

AP Physics 1 Summer Work

Physics is the natural science that studies matter, its motion and behavior through space and time, and the related entities of energy and force. Physics is the most fundamental scientific discipline, and its main goal is to understand how the universe behaves. Physics is one of the oldest academic disciplines and, through its inclusion of astronomy, perhaps *the* oldest. Over much of the past two millennia, physics, chemistry, biology, and certain branches of mathematics were a part of natural philosophy, but during the Scientific Revolution in the 17th century these natural sciences emerged as unique research endeavors in their own right. Physics intersects with many interdisciplinary areas of research, such as biophysics and quantum chemistry, and the boundaries of physics are not rigidly defined. New ideas in physics often explain the fundamental mechanisms studied by other sciences and suggest new avenues of research in academic disciplines such as mathematics and philosophy. Advances in physics often enable advances in new technologies. For example, advances in the understanding of electromagnetism, solid-state physics, and nuclear physics led directly to the development of new products that have dramatically transformed modern-day society, such as television, computers, domestic appliances, and nuclear weapons; advances in thermodynamics led to the development of industrialization; and advances in mechanics inspired the development of calculus.

Important information

- Due Date → 8/23/24
 - If you do not complete the summer work your first marking period grade will drop by a full letter grade.
 - Late summer work turned in after 8/23/24 will suffer a 5% reduction in points per day.
 - No summer work will be accepted after 9/7/24.
- How can I turn in the summer work?
 1. Drop a hard copy off to the main office.
 2. Email it directly to me via kevin.gerardi@cape.k12.de.us (be sure to attach your summer work before hitting send).
 3. Send me a message in Schoology, with the summer work attached.

Show your work on all problems

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Variables Symbols

In physics, variables are used to denote a variety of unknowns and concepts. Many of these variables are represented with letters of the Greek alphabet. You will need to become familiar with these letters. There is no actual work for this section, neither are you required to “memorize” them. This is to expose you to them before class starts. These variables have specific names and I will be using these names. You should do this as well.

Greek Letter	Name	Commonly used for
α	Alpha (lowercase)	Angular acceleration, radiation particle
β	Beta (lowercase)	Radiation particle
Δ	Delta (uppercase)	Showing a change in a quantity
ϵ	Epsilon (lowercase)	Permittivity
ϕ	Phi (lowercase)	Magnetic Flux, work function
γ	Gamma (lowercase)	Radioactivity, relativity
λ	Lambda (lowercase)	Wavelength
μ	Mu (lowercase)	coefficient of friction
π	Pi (lowercase)	Mathematical constant
θ	Theta (lowercase)	Angle name
ρ	Rho (lowercase)	Density, resistivity
Σ	Sigma (uppercase)	Showing the sum of numbers
τ	Tau (lowercase)	Torque
ω	Omega (lowercase)	Angular velocity
ξ	Xi (uppercase)	Electromotive force; induced voltage

The Metric System

In physics, we use the metric system to measure everything. The metric system is also called the SI system. The English system (feet, pounds, gallons) will not be used. The only exception is when you convert them to metric units. The fundamental quantities of the metric system are measured in meters, kilograms, liters, and seconds. Below are the metric system prefixes we will use throughout the year.

Name of prefix	Numerical value	Abbreviation
pico-	10^{-12}	p
nano-	10^{-9}	n
micro-	10^{-6}	μ
milli-	10^{-3}	m
centi-	10^{-2}	c
kilo-	10^3	k
mega-	10^6	M
Giga	10^9	G

Units and unit symbols

Reference table for linking variables to their symbols and their accompanying units and symbol.

Variable	Variable Symbol	Units	Unit symbol
Linear Displacement	$\Delta x / \Delta y$	meter	m
Linear Velocity	v	Meter per second	m/s
Linear Acceleration	a	Meter per second squared	m/s ²
Time	t	second	s
Mass	m	kilogram	kg
Force	F	Newtons	N
Momentum	p	Kilogram * meter per second	Kg*m/s
Length/Radius	L / r	meter	m
Work	W	Joules	J
Energy	KE, PE, U, ME	Joules	J
Elastic constant	k	Newton per meter	N/m
Moment of inertia	I	Kilogram*meter squared	Kg*m ²
Moment arm	r	meter	m
Torque	τ	Newton meter	N*m
Angular Displacement	θ	radian	unitless
Angular Velocity	ω	Radian per second	s ⁻¹
Angular Acceleration	α	Radian per second squared	s ⁻²
Power	P	Watts	W
Voltage	V	Volts	V
Current	I	Amperes	A
Charge	Q	Coulombs	C
Resistance	R	Ohms	Ω
Area	A	Meters squared	m ²
Height	h	meter	m
Electrical Field Strength	E	Newtons per Coulomb	N/C

Gravitational Field Strength	g	Newtons per kilogram	N/kg
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Solving Symbolically

Throughout the year in class and on the AP exam, problems will be tackled with variables only. Solve for the variable indicated, and do not let the different variables confuse you: we will cover these relationships in class. Manipulate/rearrange these equations algebraically as if they were numbers. Two examples of this technique are shown below.

Example 1:

Solve for Q :

$$U = \frac{kQ}{r^2}$$

Multiply r^2 to both sides:

$$r^2 * U = \frac{kQ}{r^2} * r^2$$

Divide both sides by k :

$$\frac{r^2 * U}{k} = \frac{kQ}{k}$$

$$Q = \frac{r^2 * U}{k}$$

Example 2:

Solve for r :

$$U = \frac{kQ}{r^2}$$

Multiply r^2 to both sides:

$$r^2 * U = \frac{kQ}{r^2} * r^2$$

Divide both sides by U :

$$\frac{r^2 * U}{U} = \frac{kQ}{U}$$

Take the square root of both sides:

$$\sqrt{r^2} = \sqrt{\frac{kQ}{U}}$$

$$r = \sqrt{\frac{kQ}{U}}$$

$mgh = \frac{1}{2}mv^2$	1. Solve for v
$T = 2\pi \sqrt{\frac{L}{g}}$	2. Solve for L
$pV = nRT$	3. Solve for T
$F = \frac{kQ_1Q_2}{r^2}$	4. Solve for r
$v_f^2 = v_o^2 + 2g\Delta y$	5. Solve for v_o
$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2}$	6. Solve for R_2
$v = \sqrt{2a\Delta x}$	7. Solve for Δx
$a = \frac{mgsin\theta - \mu mgcos\theta}{m}$	8. Solve for g
$F_c = \frac{mv^2}{r}$	9. Solve for m
$B = \frac{\mu_o I}{2\pi r}$	10. Solve for r

$v = \frac{(x_f - x_o)}{t}$	11. Solve for x_f
$\sin\theta_c = \frac{n_1}{n_2}$	12. Solve for θ_c
$m_1v_1 + m_2v_2 = (m_1 + m_2)v_f$	13. Solve for v_f
$\frac{Gm_1m_2}{r^2} = \frac{m_1v^2}{r}$	14. Solve for v
$-kx + m(-g) = ma$	15. Solve for k
$v = \lambda \frac{1}{T}$	16. Solve for T
$x_f = x_o + v_ot + \frac{1}{2}at^2$	17. Solve for x_o
$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2}$	18. Solve for R_{total}
$\frac{v_f + v_o}{2} = \bar{v}$	19. Solve for v_f
$a_{system} = \frac{F_T + F_R - F_f}{(m_1 + m_2)}$	20. Solve for F_f
$T^2 = \frac{4\pi^2r^3}{GM}$	21. Solve for G

Algebraic Manipulation with Numbers

22. Find: v_f Given that: $v_o = 0$, $t = 4$, $a = 3.2$

- $v_f = v_o + at$

= _____

23. Find: v_o Given that: $x_o = 0$, $x_f = 25$, $t = 2$, $a = 10$

- $x_f = x_o + v_o t + \frac{1}{2}at^2$

= _____

24. Find: μ Given that: $F_f = mg\sin\theta$, $F_N = mg\cos\theta$, $\theta = 30^\circ$

- $F_f = \mu F_N$

= _____

25. Find: ρ_1 Given that: $V = A \cdot h$, $A_1 = A_2$, $h_1 = 2h_2$, $\rho_2 = 10$

- $\rho_1 V_1 g = \rho_2 V_2 g$

= _____

26. Find: t Given that: $x_{f1} = x_{f2}$

- $x_{f1} = 5 - 2t$

- $x_{f2} = -1 + \frac{1}{2}t$

= _____

27. Find: T Given that: $a_1 = a_2$, $m = 5$, $g = 10$

- $a_1 = \frac{T}{3m}$

- $a_2 = \frac{mg - T}{m}$

= _____

System of Equations

1. $F_f = \mu F_N$ and $F_N = mg \cos \theta$. Solve for μ in terms of F_f, m, g , and θ

2. $F_1 + F_2 = F_T$ and $F_1 \cdot d_1 = F_2 \cdot d_2$ Solve for F_1 in terms of F_T, d_1 , and d_2 .

3. $\sum F = ma_c$ and $a_c = \frac{v^2}{r}$. Solve for r in terms of $\sum F, m$, and v .

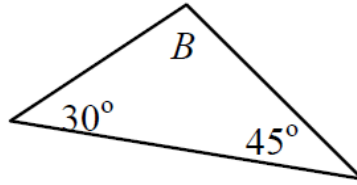
4. $T = 2\pi \sqrt{\frac{m}{k}}$ and $T = \frac{1}{f}$. Solve for k in terms of π, g , and f .

5. Consider $z = \frac{x}{y}$, $c = ab$, $l = m - n$, and $r = \frac{s^2}{t^2}$
 - a. As x increases and y stays constant, z _____.
 - b. As y increases and x stays constant, z _____.
 - c. As x increases and z stays constant, y _____.
 - d. As a increases and c stays constant, b _____.
 - e. As c increases and b stays constant, a _____.
 - f. As b increases and a stays constant, c _____.
 - g. As n increases and m stays constant, l _____.
 - h. As l increases and n stays constant, m _____.
 - i. If s is tripled and t stays constant, r (increases/decreases) by a factor of _____.
 - j. If t is doubled and s stays constant, r (increases/decreases) by a factor of _____.

Geometry Review

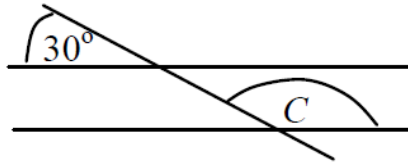
1. What is the value of angle B?

B = _____



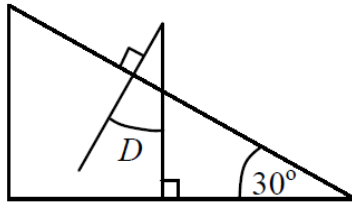
2. The two horizontal lines are parallel. What is the value of angle C?

C = _____



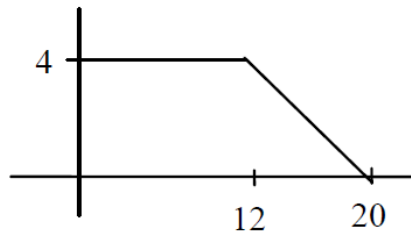
3. How large is angle D?

D = _____



4. Determine the area under the graph.

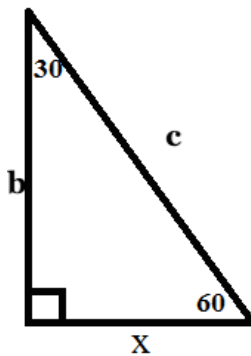
Area = _____



5. What are the values for side lengths b and c in terms of x?

b = _____

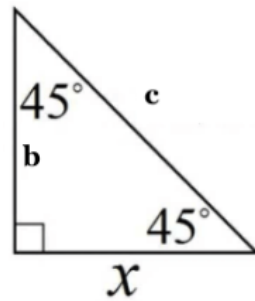
c = _____



6. What are the values for side lengths b and c in terms of x?

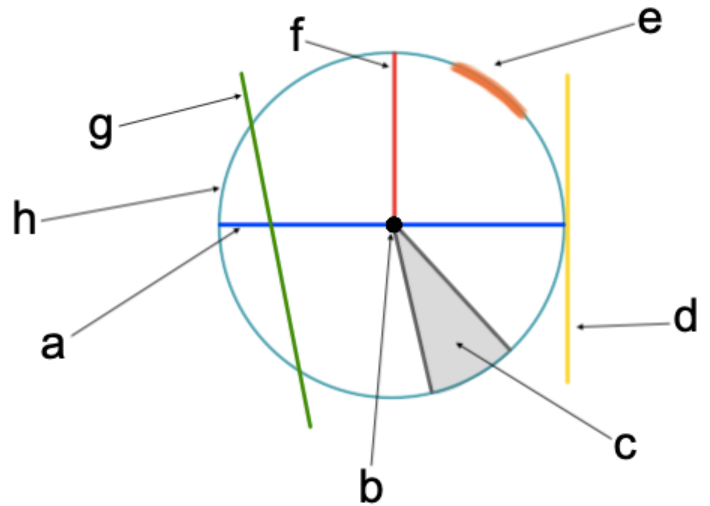
b = _____

c = _____



7. Label the parts of a circle.

- a. _____
- b. _____
- c. _____
- d. _____
- e. _____
- f. _____
- g. _____
- h. _____

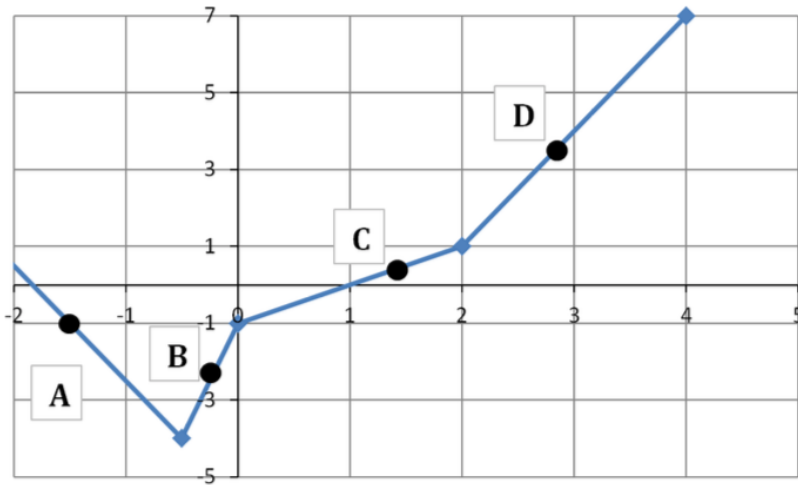


Geometric Formula Reference Sheet

Shape	Area	Perimeter	Circumference	Volume	Surface Area
Square	$(L)(w)$	$4(L)$			
Rectangle	$(L)(w)$	$2(L + w)$			
Triangle	$\frac{1}{2}(b)(h)$				
Trapezoid	$\frac{1}{2}(b_1 + b_2)(h)$				
Circle	πr^2		$2\pi r$		
Cube				$(L)(w)(h)$	$6L^2$
Cylinder				$\pi r^2 h$	$2\pi r h + 2\pi r^2$
Cone				$\frac{1}{3}\pi r^2 h$	$\pi r L$
Sphere				$\frac{4}{3}\pi r^3$	$4\pi r^2$

Graphing

1. Four points are labeled on the following graph. Rank the slopes of the curve at each of the labeled points. Explain your reasoning.



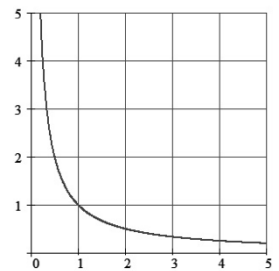
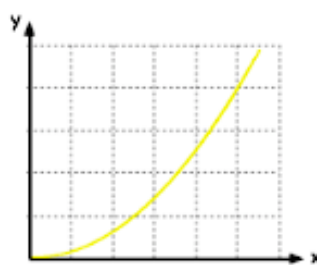
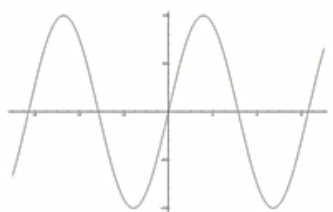
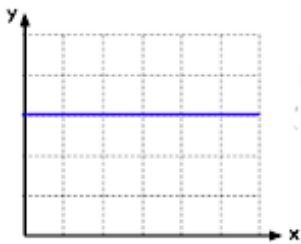
Smallest
Slope

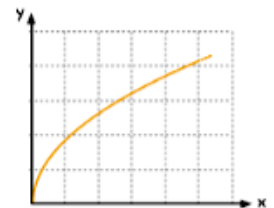
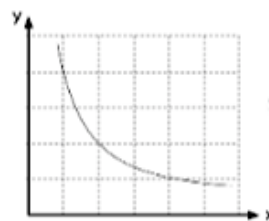
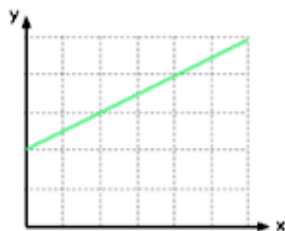
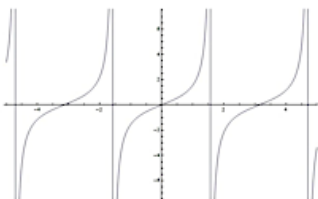
Largest
Slope

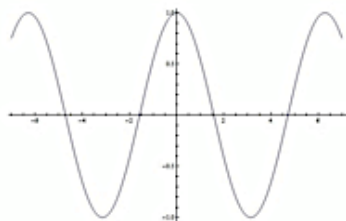
Explain:

2. Match the following graphs with their correct function relationship. (k = some constant/slope)

- a. $y = kx$ b. $y = kx + b$ c. $y = kx^2$ d. $y = k\sqrt{x}$ e. $y = k\frac{1}{x}$ f. $y = k\frac{1}{x^2}$
 b. $y = b$ h. $y = k\sin(x)$ i. $y = k\cos(x)$ j. $y = k\tan(x)$

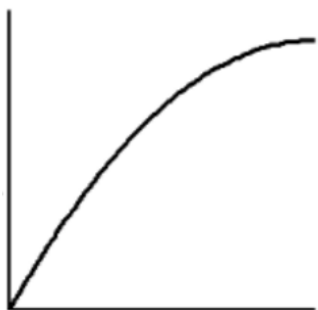






3. Match the graph to the correct description. Each description will only be used once.

- | | |
|--|--|
| a. Constant Slope (Negative) | e. Constantly Decreasing Slope in Negative Direction |
| b. Constant Slope (Positive) | f. Undefined slope |
| c. Constant Slope (Zero) | g. Constantly Increasing Slope in Positive Direction |
| d. Constantly Decreasing Slope in Positive Direction | h. Constantly Increasing Slope in Negative Direction |



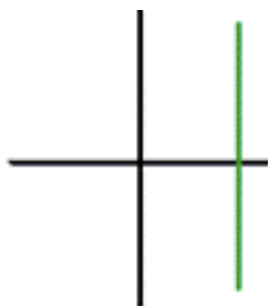














Linearizing Graphs/Functions

Linearization of data is a method for determining which. relationship is the correct one for the given data. The equation $y = mx + b$ is the mathematical representation of a linear relationship. It is called linear. because a graph of that function is a straight line. If your data graphs as a curve, the variables you have plotted have a non-linear mathematical form or relationship. So, if we are confronted with non-linear (curved) data then our goal is to convert the data to a linear (straight) form that can be easily analyzed. This process is called linearization.

In the table below are seven mathematical relationships/models. Match the modification of each relationship/model that is required to linearize its graph. (Express your answer in a form of y vs x)

Word Bank

$$y \text{ vs } \frac{1}{x}$$

$$y \text{ vs } x^2$$

$$y \text{ vs } \frac{1}{x^2}$$

$$y^2 \text{ vs } x$$

Mathematical Relationship/Model	Modification required to linearize graph
$y = b$	1. No relationship between y and x
$y = kx$	2. None already linear
$y = kx + b$	3. None already linear
$y = kx^2$	4.
$y = k\sqrt{x}$	5.
$y = k\frac{1}{x}$	6.
$y = k\frac{1}{x^2}$	7.

Vectors Reading

A vector as we learned earlier is a quantity with a magnitude (value) and a direction. It is often written as an **arrow** pointing in a certain direction along with a number giving its **magnitude**/amount. Remember the length of the arrow corresponds directly to its magnitude. Large vectors are represented by an arrow with a longer length than shorter ones.



Figure 1 - a vector with a direction and a magnitude

Some vectors are not flat like this one. They may point up, down, or to the left in direction. In addition, some are at an angle with respect to the horizontal. What is the horizontal? It is easy to think of the horizontal as the x-axis on a graph in figure 2.

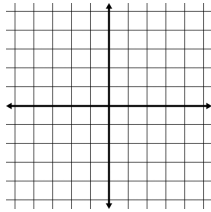


Figure 2 – The x-axis is the horizontal solid black line on the graph

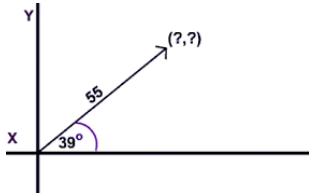


Figure 3 – A vector with a magnitude of 55 and a 39 degree angle with respect to the horizontal

The question of how can we represent vectors so that they make sense to us, comes to mind. There are two ways which are most common. The first is to use what are called **x-y coordinates**. We most commonly see x-y components on graphs represented as a dot (x, y). Some examples are (2, 1), (-3, 2), (7, 0). The second way to represent a vector is to use **polar coordinates**, which includes a length and an angle. An example is 5 m at 37 degrees (5 m, 37 degrees).

Vectors have a special property that makes them very useful. They can be broken down into their components. Creatively, we give their components the appropriate names of the horizontal (**x**) **component** and vertical (**y**) **component**. Each vector only has one vertical and one horizontal component. When we break a vector into its components we get the familiar shape of a triangle in figure 4 below. Label the vertical and horizontal component.

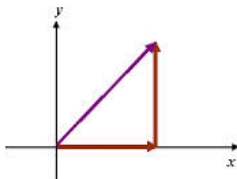


Figure 4 – a vector with its vertical (y) and horizontal (x) component

When you want to find the horizontal (x) and vertical (y) components of a vector you will have to use trigonometry. You have practiced this a lot so make sure you do not forget that you already know how to do this. The only difference is now we are applying it to a certain situation, most likely a word problem that involves an object's motion. Some other

examples you will see later this year that include vectors are when we examine forces, circular motion, acceleration, and particles. Remember no matter what we are learning the steps are the same.

How do we do the math to find the horizontal (x) and vertical (y) components of a vector?

Steps:

- 1) Take note of the vectors magnitude (value), its units, and its angle with respect to the horizontal
- 2) Draw the vectors legs that make a triangle, remembering the original vector itself is the **hypotenuse**
- 3) Use the following formulas:
 - a. Vertical component (y) = (hypotenuse)(sin θ)
 - b. Horizontal component (x) = (hypotenuse)(cos θ)
- 4) Make sure both components have the same units as the original vector. If they do not, you must convert them so that they do before using the equations in step 3 above.

Example 1

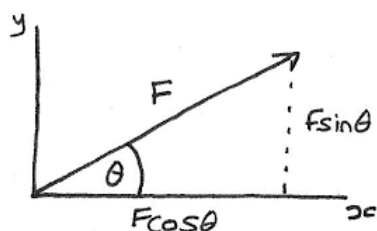
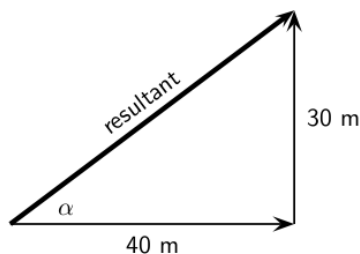


Figure 5 – The original vector is labeled with a F. Remember this is the hypotenuse of the triangle.

For this case we will say that $F = 35 \text{ N}$ (N being the units) and the angle $\theta = 27$ degrees. Below is the math

1. Vertical component (y) = (hypotenuse)(sin θ) $\rightarrow F_y = (35)(\sin 27) = 15.88 \text{ N}$
2. Horizontal component (x) = (hypotenuse)(cos θ) $\rightarrow F_x = (35)(\cos 27) = 31.18 \text{ N}$
3. To check your answer use the Pythagorean theorem $F = \sqrt{F_x^2 + F_y^2}$
 - i. $\sqrt{31.18^2 + 15.88^2} = 34.99 \text{ N}$ this rounds to 35N

Vectors appear in math problems all the time. Two or more vectors can be added or subtracted. In the previous example, we broke a vector labeled F into its x-component (F_x) and y-component (F_y). The Pythagorean Theorem was used to check the answers we got for the two components. The original vector is called the **resultant** vector, because when we added the x-component and y-component together the result was the resultant vector's magnitude.



Remember that when you add two vectors together you cannot just add them together like $1+1 = 2$. You must use the Pythagorean Theorem for right triangles.

What happens if you have more than two vectors that you want add together? You guessed it, you can no longer just use the Pythagorean Theorem because they will no longer form a right triangle. Seriously Mr. Gerardi? Yes, seriously, but no need to worry the steps are simple, but remember practice makes perfect.

Example 2

Say you have three vectors on a graph and each has x-y coordinate (x, y).

Vector 1 $\rightarrow (2, 3)$

Vector 2 $\rightarrow (-1, 7)$

Vector 3 $\rightarrow (4, 0)$

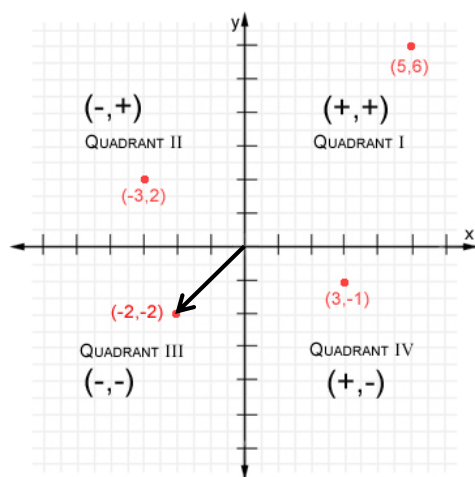
To find the resultant vector from these you add up all the x components ($2 + -1 + 4 = 5$) and all the y components ($3 + 7 + 0 = 10$). The new x-y coordinate is (5, 10). This means the resultant vector has an x component of 5 and a y component of 10. From here you just use the Pythagorean Theorem, the math is below. The resultant vector has a magnitude of 11.1. There are many vector quantities and each has a specific unit. When working with vectors the unit tells you which vector quantity you are dealing with. Vector caps may be used to indicate whether a quantity is a scalar quantity or a vector quantity. A vector cap is just an arrow that is drawn above any quantities symbol to indicate that quantity is a vector. (Example $\rightarrow \vec{v}, \vec{a}, \vec{\Delta x}, \vec{F}$)

$$\text{resultant} = \sqrt{x^2 + y^2} \rightarrow \sqrt{5^2 + 10^2} = 11.1$$

Here it is the last section. Remember that you read that vectors also have a direction along with their magnitude. Well how do we find the angle at which this vector is to the horizontal? We did this in our exploration of trigonometry in the previous unit. To find the angle of a vector we will use the inverse tangent function. To get this on your calculator first hit the **2nd** button then the **tan** button. You will see this symbol appear, $\tan^{-1}$. Now you just divide the resultant vector's y-component by the x-component. And input it into the inverse tangent function. The math is below.

$$\frac{y}{x} = \frac{10}{5} = 2 \rightarrow \theta = \tan^{-1}(2) = 63.43$$

The angle of the vector to the horizontal is 63.43 degrees. The resultant vector can now be represented as the **polar coordinates (11.1, 63.43 degrees)**.



Can a vector's angle be greater than 90 degrees? Can one or more of a vector's components be negative? The answer is yes. For example, if a vector has an angle between 90 and 180 degrees, its x component will be negative and its y component will be positive. This is because the signs of any point (x,y) in the second quadrant on a graph have the same accompanying signs. Whether a vector's signs are positive or negative and which component (x, y, or both) are positive or negative tells you a lot about the angle you are trying to calculate. The total counter clockwise angle from the positive x axis needs to be calculated for the correct direction of your resultant vector. We still use the inverse tangent function here, but must account for any quadrant(s) that proceeds the quadrant the resultant points into. For example, the vector pointing in the third quadrant should have an angle between 180 and 270 degrees. The inverse tangent function using the vector's (x,y) components give us an angle of 45 degrees from the negative x axis to the resultant vector.

To find the total counter clockwise angle from the positive x axis we must add 45 degrees to 180 degrees. The correct total counter clockwise angle is 225 degrees. If the vector is in the second quadrant you must subtract the calculated angle from 180 degrees. If a vector is in the fourth quadrant you subtract the calculated angle from 360 degrees. Any vector in the first quadrant only needs the angle calculated for the total counter clockwise angle.

Questions

1. A vector is a quantity that has a _____ and a _____.
2. Vectors can point up, down, left, right, or at an angle with respect to the _____.
3. Vectors can be represented using _____ or _____.
4. Create three (x, y) coordinates of your choice and write them as you would points on a graph.

X	Y

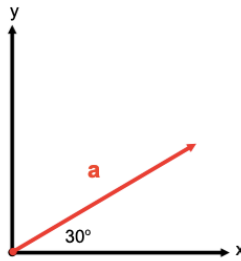
5. Represent a vector with a magnitude of 12 m and a direction on 48 degrees to the horizontal in polar coordinates.
6. Vectors have an ____ component and a ____ component.
7. How do we do the math to find the horizontal (x) and vertical (y) components of a vector?
8. What is the resultant vector of the vectors (1, 2), (5, -3), (4, 4)?
9. What is the angle of the resultant vector from question 8?

Vectors Components

Decompose the following vectors into its x and y components. Include the quadrant the vector is located in.

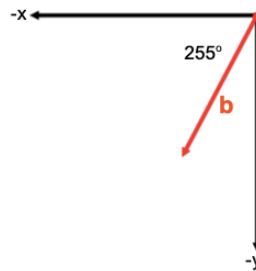
1. Vector $a = 12\text{m}$

- $a_x =$ _____
- $a_y =$ _____
- Quadrant _____



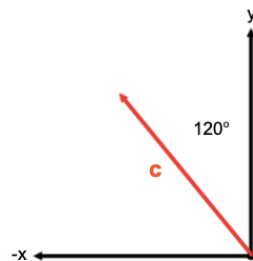
2. Vector $b = 9\text{ m/s}$

- $b_x =$ _____
- $b_y =$ _____
- Quadrant _____



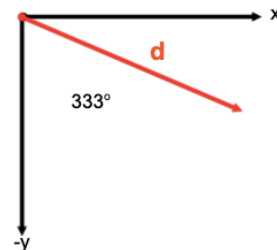
3. Vector $c = 41\text{ m/s/s}$

- $c_x =$ _____
- $c_y =$ _____
- Quadrant _____



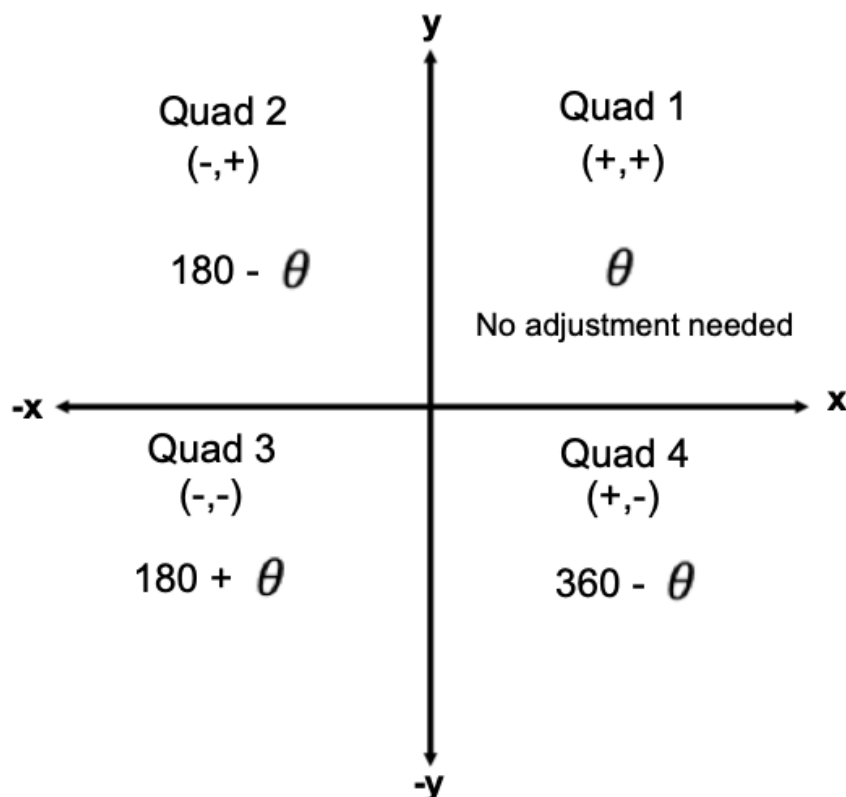
4. Vector $d = 16\text{ N}$

- $d_x =$ _____
- $d_y =$ _____
- Quadrant _____



Vector Addition

- Step 1: Break down each vector into its x and y components
- Step 2: Combine all the x components from each vector ($x_1 + x_2 + x_3 = x_{\text{total}}$).
- Step 3: Combine all the y components from each vector ($y_1 + y_2 + y_3 = y_{\text{total}}$).
- Step 4: Use the Pythagorean Theorem to find the resultant vector's magnitude using the values of x_{total} and y_{total} from steps 2 and 3.
- Step 5: Find the angle using the inverse tangent function and using your values of x_{total} and y_{total} from steps 2 and 3.
- Step 6: Check the signs (+ or -) of your values of x_{total} and y_{total} from steps 2 and 3. The signs tell you the quadrant the resultant vector is located in.
- Step 7: Adjust your angle based on the quadrant the resultant vector is located in. This will give you the full counter-clockwise angle needed for the resultant's direction.



Vector Addition Problems

5. Add a vector whose magnitude is 16.0 and at an angle of 56 degrees to one whose magnitude is 10.0 at an angle of 45 degrees.

6. Add a vector whose magnitude is 10.0 and at an angle of 257 degrees to one whose magnitude is 11.0 at an angle of 105 degrees.

7. Add a vector whose magnitude is 52.0 and at an angle of 347 degrees to one whose magnitude is 93.0 at an angle of 79 degrees.

Name: _____
 Period: _____

Ch. 2:1

Acceleration and Average Speed

Acceleration

Acceleration is how fast you change speed OR how much the speed changed in a certain amount of time.

$$\text{Acceleration (in meter/sec}^2\text{)} \rightarrow a = \frac{\Delta V}{\Delta T}$$

Change of Speed
(in meters/sec)
Change of Time
(in seconds)

*Speed equal change of distance
divided by change of time.*

$$\Delta V = V_f - V_i$$

$$\Delta T = T_2 - T_1$$

$a = \Delta S / \Delta T$, not $a = S / T$.
 Why? If a car is traveling at 60 m/s for 20 sec,
 $S = 60$ m/s, but $\Delta S = 0$ m/s.
**No change of speed:
 no acceleration.**

Example: Calculate Acceleration

*Ex. A plane starts at rest and ends up going 200 m/s in 10 secs.
 Calculate acceleration.*

Step 1: Variables

$$\begin{aligned} S_1 &= 0 \text{ m/s ("starts at rest")} \\ S_2 &= 200 \text{ m/s} \\ \Delta T &= 10 \text{ seconds} \\ a &= ? \end{aligned}$$

Step 2: Find ΔS

$$\begin{aligned} \Delta S &= S_2 - S_1 \\ &= 200 - 0 = 200 \text{ m/s} \end{aligned}$$

Step 3: Formula

$$a = \Delta S / \Delta T$$

Step 4: Solve

$$\begin{aligned} a &= (200 \text{ m/s}) / (10 \text{ s}) \\ &= 20 \text{ m/s}^2 \end{aligned}$$

Example: Calculate Deceleration

*Ex. A race car starts at 400 m/s and then stops in 20 seconds.
 Calculate the car's acceleration.*

Deceleration means an object is slowing down and has a negative sign.

Step 1: Variables

$$\begin{aligned} S_1 &= 400 \text{ m/s} \\ S_2 &= 0 \text{ m/s ("then stops")} \\ \Delta T &= 20 \text{ seconds} \\ a &= ? \end{aligned}$$

Step 2: Find ΔS

$$\begin{aligned} \Delta S &= S_2 - S_1 \\ &= 0 - 400 = -400 \text{ m/s} \end{aligned}$$

NOTICE NEGATIVE ΔS

Step 3: Formula

$$a = \Delta S / \Delta T$$

Step 4: Solve

$$\begin{aligned} a &= (-400 \text{ m/s}) / (20 \text{ s}) \\ &= -20 \text{ m/s}^2 \end{aligned}$$

Negative sign means deceleration.

Average Speed

$$S_{\text{ave}} = \frac{D_{\text{total}}}{T_{\text{total}}}$$

Ex. A person walks 4 miles in 2 hours, then stops for an hour for lunch. After lunch they walk 8 miles in 3 hours. Calculate the person's average speed.

Careful—distance is 0 miles because “stops ... for lunch”.

Distance	Time
4 miles	2 hours
0 miles	1 hour
8 miles	3 hours
TOTALS:	12 miles 6 hours

$$\begin{aligned} S_{\text{ave}} &= D_{\text{total}} / T_{\text{total}} \\ &= 12 \text{ mi} / 6 \text{ sec} \\ &= 2 \text{ mph} \end{aligned}$$

Speed vs. Velocity

Speed is a Scalar
Velocity is a Vector

Speed has no direction; Scalars have no direction.
 Velocity has direction; Vectors have direction.

*A person walks 4 m/s—speed (no direction).
 A person walks 2 m/s north—velocity (direction is given).*

*A car drives 60 mph toward Dallas—velocity.
 A car drives 30 mph—speed.*

*A 14 newton force pull 30° left of north—vector.
 A boat is pulled by a 53 newton force—scalar.*

**Vectors have magnitude and direction.
 Velocity is a vector with magnitude and direction.**

Name: _____

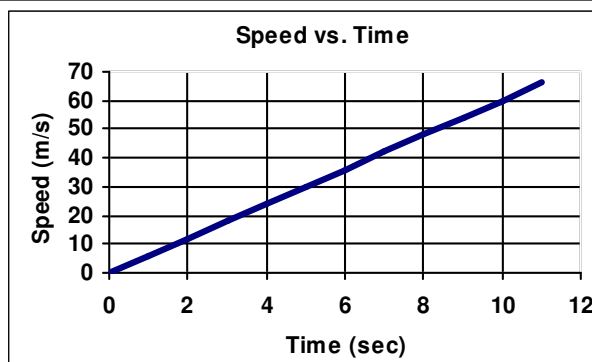
speed vs. time graphs;

Ch. 2:1

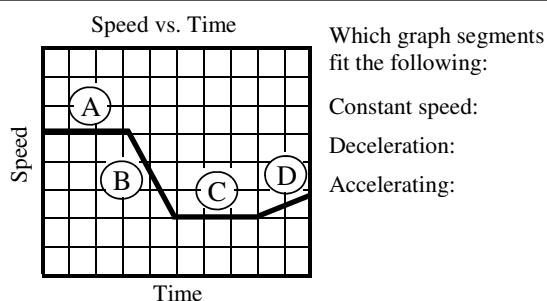
Period: _____

Speed (S) or Velocity (V)	Scalar (S) or Vector (V)	Match the variables with quantities.	
___ A bike goes 25 m/s toward main street.	___ 40 mph toward Dallas.	1. a = _____	23 kilograms
___ A person walks 4 mph.	___ A 25 N force pulls on a wagon.	2. S or v = _____	23 sec
___ A plane flies 200 m/s.	___ 10 meters up the hill.	3. m = _____	3 m/s ²
___ A bird flies 100 mph due south.	___ 12 meter per sec ² .	4. D = _____	23 meters/sec
		5. F = _____	23 meters
		6. T = _____	23 newtons

A person starts running from 2 m/s to 6 m/s in 2 seconds. Calculate the person's acceleration.		A plane stops from 250 mph in 25 seconds. Calculate the planes acceleration.	
Variables:	Solve:	Variables:	Solve:
Formula:		Formula:	
A guy bikes 15 miles in 1 hour, then rests for an hour. Then he bikes 25 in 2 hours. What was his average speed for the trip?		A dragster's top acceleration is 60 m/s ² . If it accelerates for 3 seconds from the starting line, how fast will it be going?	
Variables:	Solve:	Variables:	Solve:
Formula:		Formula:	



Find the acceleration for the above graph:



The slope of a position vs. time graph means:

The slope of a speed vs. time graph means:

Name: _____
 Period: _____

Ch.3:1

Isaac Newton's 3 Laws of Motion

Sir Isaac Newton (1642-1727) was an English physicist and mathematician. Before the age of 30 he formulated the laws of motion and invented calculus. Much of our modern science is based on Newton's

Newton's Laws of Motion

Law One – Law of Inertia

An object at rest will stay at rest unless acted on by an unbalance force.
 An object in motion will stay in motion unless acted upon by an unbalanced force.

OR

Things keep moving or stay at rest, unless a net force acts upon them.

Law Two – $F = ma$

The acceleration of an object is proportional to the force acting on it and inversely proportional to its mass.

OR

Force causes acceleration, while mass resists acceleration

Law Three –

Law of Equal and Opposite Forces.
 Whenever one object exerts a force on another object, the second exerts an equal and opposite force on the first.

OR

For every action there is an equal and opposite reaction.

Inertia

Inertia is the property of an object that resists change of motion.

Moving objects have inertia: they want to keep moving; stopped objects have inertia: they want to stay at rest.

More mass = more inertia!

Something that is harder to push has more inertia!



More mass, more inertia



Less mass, less inertia

Force

A **force** is any action that can change or cause motion.

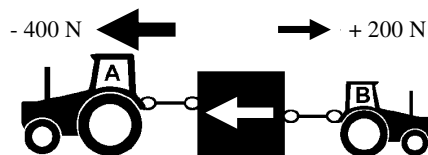
A force is any push or pull.

We use Newtons (N) to measure force.

Net Force

Net force is the sum of all the forces and has direction. (Be sure to make right positive and left negative.)

An object will move in the direction of the net (or unbalanced) force.



Net Force = $+200\text{ N} - 400\text{ N} = -200\text{ N}$ (left)

Newton's Second Law

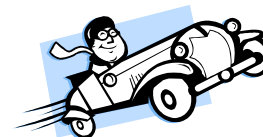
Force (in Newtons) $\rightarrow$ **$F = ma$** $\leftarrow$ Mass (in kg)
 $\nwarrow$ Acceleration (in m/sec^2)

Force equals mass times acceleration.

$F = ma$ tells us:

For the same acceleration,
more mass requires more force.

For the same mass,
more acceleration requires more force.



Newton's 2nd Law tells us that when you accelerate (stomp on the gas) or decelerate quickly (brake fast) you use more force and wear out engine parts and brakes faster.

Ex. How big a force does it take to give a 50 kg object an acceleration of 40 m/s^2 .

Variables:	Solve:
$40\text{ m/s}^2 = a$	$F = ma$
$50\text{ kg} = m$	$F = 50(40)$
$F = ?$	$F = 50 \times 40$
Equation:	$F = 2000\text{ N}$
$F = ma$	

Ex. If a 50 N force pulls on a 10 kg object, how much acceleration will occur?

Variables:	Solve:
$50\text{ N} = F$	$F = ma$
$10\text{ kg} = m$	$50 = 10a$
$a = ?$	$\frac{50}{10} = \frac{10a}{10}$
Equation:	$a = 5\text{ m/s}^2$
$F = ma$	

Ex. A force of 49 N causes a 7 m/s^2 acceleration. Find the mass of the object it was pulling.

Variables:	Solve:
$49\text{ N} = F$	$F = ma$
$7\text{ m/s}^2 = a$	$49 = m7$
$m = ?$	$\frac{49}{7} = \frac{m7}{7}$
Equation:	$m = 7\text{ kg}$
$F = ma$	

Ch.3:1

1. $F =$ _____
2. $m =$ _____
3. $a =$ _____
4. $v =$ _____
5. $D =$ _____
6. $p =$ _____

125 kilograms
23 kgm/s
3 m/s²
29 meters/sec
228 meters
6 newtons

- ___ When you put a book on a table the table pushes on the book.
- ___ A person is pushed forward into their seatbelt when a car stops.
- ___ A larger car takes more force to move.
- ___ A person leans on a wall and the wall pushes back.
- ___ A brick sits on a table until you push on it.

1. Inertia	A. An action that can causes motion.
2. Mass	B. Force pulling all object toward each other.
3. Gravity	C. The amount of matter in an object
4. Net force	D. Total of all of the forces on an object.
5. Force	E. Ability of an object to resist change of motion.

A baseball	A small car	A truck	A feather	A large train
------------	-------------	---------	-----------	---------------

Fast car	Parked truck	Slow car	Fast baseball	Fast feather
----------	--------------	----------	---------------	--------------

Which way will
it accelerate?

6 N ← **M** → 8 N

A 20 kg bike accelerates at 10 m/s^2 . With what force was the person pedaling?

If a person is pushing a cart with a force of 40 Newtons and it accelerates at 0.5 m/s^2 , what is the mass of the cart?

What is the acceleration of a 3 kg rock that is thrown with a force of 18 N?

Name: _____

Period: _____

Ch.3:3

Momentum and Conservation of Momentum

Momentum

$$\text{Momentum (in kgm/sec)} \rightarrow p = mv$$

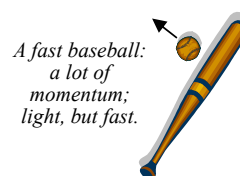
$\swarrow$ Mass (in kg) $\nwarrow$ Velocity (in m/sec)

Momentum equals mass times velocity.



A house that is not moving has no momentum.

Something has to be moving to have momentum.



A fast baseball: a lot of momentum; light, but fast.

Slow bowling ball: little momentum; heavy, but slow.



Something with more momentum would hurt worse if it hit you.

Ex. How much momentum does a 30 kg object going 4 m/s have?		Ex. An object going 3 m/s has 36 kgm/s of momentum. Find mass.		Ex. How fast is a 15 kg object going if it has 45 kgm/s.	
Variables: 30 kg = m 4 m/s = v p = ?	Solve: $p = mv$ $= (30\text{kg})(4\text{m/s})$ $= 120 \text{ kgm/s}$	Variables: 3 m/s = v 36 kgm/s = p m = ?	Solve: If $p = mv$ Then $m = p/v$ $= (36\text{kgm/s})/(3\text{m/s})$ $= 12 \text{ kg}$	Variables: 45 kgm/s = p 15 kg = m v = ?	Solve: If $p = mv$ Then $v = p/m$ $= (45\text{kgm/s})/(15\text{kg})$ $= 3 \text{ m/s}$
Equation: $p = mv$	<i>Just put together the units for m and v.</i>	Equation: $p = mv$		Equation: $p = mv$	

Newton's Third Law says that when you throw a ball, the ball pushes on you, too. Using momentum, you can describe what happens between pairs of forces.

Law of Conservation of Momentum

"Momentum is conserved in a closed system" OR "The total amount of momentum does not change."

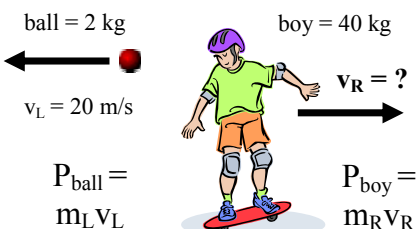
Law of Conservation of Momentum:

$$p_{\text{change}} = 0$$

$$p_{\text{left}} = p_{\text{right}}$$

$$m_L v_L = m_R v_R$$

Ex. A 40 kg boy on a skateboard throws a 2 kg, 20 m/s to the left. Find how fast the boy is going afterward.



Use The Law of Conservation of Momentum

Solution:

$$p_{\text{change}} = 0 = p_R - p_L$$

$$p_L = p_R$$

$$p_{\text{ball}} = p_{\text{boy}}$$

$$m_L v_L = m_R v_R$$

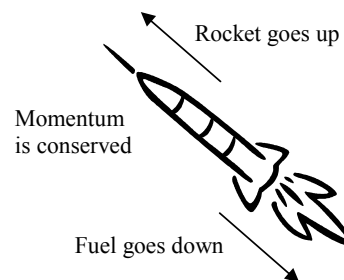
$$\frac{m_L v_L}{m_R} = v_R$$

$$\frac{(2\text{kg})(20\text{m/s})}{40\text{kg}} =$$

$$\frac{40 \text{ m/s}}{40} = 1 \text{ m/s}$$

The boy ends up going 1 m/s to the right.

Conservation of momentum is also how rockets fly. A rocket expels gases at very fast velocity and the rocket goes the opposite direction.



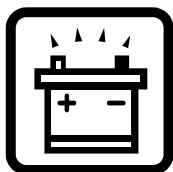
$$p_{\text{rocket}} = p_{\text{fuel}}$$

Name: _____
 Period: _____

Ch. 5:1

Energy, Work, and Power

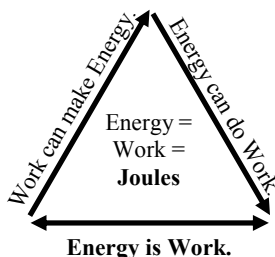
Energy and work are interconnected—one can make the other.



Energy

Energy is stored work.
 A battery can store energy to make things work whenever you want.

Energy can cause forces,
 which can cause motion,
 which can do work.



Work



Work uses energy.
 It takes energy to move things.
 Energy can make things work.

Work can create energy.
 A generator uses work to make energy,
 which can be stored to do more work.

Work

Work is defined as a force applied (moved) through a distance.

$$\text{Work (in Joules)} \rightarrow W = Fd$$

Force (in newtons) distance (in meters)

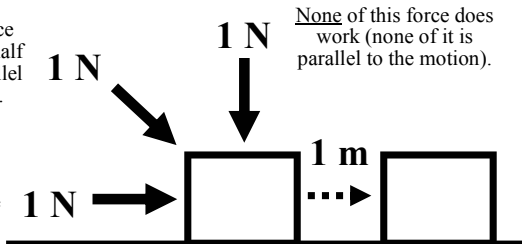
Work equals force times distance.

If you push harder (**more force**)
 you do **more work**.
 If you push longer (**more distance**)
 you do **more work**.

To do work, a force has to be in the direction of the motion.

Half of this force does work (the half that pushes parallel to the motion).

All of this force does work (it is all parallel to the motion).



None of this force does work (none of it is parallel to the motion).

*Ex: You push a 1000 newton car 5 meters.
 How much work did you do?*

$$F = 1000 \text{ N}$$

$$d = 50 \text{ m}$$

$$W = ?$$

$$W = Fd$$

$$W = (1000 \text{ N})(50 \text{ m})$$

$$= 5,000 \text{ J (joules)}$$

(Doing 5,000 J of work takes 5,000 J of energy)

*Ex: How much work does a kid do while sitting?
 The kid weighs 45 N.*

No work — the kid is not moving. ($d = 0$, $W = 0$)

Power

How fast you do work is called **power**. If you work faster, you use more power.

$$\text{Power (in watts)} \rightarrow P = \frac{W}{t}$$

Work (in joules) Time (in seconds)

Power equals work divided by time.

Putting in the work equation: $P = \frac{Fd}{t}$

A machine that **works faster** (in less time) is **more powerful**.

A **more powerful** light bulb gives off the **same** amount of light (**work**), it **just** does it **faster**.

Ex: You do 120 joules of work in 2 seconds. How much power did you use?

$$W = 120 \text{ J}$$

$$t = 2 \text{ sec}$$

$$P = ?$$

$$P = W/t$$

$$= 120 \text{ J} / 2 \text{ sec}$$

$$= 60 \text{ watts}$$

(same as a light bulb)

Ex: Two guys lift two 40 N rocks up a 5 m staircase. Bob does it in 10 seconds. Joe does it in 20 seconds. Compare their work and power.

Bob: $F = 40 \text{ N}$; $d = 5 \text{ m}$; $t = 10 \text{ s}$
 $W = Fd = 40\text{N}(5\text{m}) = 200 \text{ J}$
 $P = W/t = 200\text{J}/10\text{s} = 20 \text{ w}$

Joe: $F = 40 \text{ N}$; $d = 5 \text{ m}$; $t = 20 \text{ s}$
 $W = Fd = 40\text{N}(5\text{m}) = 200 \text{ J}$
 $P = W/t = 200\text{J}/20\text{s} = 10 \text{ w}$

*They do the **same** amount of **work** (200 J), but Bob uses more power (20 w).*

Name: _____

Period: _____

Ch. 5:1

1. F or F_w = _____	8 w	1. Energy	A. Uses energy and can create energy.
2. W or E = _____	30 N	2. Power	B. The units for energy and work.
3. MA = _____	10	3. Work	C. The rate of doing work (faster work uses more of this).
4. p = _____	25 m	4. Joules	D. Has the ability to create forces; stored work.
5. d = _____	24 kgm/s		
6. P = _____	90 J		
More, Less, or the Same amount of Work?		Is the person doing work?	
____ You use more force to move an object. ____ You lift a 20 N object faster. ____ You raise an object a shorter height. ____ You move a lighter object. ____ You move an object farther.		____ When pushing a 1000 N car 20 meters? ____ When lifting a rock off the ground? ____ When holding a book in their hands? ____ When pushing hard against a brick wall? ____ When walking up the stairs?	
More or Less Power?		You do 45 J of work in 3 seconds. How much power do you use?	
____ An engine can lift an object faster. ____ Someone takes more time to push a car. ____ You take the same amount of time to do more work. ____ Same distance; same time; more force.		_____ A car uses 2,500 Joules in 25 seconds. Find power.	
You move a 25 N object 5 meters. How much work did you do?		_____ A 60 watt light bulb runs for 5 seconds. How much energy does it use?	
You carry a 20 N bag of dog food up a 6 m flight of stairs. How much work was done?		_____ You push a 10 N object 10 meters. How much work was done on the object?	
You push down on a 3 N box for 10 minutes. How much work was done?		_____ On the same object as in the previous question, you have to push with 15 N to move it 10 meters. How much work do you do?	
You use 35 J of energy to move a 7 N object. How far did you move it?		_____ What was the difference in the work to move the object and the work you do? Why was there a difference?	

Name: _____

Period: _____

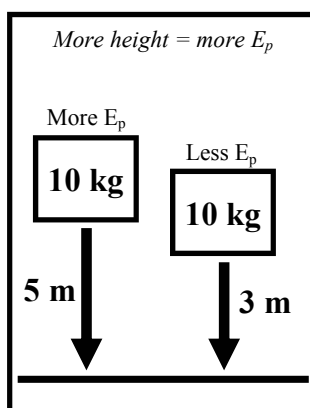
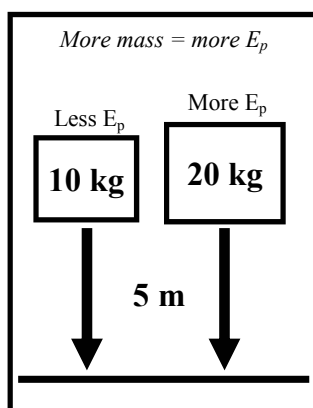
Ch. 5:2

Potential and Kinetic Energy

Potential Energy

Potential Energy is energy of position.

An object gets potential energy from height, mass and gravity. An object with potential energy has the **potential to do work**. This potential is only released if the object falls. The energy is then transformed into energy of motion or transformed into work.



Potential Energy (in Joules) $\rightarrow E_p = mgh$

mass (in kilograms) $\rightarrow$ height (in meters) $\rightarrow$ acceleration due to gravity (9.8 m/s^2)

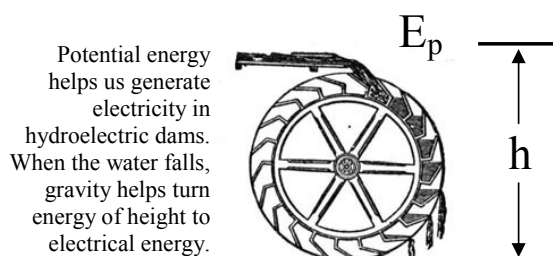
Potential energy equals mass times gravity times height.

And since $F_w = mg$, then $E_p = F_w h$

Ex: How much potential energy does a 4 kg object have that is 5 meters off the ground?

$m = 4 \text{ kg}$
 $h = 5 \text{ m}$
 $g = 10 \text{ m/s}^2$
 $E_p = ?$

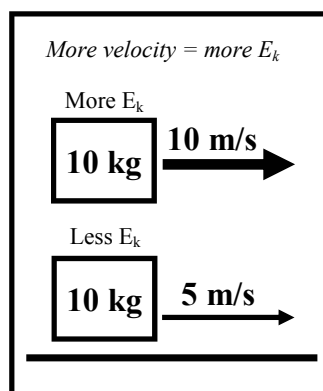
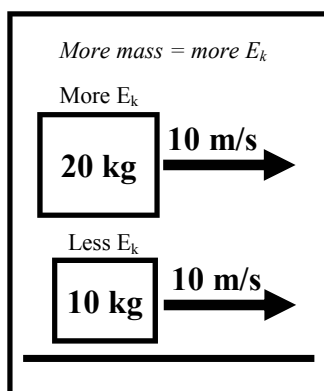
$E_p = mgh$
 $E_p = (4 \text{ kg})(10 \text{ m/s}^2)(5 \text{ m})$
 $= (40 \text{ kgm/s}^2)(5 \text{ m})$
 $= 200 \text{ Joules}$



Kinetic Energy

Kinetic Energy is energy of motion.

An object gets kinetic energy from its mass and velocity. An object with kinetic energy has energy stored in motion. When the object slows down the energy is released into potential energy (if going up) or some other kind of energy (like heat [thermal energy] in the brakes of car).



Kinetic Energy (in Joules) $\rightarrow E_k = \frac{1}{2}mv^2$

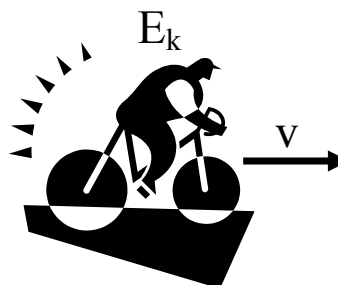
mass (in kilograms) $\rightarrow$ velocity (m/s) $\rightarrow$

Kinetic energy equals one-half times mass times velocity squared.

Ex: How much kinetic energy does a 10 kg object traveling 3 m/s?

$m = 10 \text{ kg}$
 $v = 3 \text{ m/s}$
 $E_k = ?$

$E_k = \frac{1}{2}mv^2$
 $E_k = \frac{1}{2}(10 \text{ kg})(3 \text{ m/s})^2$
 $= (5 \text{ kg})(9 \text{ m}^2/\text{s}^2)$
 $= 45 \text{ Joules}$



Kinetic energy helps you bike up a hill. The energy of motion helps you overcome gravity. The faster you are moving, the easier it is to get up a hill.

Name: _____

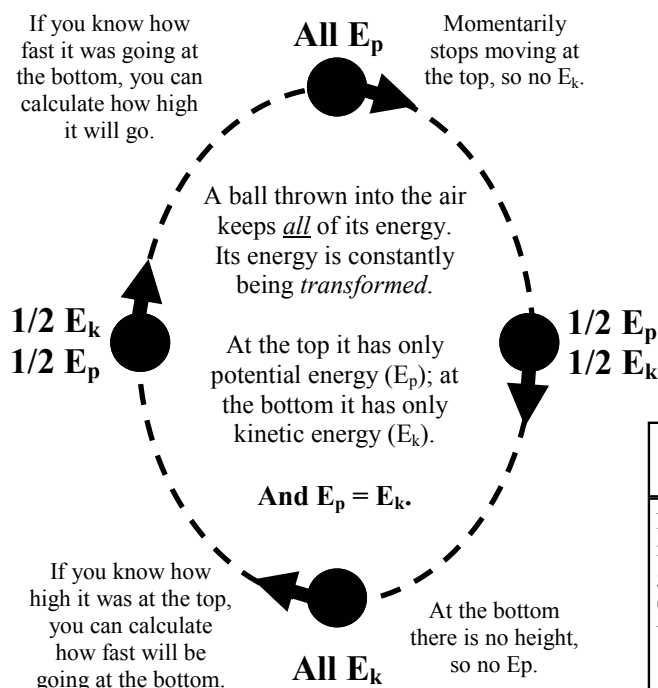
Period: _____

Ch. 5:2

1. F or F_w = _____	8 w	1. Kinetic Energy	A. Uses energy and can create energy; calculated by multiplying force times distance.
2. v = _____	8 N	2. Potential Energy	B. How far above the ground an object is.
3. p = _____	8 m	3. Work	C. Energy of motion.
4. h = _____	8 kgm/s	4. Joules	D. Units for energy and work.
5. W or E = _____	8 J	5. h	E. Energy of position.
6. P = _____	8 m/s		
Potential (E_p) or Kinetic (E_k) Energy			
____ A car is traveling 45 mph. ____ A rock is on a ledge 5 meters high. ____ A car is resting at the top of a hill. ____ A ball is thrown into the air and is still moving. ____ A ball rolling on the ground.		Circle the one with more Potential Energy A 25 kg mass or a 30 kg mass at the top of a hill? A car at the top of the hill or the bottom of a hill? A plane on the ground or a plane in the air? A full plane or an empty plane (both are flying)?	
Circle the one with more Kinetic Energy A 25 kg mass or a 30 kg mass going 5 m/s. Two 10 kg masses, one going 75 m/s, one going 45 m/s. A car at rest or a car rolling down a hill. A heavy bike or a light bike.		A 4 kg rock is rolling 10 m/s. Find its kinetic energy. _____ A 8 kg cat is running 4 m/s. How much kinetic energy does it have? _____ A rolling ball has 18 joules of kinetic energy and is rolling 3 m/s. Find its mass. _____ A 4 kg bird has 8 joules of kinetic energy. How fast is it flying? _____ Find the work done by a 25 N force applied for 6 meters.	
Calculate the potential energy of a 5 kg object sitting on a 3 meter ledge. _____ A rock is at the top of a 20 meter tall hill. The rock has a mass of 10 kg. How much potential energy does it have? _____ A 25 N object is 3 meters up. How much potential energy does it have. (Hint, notice the <u>units</u> of the object.) _____ How high up is a 3 kg object that has 300 joules of energy?			

Name: _____
 Period: _____

Conservation of Energy



Law of Conservation of Energy:
“Energy is never created nor destroyed, just transformed into other forms of energy.”

If energy can only be transformed, then, for any object being thrown into the air or dropped:

$$E_p = E_k \text{ OR } mgh = (1/2)mv^2$$

The potential energy at the top equals the kinetic energy at the bottom.

Ex. A 4 kg ball is thrown into the air. It reaches a height of 1.8 meters. How fast was it going when thrown into the air?

$h = 1.8 \text{ m}$
 $m = 4 \text{ kg}$
 $g = 9.8 \text{ m/s}^2$
 (use $g = 10$)
 $v = ?$

The Law of Conservation of Energy says that the E_p at the top = E_k at the bottom.

$$E_p = E_k$$

$$mgh = (1/2)mv^2$$

$$gh = (1/2)v^2$$

$$2gh = v^2$$

$$2(10)(1.8) = v^2$$

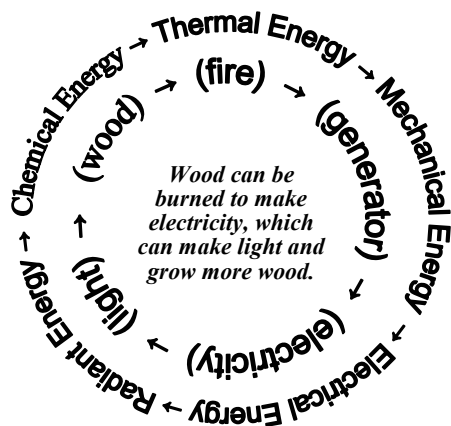
$$2(18) = v^2 = 36$$

$$v = \sqrt{36}$$

$$v = 6 \text{ m/s}$$

Energy Transformations

No one really “makes” energy: it has to come from somewhere. And no one really “uses up” energy: it has to go somewhere. The energy is transformed from one form to another.



Although this diagram may lead you to think that energy can be changed from one form to another perfectly, that is not true. Some energy always ends up as forms we don’t want, so it seems to be “lost”, as in friction. This is known as “inefficiency”.

Chemical Energy—Stored in chemical bonds; includes food, plants, and batteries (which produce electricity by combining chemicals).

Thermal Energy—Heat energy; the end product of many transformations.

Nuclear Energy—Energy from radiation (atom decay), fission (splitting atom), or fusion (fusing atoms); makes huge amounts of energy.

Mechanical Energy—Energy of an object’s motion (E_k) or position (E_p), which can become work.

Electrical Energy—Energy from moving electrons; what we generally think of as “energy”.

Radiant Energy—Light energy; actually electromagnetic radiation from light bulbs or the sun (actually the source of most power on earth).

Efficiency

Input work is always less than the output work. Friction always takes a portion. A perfect machine would be 100% efficient, but it doesn’t exist. Cars are around 15% efficient; bicycles are around 95%.

Efficiency (in %) $\rightarrow \text{Eff} = \frac{W_{\text{out}}}{W_{\text{in}}} \times 100$

Work out (in J) $\nearrow$
 $\nwarrow$ Work in (in J)

Efficiency equals the Work (or Energy) out divided by the Work (or Energy) in multiplied by 100.

Ex. If you use 20 N to push a 15 N object 3 meters, how efficient was your work?

$F_{\text{in}} = 20 \text{ N}; F_{\text{out}} = 15 \text{ N}; d = 3 \text{ m}$
 $W_{\text{in}} = F_{\text{in}}(d) = (20 \text{ N})(3 \text{ m})$
 $W_{\text{in}} = 60 \text{ J}$
 $W_{\text{out}} = F_{\text{out}}(d) = (15 \text{ N})(3 \text{ m})$
 $W_{\text{out}} = 45 \text{ J}$

$\text{Eff} = W_{\text{out}}/W_{\text{in}} \times 100$
 $\text{Eff} = (45 \text{ J}/60 \text{ J}) \times 100$
 $\text{Eff} = (.75) \times 100$
 $\text{Eff} = 75\% \text{ efficient}$
 (friction took 25%)

Name: _____

Period: _____

Ch. 5:3

1. Efficiency	A. Units for efficiency.	1. Thermal	A. Energy of the atom being split or fused.
2. Law of Conservation of Energy	B. Ratio of work out to work in (how good a machine or energy transformation is).	2. Nuclear	B. Energy of moving electrons.
3. Percent	C. Energy can never be lost or gain, just transformed.	3. Radiant	C. Heat energy. Also caused by friction.
4. Transformation	D. Changing from one form to another.	4. Mechanical	D. Light energy—electromagnetic radiation.
		5. Chemical	E. Energy (kinetic or potential) stored in object and can do work.
		6. Electrical	F. Energy of molecular bonds.
What kind of Energy? Thermal; Nuclear; Radiant; Mechanical; Chemical; Electrical ____ A ball on top of a hill. ____ Stored in food. ____ The energy in hydrogen. ____ Given off by the sun. ____ Used to run a clock. ____ A car going 50 mph. ____ A hot stove. ____ A fire's heat. ____ Uranium in reactors. ____ A fire's light.		What energy is used or given off by a fire? What energy is transformed from what to what when you turn on a flashlight?	
A ball is thrown up into the air. When it gets to the very top, what kind of energy does it have? When it falls half-way back, what kind of energy does it have? Just before it reaches the ground, what kind of energy does it have? What does the Law of Conservation of Energy say about the energy at the top and at the bottom? A 10 kg ball is thrown into the air. It is going 3 m/s when thrown. How much potential energy will it have at the top? A 4 kg ball is on a 5 m ledge. If it is pushed off the ledge, how much kinetic energy will it have just before hitting the ground?		A 25 kg ball is thrown into the air. When thrown it is going 10 m/s. Calculate how high it travels. A 3 kg rock sits on a 0.8 meter ledge. If it is pushed off, how fast will it be going at the bottom? You are pushing a 20 N object for 3 meters. If you have to push with 30 N to do this, how efficient is your work?	

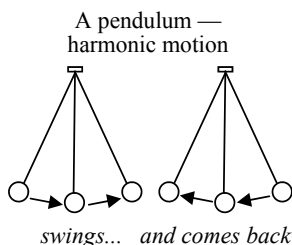
Name: _____

Period: _____

Ch 11:1

Harmonic Motion

Harmonic Motion is any motion that is repetitive (doing the same thing over and over) and caused by a **restoring force**. Pendulums, bouncing springs, wheels (circular motion), waves, music: these are all harmonic motion.



Restoring force: a force that tries to return an object to equilibrium (center resting position). If a pendulum is disturbed (moved), gravity (restoring force) pulls it back to center. Because it has too much momentum, it goes past center and keeps going back and forth.

Linear motion goes from here to there: one direction.



Linear motion—up uses a different force than down

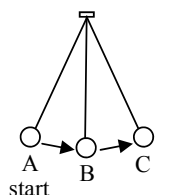
A bird flying *looks* like harmonic motion because the wings are going up and down. Actually, it is linear motion because up and down require two different sets of muscles.

Parts of Harmonic Motion

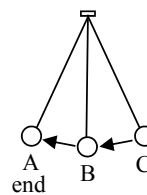
Cycle: the repeated portion of the motion; includes all of the steps of the motion.

Period: length of time for one cycle; how long it takes for one repetition.

Frequency: number of cycles per second in hertz (Hz). A hertz is a cycle per second.



From A to C is only half a cycle.



When the pendulum gets back to A it has completed one cycle and starts over.

If it takes 2 seconds for the pendulum to go from A to C and back to A, the pendulum's period is 2 seconds.

Period (in secs) → $T = \frac{1}{f}$ OR $f = \frac{1}{T}$ ← Period (in secs)

Frequency (in hertz)

Ex: A pendulum has a frequency of 4 Hz. Find its period.

$f = 4 \text{ Hz}$
 $T = ?$

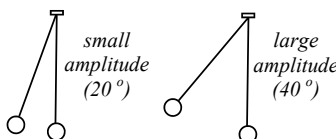
$T = 1/f$
 $T = 1/4 \text{ Hz}$
 $T = 0.25 \text{ sec}$

Ex: A wheel has a period of 2 seconds. Find its frequency.

$T = 2 \text{ sec}$
 $f = ?$

$f = 1/T$
 $f = 1/2 \text{ sec}$
 $f = 0.5 \text{ Hz}$

Amplitude: the maximum distance or angle the motion moves from its center position. Can be measured in distance (meters, centimeters) or degrees.



Amplitude = $\frac{1}{2}(\text{high} - \text{low})$

Graphing Harmonic Motion

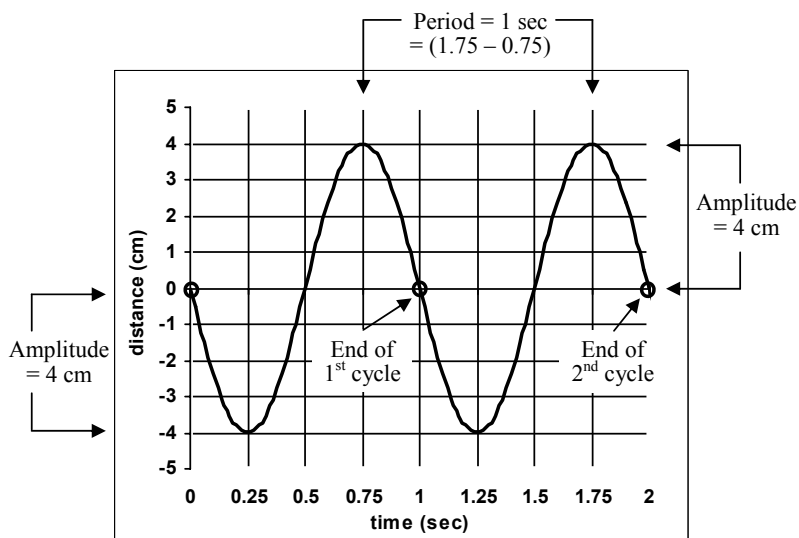
On a graph you can see all parts of harmonic motion.

Cycle—one repetition of the motion (top to top, bottom to bottom, etc.).

Period—time for one cycle; time from top to top, etc.

Frequency—how many cycles in one second.

Amplitude—how far the graph goes away from the center (or use the equation: Amplitude = $\frac{1}{2}(\text{high} - \text{low})$)



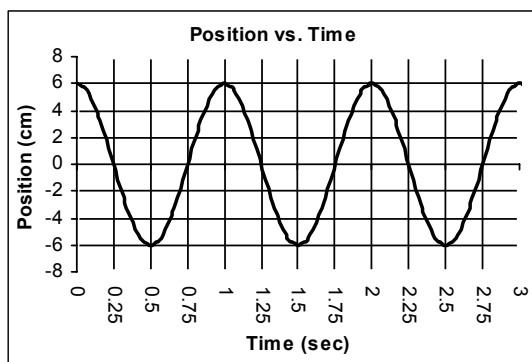
Name: _____

Ch 11:1

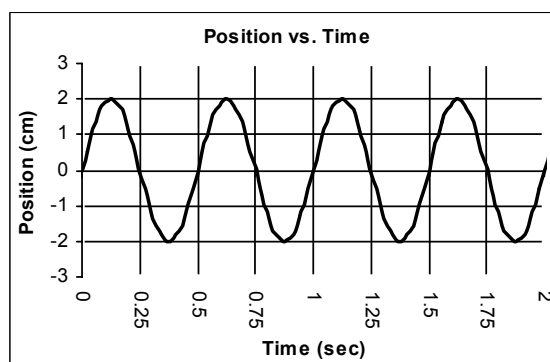
Period: _____

Harmonic (H) or Linear (L) motion?			1. Period	A. The number of cycles per second.
Person running: _____	A swing: _____	Music: _____	2. Amplitude	B. A unit of one cycle per second.
The moon: _____	A car moving: _____	Bird flying: _____	3. Frequency	C. The size or strength of a cycle.
Clock pendulum: _____	Jumping Jacks: _____	Bouncing spring: _____	4. Cycle	D. Time it takes to complete one cycle.
Ocean waves: _____	Moving bicycle: _____	A radio wave: _____	5. Hertz	E. A part of motion that repeats over and over with a set series of events.

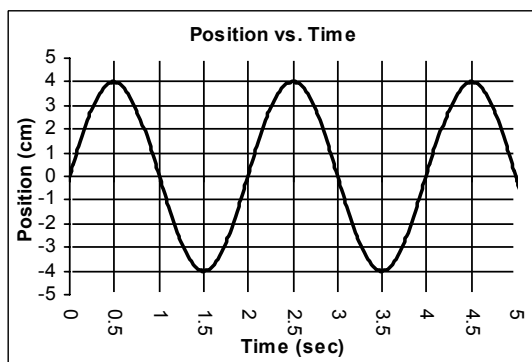
Convert from period (T) to frequency (f):		Convert from frequency (f) to period (T):	
1 sec = _____	4 sec = _____	1 Hz = _____	10 Hz = _____
0.1 sec = _____	2 sec = _____	2 Hz = _____	5 Hz = _____
0.5 sec = _____	0.25 sec = _____	0.5 Hz = _____	0.1 Hz = _____



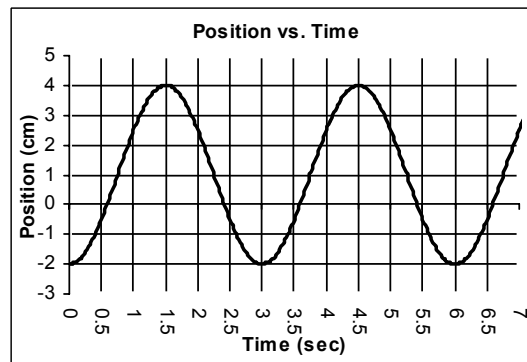
Mark 1 cycle of the harmonic motion.
 Starting at 0 secs, when does the 1st cycle end:
 Number of complete cycles:
 Period: _____ Frequency: _____
 Amplitude: _____



Mark 1 cycle of the harmonic motion.
 Starting at 0.25 secs, when does the 2nd cycle end:
 Number of complete cycles:
 Period: _____ Frequency: _____
 Amplitude: _____



Mark 1 cycle of the harmonic motion.
 Starting at 1 secs, when does the 1st cycle end:
 Number of complete cycles:
 Period: _____ Frequency: _____
 Amplitude: _____



Mark 1 cycle of the harmonic motion.
 Starting at 0 secs, when does the 1st cycle end:
 Number of complete cycles:
 Period: _____ Frequency: _____
 Amplitude: _____

Moments & Torques

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-
-

-

-
-
-
-

-
- A diagram of a lever system. A horizontal beam is supported by a triangular fulcrum. To the left of the fulcrum, a blue block exerts a downward force F at a distance of 1.25 m . To the right of the fulcrum, a yellow block exerts a downward force of 400 N at a distance of 0.8 m , and a red block exerts a downward force of 150 N at a distance of 0.2 m .

5) Explain the meaning of the term 'couple.'

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6) The Explain the meaning of the term 'torque.'

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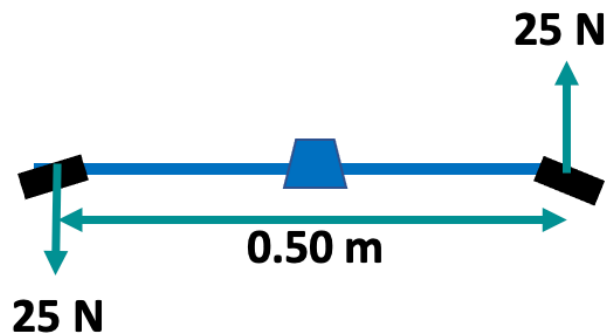
.....

7) Write down the equation for torque stating the units of each quantity.

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8) The ends of the handlebars of a bicycle experience equal and opposite forces as a cyclist changes direction. Using the diagram and information below, calculate the torque applied to the handlebars.



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