine is at 0.958 atm and 23 °C, what is the volume of air measured by the machine?

h. In a diesel engine, the piston compresses air at 305 K to a volume that is one-sixteenth of the original volume and a pressure that is 48.5 times the original pressure. What is the temperature of the air after the compression?

Name SOLUTIONS 2011

1. Compute the following physics expressions. If the expression has units, then apply the same mathematical operations to the units that were applied to the numbers. Simplify the units if possible. The units are just as important as the numbers.

Sample: $T = 2\pi\sqrt{\frac{4.5\times10^{-2}kg}{2.0\times10^{3}\ kg/s^2}} =$ ____________

$$T = 2\pi\sqrt{\frac{4.5\times10^{-2}}{2.0\times10^{3}}}\ \sqrt{\frac{kg}{kg/s^2}}$$

$$T = 2\pi\sqrt{2.25\times10^{-5}}\ \sqrt{kg \div (kg/s^2)}$$

$$T = 2\pi(4.74\times10^{-3})\ \sqrt{\cancel{kg} \times (s^2/\cancel{kg})}$$

$$T = 3.0\times10^{-2}\ s$$

a. $K = \frac{1}{2}(6.6\times10^{2}\ kg)(2.11\times10^{4}\ m/s)^2 =$ $\cancel{1.47\times10^{11}\ kgm^2/s^2}$ $1.5\times10^{11}\ kgm^2/s^2$

$(3.3\times10^{2}\ kg)(4.45\times10^{8} m^2/s^2)$

$146919300000\ kgm^2/s^2$

b. $F = \left(9.0\times10^{9}\frac{N\cdot m^2}{C^2}\right)\frac{(3.2\times10^{-9}C)(9.6\times10^{-9}C)}{(0.32m)^2} =$ $2.7\times10^{-6}N$

$\frac{(9\times10^{9}\ N\cancel{m^2}/\cancel{C^2})(3.072\times10^{-17}\cancel{C^2})}{0.1024\cancel{m^2}}$

c. $e = \frac{1.7\times10^{3}\ J - 3.3\times10^{2}\ J}{1.7\times10^{3}\ J} =$ 0.81

$e = \frac{1370\cancel{J}}{1.7\times10^{3}\cancel{J}}$

d. $K_{max} = (6.63\times10^{-34}\ J\cdot\cancel{s})(7.09\times10^{14}\cancel{s^{-1}}) - 2.17\times10^{-19}\ J =$ $2.53\times10^{-19}J$

$4.7\times10^{-19}\ J - 2.17\times10^{-19}\ J$

2. Often problems on the AP exam are done with variables only. Solve for the variable indicated. Don't let the different letters confuse you. Manipulate the letters algebraically as though they were numbers.

Sample $v^2 = v_o{}^2 + 2a(x - x_o)$, $a = ?$

$$v^2 - v_o{}^2 = 2a(x - x_o)$$

$$\tfrac{1}{2}(v^2 - v_o{}^2) = a(x - x_0)$$

$$\frac{\frac{1}{2}(v^2 - v_o{}^2)}{(x - x_o)} = a$$

$$a = \frac{\frac{1}{2}(v^2 - v_o{}^2)}{(x - x_o)}$$

a. $U = \frac{1}{2}kx^2$, $x =$ $\sqrt{\frac{2U}{k}}$

$2U = kx^2$

$\frac{2U}{k} = x^2$

b. $T_p = 2\pi\sqrt{\frac{\ell}{g}}$, $g =$ $\frac{4\pi^2\ell}{T_p{}^2}$

$T_p{}^2 = 4\pi^2\left(\frac{\ell}{g}\right)$

$T_p{}^2 g = 4\pi^2\ell$

c. $F_g = G\frac{m_1 m_2}{r^2}$, $r =$ $\sqrt{\frac{Gm_1m_2}{F_g}}$

$F_g r^2 = Gm_1m_2$

$r^2 = \frac{Gm_1m_2}{F_g}$

d. $mgh = \frac{1}{2}mv^2$, $v =$ $\sqrt{2gh}$

$2mgh = mv^2$

e. $x = x_o + v_o t + \frac{1}{2}at^2$, $t =$

$0 = -\Delta x + v_o t + \frac{1}{2}at^2$

$\frac{b \pm \sqrt{b^2 - 4ac}}{2a}$

$\frac{v_o \pm \sqrt{v_o{}^2 + 2a\Delta x}}{a}$

f. $B = \frac{\mu_o I}{2\pi r}$, $r =$ $\frac{\mu_o I}{2\pi B}$

$B2\pi r = \mu_o I$

r

g. $x_m = \frac{m\lambda L}{d}$, $d =$ $\frac{m\lambda L}{x_m}$

h. $pV = nRT$, $T =$ $\frac{pV}{nR}$

i. $\sin\theta_c = \frac{n_1}{n_2}$, $\theta_c =$ $\sin^{-1}\left(\frac{n_1}{n_2}\right)$

j. $\frac{1}{f} = \frac{1}{s_o} + \frac{1}{s_i}$, $s_i =$ $\frac{s_o f}{s_o + -f}$

$\frac{1}{f} + \frac{-1}{s_o} = \frac{1}{s_i}$

$\frac{s_o}{s_o f} + \frac{-f}{s_o f} = \frac{1}{s_i}$

$\frac{s_o + -f}{s_o f} = \frac{1}{s_i}$

3. Physicists usually use the *MKS* System of measurement. MKS stands for meter, kilogram, and second. This is also known as the SI System of measurement. SI stands for System International. It is often necessary to convert measurements to MKS units. Use the factor-label method (some teachers call it dimensional analysis or the multiplying by one method) to convert the below measurements. Be sure to use this method as shown in the sample. The following conversion factors may be needed.

Kelvin temp. = °C + 273
1 atm = 1.013×10^5 Pa
1 m^3 = 1×10^3 L

Factor	Prefix	Symbol
10^9	giga	G
10^6	mega	M
10^3	kilo	k
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p

Sample: 4008 km/h = ? m/s

$$4008\frac{\cancel{km}}{\cancel{h}}\left(\frac{1\times 10^3 m}{1\,\cancel{km}}\right)\left(\frac{1\,\cancel{h}}{60\,\cancel{min}}\right)\left(\frac{1\,\cancel{min}}{60\,s}\right) = 1113\,\frac{m}{s}$$

a. 1.2 *km* = 1200 *m*

$1.2\,km\left(\frac{1000m}{km}\right) = 1200m$

b. 823 *nm* = 8.23×10^{-7} *m*

$823\times10^{-9}m$

$823\,\cancel{nm}\left(\frac{1\times10^{-9}m}{1\,\cancel{nm}}\right)$

c. 298 *K* = 25 °C

298K = °C + 273

d. 0.77 *m* = 77 *cm*

$0.77m\left(\frac{100cm}{1m}\right)$

e. 8.8×10^{-8} *m* = 8.8×10^{-5} *mm*

$8.8\times10^{-8}\cancel{m}\left(\frac{1000mm}{1\cancel{m}}\right)$

f. 1.2 *atm* = 121560 *Pa*

$1.2\,\cancel{atm}\left(\frac{1.013\times10^5 Pa}{1\,\cancel{atm}}\right)$ $1.21560\times10^5 Pa$

g. 25.0 *μm* = 2.5×10^{-5} *m*

$25\times10^{-6}m$

$25\mu m\left(\frac{1\times10^{-6}m}{1\mu m}\right)$

h. 2.65 *mm* = 0.00265 *m*

$2.65\,\cancel{mm}\left(\frac{1\times10^{-3}m}{1\,\cancel{mm}}\right)$ $2.65\times10^{-3}m$

i. 8.23 *m* = 0.00823 *km*

$8.23\,\cancel{m}\left(\frac{1\,km}{1000\,\cancel{m}}\right)$ $8.23\times10^{-3}km$

j. 5.4 *L* = 0.0054 m^3

$5.4\,\cancel{L}\left(\frac{1m^3}{1000\cancel{L}}\right)$ $5.4\times10^{-3}m^3$

k. 40.0 *cm* = 0.40 *m*

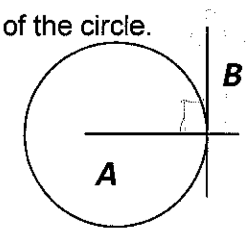
$40\,\cancel{cm}\left(\frac{1m}{100\cancel{cm}}\right)$

l. 6.23×10^{-7} *m* = 623 *nm*

$6.23\times10^{-7}m\left(\frac{1\,nm}{1\times10^{-9}\,nm}\right)$

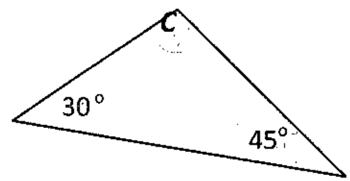
4. Solve the following geometric problems.

a. Line **B** touches the circle at a single point. Line **A** extends through the center of the circle.

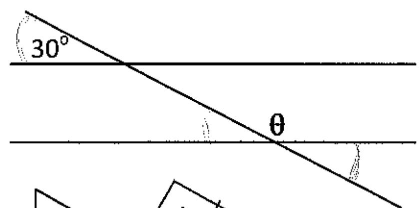


i. What is line **B** in reference to the circle? tangent

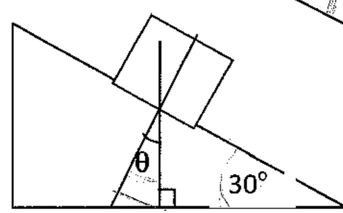
ii. How large is the angle between lines **A** and **B**? 90°



b. What is angle **C**? 105°



c. What is angle θ ? 150°



d. How large is *θ*? 30°

5. Calculate the following. Be sure to use the factor-label method when converting. Be sure to write down the formula used, the substitution of the values with units, and the final answer with units.

<u>**Sample**</u> The radius of a circle is 5.5 *cm*. What is the circumference of this circle in <u>meters</u>?

$$5.5\ cm\left(\frac{1\ m}{100\ cm}\right) = 0.055\ m$$

$$C = 2\pi r$$
$$C = 2\ \pi\ (0.055\ \text{m})$$
$$C = .35\ m$$

a. The radius of a circle is 57.4 mm. What is its area of this circle in <u>square meters</u>?

$A = \pi r^2$

$A = \pi (0.0574 m)^2$

$A = 0.01 m^2 = 0.003\pi m^2$

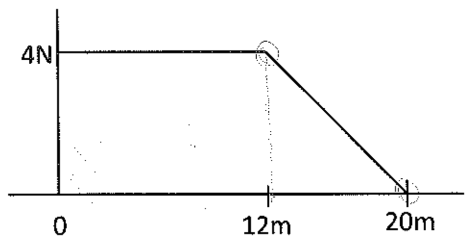
b. The base and height of a right triangle are 9.4 nm & 4.5 nm respectively. What is the area of this triangle in <u>square meters</u>?

$A = \frac{1}{2} bh$

$A = \frac{1}{2}(9.4\times10^{-9} m)(4.5\times10^{-9} m)$

$A = 2.12\times10^{-17} m^2$

Parts c, d, and e refer to the graph on the right:
(Remember to write down the formula used, the substitution of the values with units, and the final answer with units)



c. What is the slope of the line between 0 and 12 meters?

$$\text{Slope} = \frac{\Delta y}{\Delta x}$$

$$\text{slope} = 0$$

d. What is the slope of the line between 12 and 20 meters?

$$\text{slope} = \frac{\Delta y}{\Delta x} = \frac{0\text{-}4N}{20m-12m}$$

$$\text{slope} = {}^{-}0.5\ N/m$$

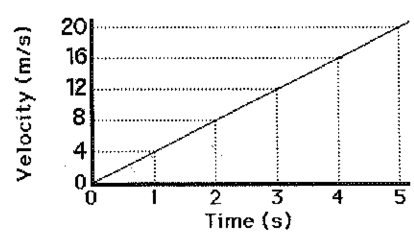
e. What is the area under the curve between 0 and 12 meters?

$$\text{Area} = l \times w$$

$$\text{Area} = 12m \times 4N$$

$$\text{Area} = 48\ Nm.$$

Parts f and g refer to the graph on the right:
(Remember to write down the formula used, the substitution of the values with units, and the final answer with units)



f. What is the slope of the line?

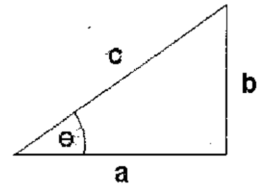
$$\text{Slope} = \frac{\Delta y}{\Delta x} = \frac{20\,m/s - 0}{5s - 0} = 4\ m/s^2$$

g. What is the area under the curve between 0 and 5 seconds?

$$\text{Area} = l \times w$$

$$\text{Area} = \frac{(5s)(20\,m/s)}{2} = 50m$$

SOH CAH TOA



6. Using the generic triangle shown above and right triangle trigonometry, solve the following. Be sure to write down the equation used, the substitution of values with units, and the final answer with units. ***Your calculator must be in degree mode.***

Sample

θ = 55° and ***c*** = 32 *m*, solve for ***a*** and ***b***. 18 m (a) 26 m (b)

$$\sin\theta = \frac{\text{Opposite}}{\text{Hypotenuse}} \qquad \cos\theta = \frac{Adjacent}{\text{Hypotenuse}}$$

$$\sin 55^\circ = \frac{b}{32m} \qquad \cos 55^\circ = \frac{a}{32m}$$

$$b = (\sin 55^\circ)(32m) = 26m \qquad a = (\cos 55^\circ)(32m) = 18m$$

b. θ = 45° and ***a*** = 15 *m/s*, solve for ***b*** and ***c***. 15 m/s (**b**) 21 m/s (**c**) 21.21 m/s

$\tan\theta = \frac{opp}{adj}$ $\cos\theta = \frac{adj}{hyp}$

$\tan 45^\circ = \frac{b}{15 m/s}$ $\cos 45^\circ = \frac{15 m/s}{c}$

$b = (15 m/s)\tan 45$ $c = (15 m/s)/\cos 45^\circ$

c. ***b*** = 17.8 *m* and θ = 65°, solve for ***a*** and ***c***. 8.3m (**a**) 19.64m (**c**)

$\tan\theta = \frac{opp}{adj}$ $\sin\theta = \frac{opp}{hyp}$

$\tan 65^\circ = \frac{17.8m}{a}$ $\sin 65^\circ = \frac{17.8m}{c}$

$a = \frac{17.8m}{\tan 65^\circ}$ $c = 17.8m/\sin 65^\circ$

d. ***a*** = 250 *m* and ***b*** = 180 *m*, solve for θ and ***c***. 36° (**θ**) 308 m (**c**)

$\tan\theta = \frac{a}{b}$ $a^2 + b^2 = c^2$

$\tan\theta = \frac{180m}{250m}$ $(250m)^2 + (180m)^2 = c^2$

$\theta = \tan^{-1}\left(\frac{180m}{250m}\right)$ $c = 308m$

e. ***a*** =25 *cm* and ***c*** = 32 *cm*, solve for ***b*** and θ. 20 cm (**b**) 39° (**θ**)

$\cos\theta = \frac{adj}{hyp}$ $a^2 + b^2 = c^2$

$(25cm)^2 + b^2 = (32cm)^2$

$\cos\theta = \frac{25cm}{32cm}$ $b^2 = 1024cm^2 - 625cm^2$

$\theta = \cos^{-1} 0.78125$ $b^2 = 399 cm^2$

7. There is a small part of the physics curriculum that revisits some topics covered in chemistry. Answer the questions using complete sentences, and answer the problems by writing down the formula used, the substitution of values with units, and the final answer with units. Be sure to use the factor-label method when converting. Keep the following in mind when using the ideal gas equations:

T must be in Kelvins
R = 8.31 J/(mol·K) = 0.0821 (L·atm)/(mol·K)

Sample

A Goodyear blimp typically contains 5400 m^3 of helium (He) at an absolute pressure of 1.1×10^5 Pa. The temperature of the helium is 280 K. What is the mass (in kilograms) of the helium (4 g/mol) in the blimp?

$V = 5400\ m^3$ $P = 1.1 \times 10^5\ Pa$ $T = 280\ K$ $R = 8.31\ J/(mol \cdot K)$ $n = ?$

$$PV = nRT$$
$$(1.1 \times 10^5\ Pa)(5400\ m^3) = n(8.31\ J/(mol \cdot K))(280\ K)$$
$$n = 2.6 \times 10^5\ mol$$

$$2.6 \times 10^5 \text{mol} \left(\frac{4\text{ g}}{1\text{ mol}}\right)\left(\frac{1\text{ kg}}{1000\text{ g}}\right) = \underline{1.0 \times 10^3\text{ kg}}$$

a. Above the liquid in a can of hair spray is a gas at relatively high pressure. The label on the can includes the warning "Do not store at high temperatures." Use the ideal gas law and explain why the warning is given.

$PV = nRT$ The volume of the gas is fixed since it is contained within a rigid container. The number of moles of gas in the can is also fixed since it is a closed container. According to the ideal gas law there is a direct relationship between pressure and temperature. So, at high temperatures, the pressure of the gas in the can will also be very high.

b. Assuming that air behaves like an ideal gas, explain what happens to the pressure in a tightly sealed house when the electric furnace turns on for a while.

This explanation is the same as the gas in a can of hair spray. As the temperature of the air in the house increases due to the furnace, the pressure in the house also increases.

c. Atmospheric pressure decreases with increasing altitude. With this fact in mind, explain why helium-filled weather balloons are underinflated when they are launched from earth.

As the balloons rise, the pressure outside the balloons decreases which allows the helium inside the balloon to expand. If the balloons were properly inflated at sea level, they would become over-inflated, and perhaps burst, when they reached altitude.

d. A commonly used packing material consists of "bubbles" of air trapped between bonded layers of plastic, known as bubble wrap. Using the ideal gas law, explain why this packing material offers less protection on cold days than on warm days.

On cold days, when the temperature is low, the pressure of the gas in the "bubbles" is also low. This leads to less "cushiony" bubbles which offer less protection.

e. At the start of a trip, a driver adjusts the absolute pressure in her tires to be 2.81×10^5 Pa when the outdoor temperature is 284 K. At the end of the trip she measures the pressure to be 3.01×10^5 Pa. Ignoring the expansion of the tires, find the air temperature inside the tires at the end of the trip.

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{2.81 \times 10^5 \text{ Pa}}{284\text{K}} = \frac{3.01 \times 10^5 \text{ Pa}}{T_2}$$

$$T_2 = 304\text{K}$$

f. A 50 mL glass vial of xenon gas at 23 °C and 130 kPa was placed in the refrigerator, where the temperature was 3.6 °C. What is the pressure of the chilled xenon gas in the vial?

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{130\text{kPa}}{296\text{K}} = \frac{P_2}{276.6\text{K}}$$

$$P_2 = 121.5 \text{ kPa}$$

g. A lung-full of air (350 cm^3) is exhaled into a machine that measures lung capacity. If the air is exhaled from the lungs at a pressure of 1.08 atm at 37 °C, but the machine is at 0.958 atm and 23 °C, what is the volume of air measured by the machine?

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{(1.08\text{atm})(350\text{cm}^3)}{310\text{K}} = \frac{(0.958\text{atm})(V_2)}{296\text{K}}$$

$$V_2 = 377 \text{cm}^3$$

h. In a diesel engine, the piston compresses air at 305 K to a volume that is one-sixteenth of the original volume and a pressure that is 48.5 times the original pressure. What is the temperature of the air after the compression?

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

$$\frac{1}{305\text{K}} = \frac{(48.5)(1/16)}{T_2}$$

$$T_2 = 925\text{K}$$