AP® Physics B

Summer Assignment

1. For each of the following equations, solve for the variable in **bold** print. Be sure to show each step you take to solve the equation for the **bold** variable.

a. $v_{rms} = \sqrt{\frac{3RT}{\mathbf{M}}}$ ________________

b. $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{\mathbf{r}^2}$ ________________

c. $x = x_0 + v_0 t + \frac{1}{2}\mathbf{a}t^2$ ________________

d. $\lambda = \frac{\mathbf{h}}{p}$ ________________

e. $V = \frac{4}{3}\pi\mathbf{r}^3$ ________________

f. $P + \mathbf{D}gy + \frac{1}{2}\mathbf{D}v^2 = C$ ________________

g. $U = \frac{G\mathbf{m}_1 m_2}{r}$ ________________

h. $\frac{1}{C_{EQ}} = \frac{1}{\mathbf{C}_1} + \frac{1}{C_2}$ ________________

i. $C = \frac{5}{9}(\mathbf{F} - 32)$ ________________

j. $v^2 = v_0{}^2 + 2\mathbf{a}\Delta x$ ________________

k. $n_1 \sin\theta_1 = n_2 \sin\boldsymbol{\theta}_2$ ________________

l. $\frac{1}{s_i} + \frac{1}{s_o} = \frac{1}{\mathbf{f}}$ ________________

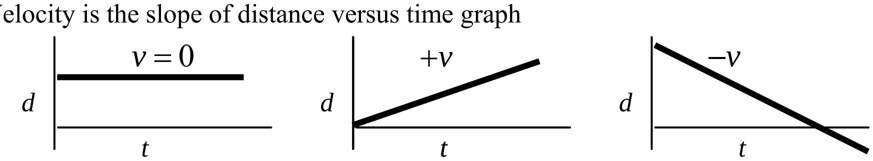
Rates and Graphing

We often create a graph to describe the motion of an object. Remember that when we state two variables using the "versus" terminology that we always state what is being graphed as a *y*-axis variable versus the *x*-axis variable. You have already learned that the slope of a position vs. time graph for a moving object is the object's velocity and that a straight line on that graph represents *constant* velocity. You have also learned that if a position vs. time graph is a curve, that the object is changing its velocity which means it is experiencing an acceleration. Additional specific features of the motion of objects are demonstrated by both the shape and the slope. In the graphed examples the y intercepts and slopes would depend on where the problem started and on how fast the rate is changing.

- The slope of a position vs. time graph = velocity.
- The slope of a velocity vs. time graph = acceleration.
- Slope is calculated as $\frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{\text{“}rise\text{”}}{\text{“}run\text{”}}$
- If the graph shows a *horizontal* straight line, the object is moving at constant velocity with acceleration = zero.
- If the graph shows a *sloped* straight line, the object's velocity is changing, thus the object is accelerating.

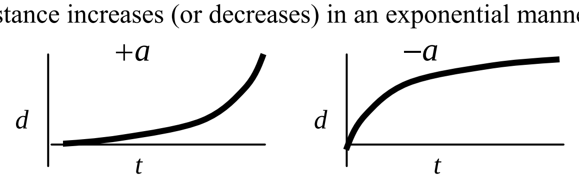
Constant Velocity: change in position $\boxed{v = \frac{d}{t}}$

Velocity is the slope of distance versus time graph

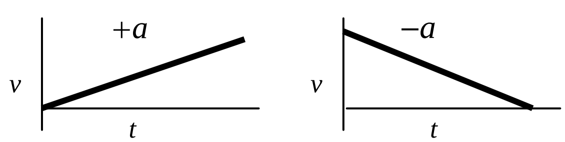


Acceleration:change in velocity $\boxed{a = \frac{\Delta v}{t}}$

Distance increases (or decreases) in an exponential manner.



Acceleration is the slope of velocity versus time graph



Importance of Area Under the Curve

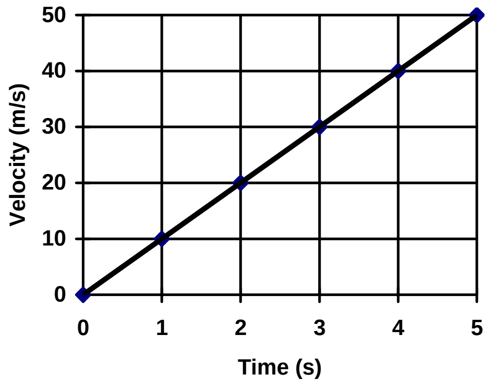
Velocity is the area under the acceleration versus time graph.
Displacement is the area under the velocity versus time graph.

Work is the area under the force versus distance curve.

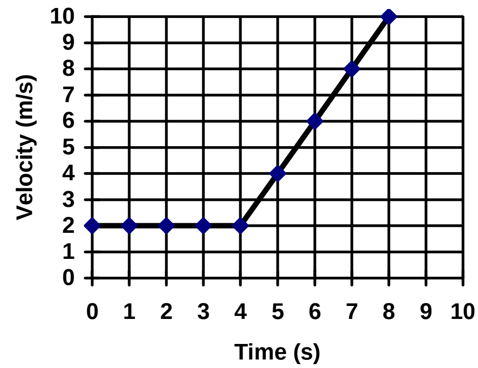
Impulse is the area under the force versus time curve.

Analyze the following velocity vs. time graphs and answer the questions that follow.

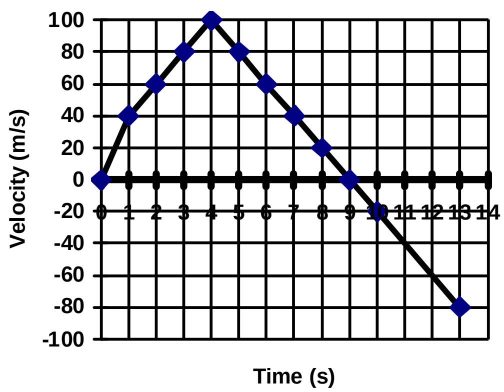
Graph A



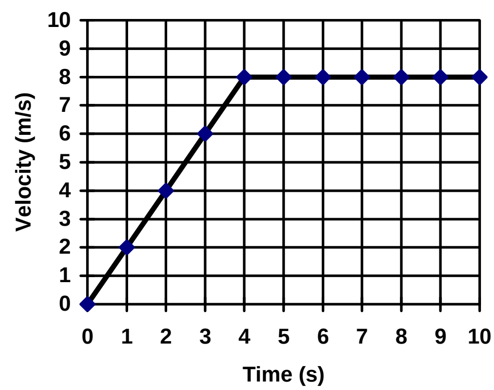
Graph B



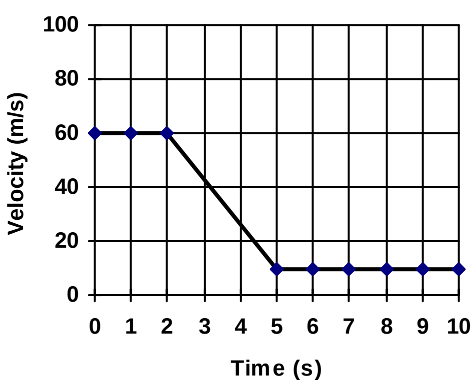
Graph C



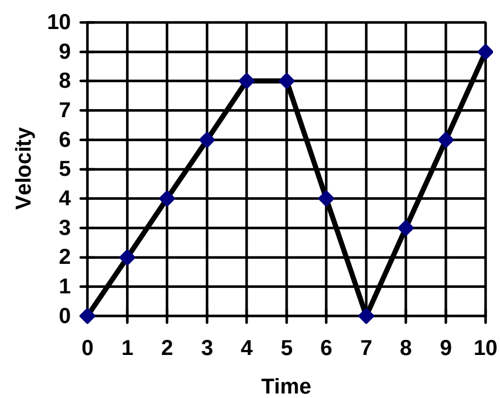
Graph D



Graph E



Graph F



1. Which of the graphs involve a time interval where the velocity of an object was held constant?

2. Which of the graphs involve a time interval where the acceleration of an object was held constant?

3. Calculate the acceleration of the object for any graph(s) you chose as answers to question 2. Show all work in the space provided paying particular attention to units and significant digits.

4. Which of the graphs involve an object that was negatively accelerating?

5. Which of the graphs involve an object that came to a stop?

6. Which of the graphs involve an object that changed direction?

7. Analyze Graph F. For which of the time intervals was the object experiencing the greatest positive acceleration?

8. Calculate the net displacement for the object in Graph B.

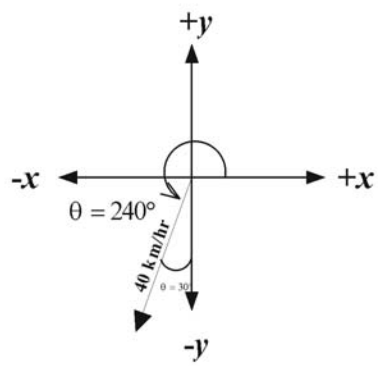
9. Calculate the net displacement for the object in Graph D.

10. Calculate the displacement for the object in Graph F for the time interval t = 0s to t = 4 s.

Component Vectors

Any vector can be resolved into its components. If a vector lies on either the x-axis or y-axis, it only has one component and the other component is zero. If a vector does not lie on either the x or y-axis, then it has both an x-component and a y-component. Consider the vector 40 km/h at 240°. The easiest way to resolve this vector is to place an x and y-coordinate system at the tail of the vector. When using an x-y coordinate system, all angles are measured counterclockwise relative to the positive x-axis which corresponds to east or 0°. Notice that the x-component is negative and that the y-component is negative. Make sure and assign those signs to component vectors, V_x and V_y. The x and y-components are found using the following relationships: $V_x = V\cos\theta$ $V_y = V\sin\theta$

$$v_x = v\cos\theta = (40km/h)\cos 240° = -20km/h \qquad v_y = v\sin\theta = (40km/h)\sin 240° = -35km/h$$



Construct a chart similar to the following:

Vector name:	x-component $V_x = V\cos\theta$	y-component $V_y = V\sin\theta$
V_1		
V_2		
V_R	$V_{Rx} =$	$V_{Ry} =$

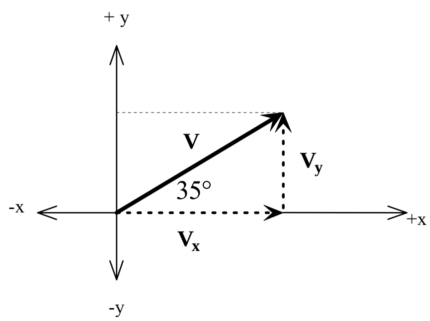
To obtain the magnitude of the resultant vector, V_R:

1. Read the problem and draw a diagram using an appropriate coordinate system.
2. Construct a chart similar to the one above. If more than two vectors are being added, simply add additional rows to the chart.
3. Determine the sign of each component from your diagram and place it in the chart before calculating any values.
4. Use a scientific calculator to determine the magnitude of each vector's x-component and y-component.
5. Add all of the x-components from the x column to determine V_{Rx} and do the same for the y column to determine V_{Ry}. Pay close attention to the signs of each component for each vector.
6. Use Pythagorean's theorem to calculate the magnitude of V_R. $V_R = \sqrt{V_{Rx}^2 + V_{Ry}^2}$

7. Find the direction by using $\tan\theta_R = \frac{V_{Ry}}{V_{Rx}}$.

8. **Example 1: Determining components**
A biker travels 23.0 km on a straight road that is 35° north of east. What are the east and north components of the biker's displacement?

Solution:
First draw a diagram. Next, resolve the vector into its *x* and *y*-components using the trigonometric relationships.



V=23km and θ=35°

V_x = V cos 35° = 23km cos 35° = +18.8km East

V_y = V sin 35° = 23km cos 35° = +13.2km North

Check: $\sqrt{19^2 + 13^2}$ = 23km as expected

For each of the following questions, include a vector diagram and show all work as you solve each problem using your own paper. . ***Your calculator must be in degree mode.***

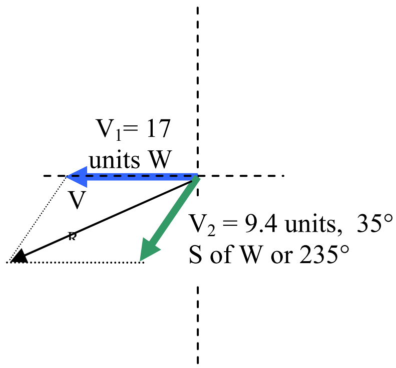
1. A hiker walks 18.5 km at an angle 35° south of east. Find the east and south components of this walk.

2. An airplane flies at 65m/s with a heading of 137°. What are the east and north components of the plane's velocity?

3. A golf ball, hit from the tee, travels 295 m in a direction 28° south of the east axis. What are the east and south components of its displacement?

Example 2: Vector Addition

A vector with a magnitude of 17 units is directed westward. A second vector acts at the same point with a magnitude of 9.4 units and an angle of 35° south of west or 235°. Find the resultant.



Vector name:	*x*-component $V_x = V \cos 2$	*y*-component $V_y = V \sin 2$
V_1: lies on the x-axis so that IS its *x*-component. It has NO *y*-component	-17	0
V_2: lies on NEITHER axis, so it has both components	-9.4(cos 35°) V_x = -7.7	-9.4 (sin 35°) V_y = -5.4
V_R	V_{Rx} = -24.7 units	V_{Ry} = -5.4 units

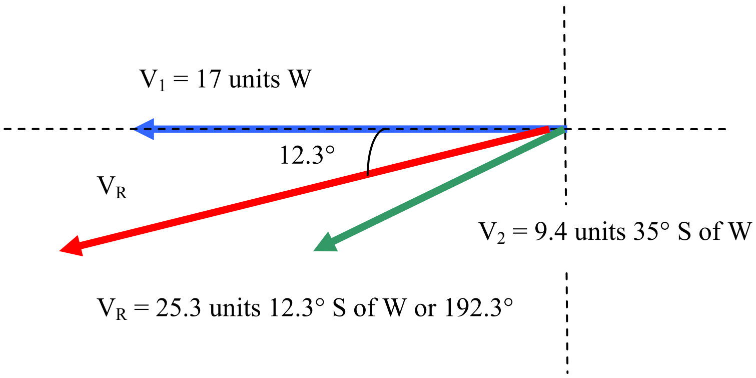
SOLVE for the resultant vector's magnitude and direction now that you know its components:

The magnitude of $\boldsymbol{V_R}$ = $\sqrt{24.7^2 + 5.4^2} = 25.3$ *units Notice that indeed BOTH the x and y-components of the resultant vector are negative which we correctly predicted from our original drawing.*

To obtain the direction of $\boldsymbol{V_R}$ *use the relationship,* $\tan\theta = \dfrac{y-component}{x-component} = \dfrac{-5.4}{-24.7}$ *= 0.2186;*

The resultant has a magnitude of 25.3 units and its direction is 12.3° S of W or 192.3°.

WE UPDATE OUR DRAWING. SINCE BOTH THE *X* & *Y*-COMPONENTS WERE NEGATIVE, THE RESULTANT IS 12.3° SOUTH OF WEST OR 192.3°.



For each of the following questions, include a vector diagram and a problem-solving chart as you solve each problem using your own paper.

4. Determine the magnitude and direction of the resultant velocity of 75.0 m/s, 25.0° east of north, and 100.0 m/s, 25.0 ° east of south.

5. An airplane flies due south at 195 km/h with respect to the air. There is a wind blowing at 75 km/h to the northeast relative to the ground. What are the plane's speed and direction with respect to the ground?

6. A person can row a boat at the rate of 8.0 km/h in still water. The person heads the boat directly across a stream that flows downstream at the rate of 6.0 km/h. Find the resultant velocity.

7. An airplane must fly at a ground speed of 425 km/h in a direction of 10.0° east of south to be on course and on schedule. If the wind velocity is 25.0 km/h 40.0° east of north, in what direction and at what speed relative to the air must the pilot fly? [Notice this problem doesn't simply ask for the resultant, you'll have to use the resultant to correct the pilot's course!]

8. A powerboat heads due northwest at 13 m/s with respect to the water across a river that flows due north at 5.0 m/s. What is the resultant velocity of the motorboat with respect to the shore?