Unit 3 Physics Updated Practice Packet

Distance and Displacement

Speed = distance/time **Velocity = Displacement/time**

Vectors vs. Scalars

1. Most of the quantities used to describe motion can be categorized as either vectors or scalars. *A vector is a quantity that is fully described by both magnitude and direction. A scalar is a quantity that is fully described by magnitude alone.* Categorize the following quantities by placing them under one of the two column headings.

displacement, distance, speed, velocity, acceleration

Scalars	Vectors

2. A quantity that is *ignorant of direction* is referred to as a _____.
   a. scalar quantity b. vector quantity

3. A quantity that is *conscious of direction* is referred to as a _____.
   a. scalar quantity b. vector quantity

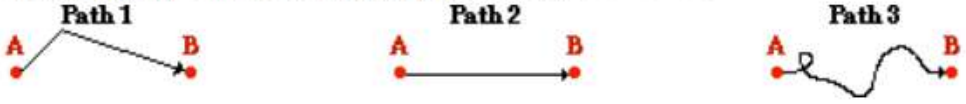
Distance vs. Displacement

As an object moves, its location undergoes change. There are two quantities that are used to describe the changing location. One quantity - **distance** - accumulates the amount of total change of location over the course of a motion. Distance is the amount of ground that is covered. The second quantity - **displacement** - only concerns itself with the initial and final position of the object. Displacement is the overall change in position of the object from start to finish and does not concern itself with the accumulation of distance traveled during the path from start to finish.

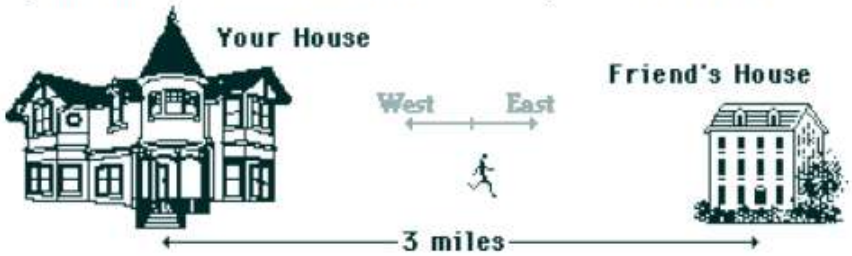
4. True or False: An object can be moving for 10 seconds and still have zero displacement.
   a. True b. False

5. If the above statement is true, then describe an example of such a motion. If the above statement is false, then explain why it is false.

6. Suppose that you run along three different paths from location A to location B. Along which path(s) would your distance traveled be different than your displacement? _____



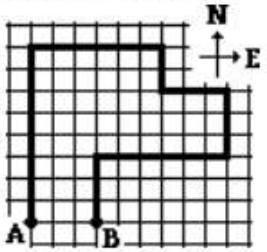
7. You run from your house to a friend's house that is 3 miles away. You then walk home.



a. What distance did you travel? _____

b. What was the displacement for the entire trip? _____

Observe the diagram below. A person starts at A, walks along the bold path and finishes at B. Each square is 1 km along its edge. Use the diagram in answering the next two questions.

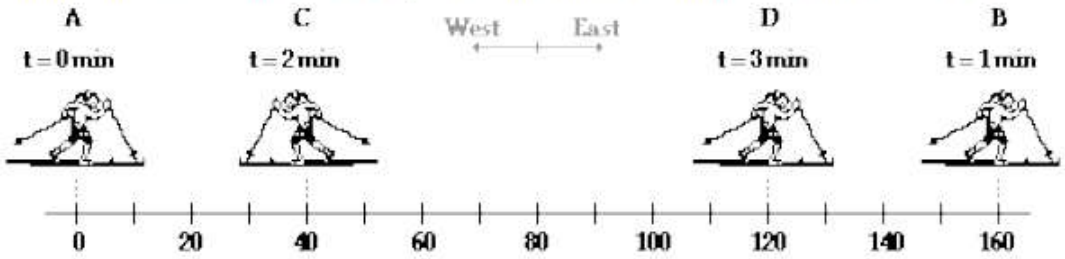


8. This person walks a distance of _____ km.

9. This person has a displacement of _____.

a. 0 km	b. 3 km	c. 3 km, E	d. 3 km, W
e. 5 km	f. 5 km, N	g. 5 km, S	h. 6 km
i. 6 km, E	j. 6 km, W	k. 31 km	l. 31 km, E
m. 31 km, W		n. None of these.	

10. A cross-country skier moves from location A to location B to location C to location D. Each *leg* of the back-and-forth motion takes 1 minute to complete; the total time is 3 minutes. (The unit is *meters*.)



a. What is the distance traveled by the skier during the three minutes of recreation?

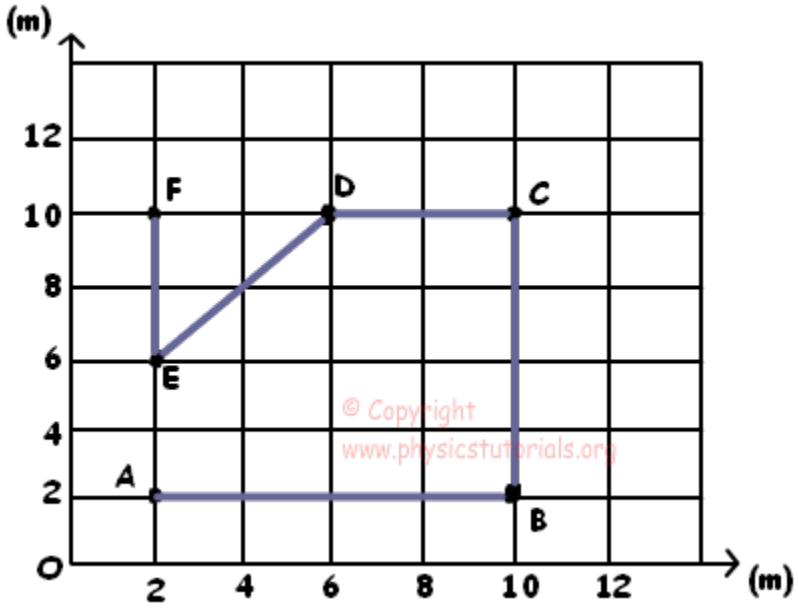
b. What is the net displacement of the skier during the three minutes of recreation?

c. What is the displacement during the second minute (from 1 min. to 2 min.)?

d. What is the displacement during the third minute (from 2 min. to 3 min.)?

Speed and Velocity

1. Describe and draw a situation where you have speed but no velocity.
2. Describe and draw a situation where your speed and velocity are the same (besides the direction with velocity)?
3. You walk 1 mile north and 0.2 miles south in 1 hour. Draw it out. What is your distance? Displacement? Average speed? Average velocity?



It takes the following times to travel in the path shown above…
A-B 10 seconds
B-C 10 seconds
C-D 5 seconds
D-E 3 seconds
E-F 2 seconds

4. Determine the distance, displacement, speed and velocity from....
    a. A-B
    b. B-C
    c. C-D
    d. E-F
5. What is the displacement from A-F? Why?

Kinematic Equations

You should never use s=d/t or v=dis/t if you have acceleration

Kinematic Equations Cheat Sheet

distance = $d = \Delta x$

acceleration = a

time = t

velocity initial (starting) = v_i

velocity final (ending) = v_f

Equation	Yes (in the equation)	No (not in the equation)
$v_f = v_i + at$	$v_i\ v_f\ a\ t$	d
$d = v_i t + \frac{1}{2} at^2$	$v_i\ a\ t\ d$	v_f
$v_f 2 = v_i 2 + 2ad$	$v_i\ v_f\ a\ d$	t

Steps for a Word Problem

1) Read the problem and draw a picture
2) Underline important information
3) Write down your knowns and unknowns with units
4) Determine which equation to use (use the chart above)
5) Rearrange the equation to solve for your unknown variable (if needed)*
6) Plug in your numbers (with units)
7) Do some math
8) Write your answer with units and circle it

* Rearranging is not required, but highly recommended for students who take AP Physics/higher-level math in the future

Horizontal 1D Motion

1. A car accelerates from rest at 4 m/s^2. What is the velocity of the car after 4 seconds?

2. A bicyclist is traveling at 25 m/s when he begins to decelerate at -4 m/s^2. How fast is he traveling after 5 seconds?

3. A skateboarder is moving at 1.75 m/s when she starts going up an incline that causes an acceleration of -0.20 m/s^2. How far does she go before she comes to a stop?

4. A rocket accelerates at a rate of 16.4m/s^2 for a distance of 50m. What is the velocity at the end of the 50m?

5. Ashton and Roman drive away from a red light at a constant 3 m/s^2. What is the velocity of their car 15 sec after leaving the red light?

6. A car speeds up from 32 m/s to 96 m/s in an 8 second time period. What is its acceleration?

7. A dragster starting from rest accelerates at 49 m/s^2. How fast is it going when it has traveled 325 m?

8. How far does a plane fly in 15 seconds while its velocity is changing from 145 m/s to 75 m/s?

9. A bicycle accelerates from 0 m/s to 4 m/s in 4 secs. What distance does it travel?

Vertical 1D Motion using Kinematic Equations

1. A stone that starts at rest in free fall for 8 sec.
    a. Calculate the stone's velocity after 8 sec.

    b. What is the stone's displacement during this time?

2. A rock gradually rolls off a cliff and falls to the ground below. It takes the rock 7.23 seconds to hit the ground below the cliff. How high is the cliff?

3. An arrow is shot straight up into the air with a velocity of 95.0 m/s. What is the maximum height of the arrow?

4. Suppose an astronaut drops a feather from 1.2 m above the surface of the moon. Is the acceleration due to gravity is 1.62 m/s^2 downwards, how long does it take the feather to hit the Moon's surface?

5. You throw a ball downward from a window at a speed of 2 m/s.
    a. How fast will it be moving when it hits the sidewalk 2.5 m below?

    b. How long will it take to reach the ground?

6. If you throw the ball from the previous problem up instead of down…

a. What is the new velocity when it hits the sidewalk?

b. How long will it take to reach the ground?

7. A kangaroo is capable of jumping to a height of 2.62 m.
    a. Determine the takeoff speed of the kangaroo.

    b. How long does it take before the kangaroo lands back on the ground?

8. A celebratory bullet is shot directly up into the air at 315 m/s.
    a. How long does it take to come back down on the ground?

    b. How high does the bullet go?

Free Body Diagrams and Net Force

Construct free-body diagrams for the following physical situations. Label all forces (e.g, F_{grav}, F_{norm}, F_{app}, F_{frict}, F_{air}, F_{tens}, etc.).

a. A physics book rests upon a level table.

b. A skydiver is falling and has reached a terminal velocity.

c. A large crate is being pushed leftward at a constant velocity.

d. A sledder has reached the bottom of a hill and is coasting rightward while slowing down.

e. A ball is moving upwards towards its peak. Ignore air resistance.

f. An air track glider moves rightward at constant speed.

g. The brakes are applied to a rightward moving car and it skids to a stop.

h. A spider is slowly descending a thin silk thread at constant speed.

i. A projectile is moving upwards and rightwards towards the peak of its trajectory.

j. An elevator is rising at a constant velocity; it is not touching the elevator shaft.

k. An upward rising elevator is slowing down; it is not touching the elevator shaft.

l. A force is applied to accelerate a crate across a rough horizontal surface.

Create each FBD and indicate the net force in the x and y as zero or nonzero. Terminal Velocity is a constant velocity.

1. A box is being pushed by two stellar science students, one on each side of the box. Dalton is pushing the box with a force of 10 N to the left. DeAndre is pushing the box with a force of 15 N to the right. Create a FBD and determine the net force.

2. During tug of war Janelle felt like she was supergirl and attempted to beat Rameek. Janelle, with one arm on the rope, applied a 100 N force to the left, while Rameek applied a 100 N force with both hands to the right. Create a FBD and determine the net force.

3. Janelle finally decided to take this seriously and put both hands on the rope and applied a 150 N force to the left, while Rameek still struggled with his 100 N force to the right. Create a FBD and determine the net force.

4. Sarah and Kyon were attempting to push Joaquin on the scooter with enough force so Joaquin would run into their teacher. They figured out they needed a 50 N force to run the scooter into Mr. Whitmore. Sarah and Kyon were both applying force toward Mr. Whitmore. Sarah was applying a 20 N force to the left, and Kyon was applying a force of 15 N to the left. Create a FBD and determine the net force. Did the Joaquin scooter rocket hit the teacher? How can they get it to hit him?

5. In a third hour battle the girls were able to overcome the boys 3 times in the tug of war. The boys had 8 individuals each pulling with a force of 30 N. The 10 girls were able to pull the rope toward them with a force of 25 N each. Create a FBD and determine the net force. Who won?

6. During 4th period Jada was a beast. She resisted the forces applied by 5 people in his class all at once. Each person applied a force of 17 N and Jada still did not move. Create a FBD and determine the net force. How much force was Jada pushing back with for her to stay still? How many people would it take to push Jada if she can withstand a force of 250 N?

Newton's Second Law and Motion

Directions: For each problem below, DRAW A FREEBODY DIAGRAM. Then write a net force equation (F=ma), determine if your object is in equilibrium, then solve. You will need to use your kinematics equation sheet!

1. A car speeds up from rest to a velocity of 25 m/s over a time interval of 10 seconds. If the car is 3000 kg, what was the net force exerted on the car?

2. Josh, with a mass of 60 kg, is running on a track. Towards the end of the race, he decides to sprint to the end. If he accelerates from 8 m/s to 10 m/s over a time interval of 30 seconds, how much force did he exert?

3. Brandon decelerates his car from a speed of 20 m/s to rest when he gets pulled over by the cop, Jon. If his car has a mass of 4500 kg and he stops in 15 seconds, how much force was exerted on the car?

4. James pushes on a shopping cart originally at rest with a force of 32 Newtons. If the cart has a mass of 19 kg and he pushes for 30 seconds, how fast is the cart going after 30 seconds?

5. Rachel can punch with a force of 27 Newtons. If she punches a punching bag that weighs 100 kg and she is in contact with the punching bag for 0.94 seconds, how fast is the bag moving?

Energy

A 200-kg boulder is 1000-m above the ground.

a) What is its potential energy when it is 1000-m above the ground?

b) What is its kinetic energy when it is 1000-m above the ground?

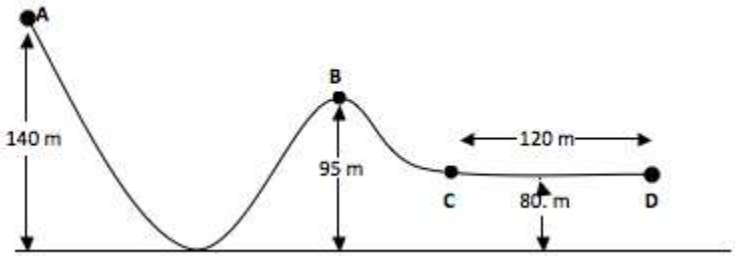
c) The boulder begins to fall. What is its potential energy when it is 500-m above the ground? Where did the "lost" potential energy go?

d) What is the kinetic energy of the boulder when it has fallen 500-m?

e) What is the kinetic energy of the boulder just before it hits the ground?

Use the figure below for the following questions. m= 100 kg

Figure 1:



What is the potential energy at Point A?

What is the potential energy at Point B?

What is the kinetic energy at Point B?

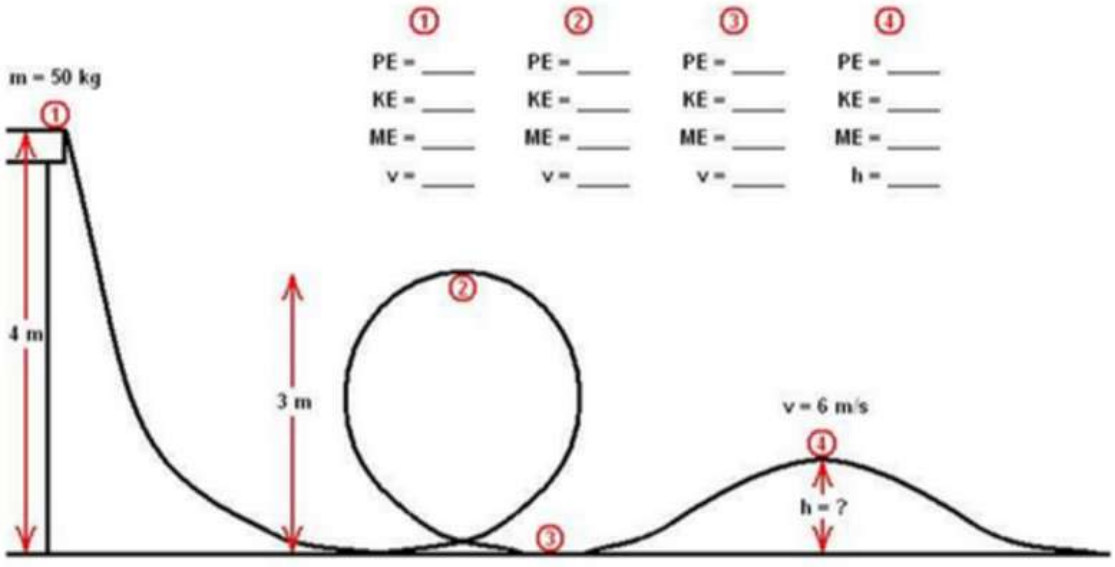
What is the speed at Point B?

What is the potential energy at point C?

What is the kinetic energy at Point C?

What is the speed at point C?

Determine the unknowns for the image below. m= 50 kg ME is Mechanical Energy which is the total energy in a system



Momentum and Impulse

1. Calculate the momentum of a 4000 kg car moving at 30 m/s.
2. Calculate the momentum of a 730 gram newspaper tossed by a newspaper boy at 5 m/s.
3. A freight train engine of 9933 kg is traveling at a speed of 0.0001 m/s. How fast does a bee with a mass of 17 grams have to fly in order to have the same momentum as the freight train?
4. Calculate the total momentum of the system:
    a. A 55 kg person sits on a 135 kg boat at rest in the middle of the lake.
    b. A 55 kg person jumps off the boat with a speed of 3 m/s and the 135 kg boat goes backwards with a velocity of 1.22 m/s.
    c. A 55 kg person runs at 4 m/s towards a docked 135 kg boat.
    d. After jumping onto the boat, the 55 kg person and the 135 kg boat both drift away with a speed of 1.16 m/s.
5. The driver accelerates a 260.0 kg snowmobile, which results in a force being exerted that speeds up the snowmobile from 6.00 m/s to 25.0 m/s over a time interval of 60.0 s.
    a. What is the snowmobile's change in momentum?
    b. What is the impulse on the snowmobile?
    c. What is the magnitude of the average force that is exerted on the snowmobile?
6. In order to slow down a 1500 kg car from a velocity of 20 m/s to a velocity of 0 m/s, the brakes were applied over a time interval of 30 seconds.
    a. What is the car's change in momentum?
    b. What is the impulse on the snowmobile?
    c. What is the magnitude of the average force that is exerted on the snowmobile?
7. A 0.144 kg baseball is pitched horizontally at 32.0 m/s. After it is hit by the bat, it moves at the same speed, but in the opposite direction.
    a. What was the change in momentum of the ball?
    b. B. What was the impulse delivered by the bat?
    c. If the bat and ball were in contact for 6.5×10^{-5} s, what was the average force the bat exerted on the ball?

Inelastic Collisions

1. Two freight cars, each with a mass of 2.0×10^5 kg, collide and stick together. One was initially moving at 2.0 m/s and the other was at rest. What is their final speed?
2. A 0.105-kg hockey puck moving at 18 m/s is caught and held by a 62-kg goalie at rest. With what speed does the goalie slide on the ice?
3. A 35.0-g bullet strikes a 3.5-kg stationary piece of lumber and embeds itself in the wood. The piece of lumber and bullet fly off together at 7.1 m/s. What was the original speed of the bullet?
4. A 0.50-kg ball that is traveling at 6.0 m/s collides head-on with a 1.00-kg ball moving in the opposite direction at a speed of 12.0 m/s. The balls stick together. Find their final velocity.

Elastic Collisions

1. A 0.195-kg plastic ball moves with a velocity of 0.30 m/s. It collides with a second plastic ball of mass 0.103 kg, which is moving along the same line at a speed of 0.10 m/s. After the collision, both balls continue moving in the same, original direction. The speed of the 0.103-kg ball is 0.0026 m/s. What is the new velocity of the 0.195-kg ball?
2. Two bumper cars at an amusement park collide elastically as one approaches the other directly from the rear. The car in front (CarA) has a mass of 550kg and the car behind it (CarB) has a mass of 450kg. The car in front was traveling at 3.70m/s while the car behind hit him with a velocity of 4.50m/s. What are their final velocities after the collision?
3. Hockey puck A (2kg) travels with a velocity of 40m/s to the right when it collides with hockey puck B (1.6kg), which was originally at rest. After the collision, puck A is stationary. Assume no external forces are in play and that the momentum of the pucks are conserved. What is the final velocity of puck B after the collision?

Explosions

1. A 0.053 kg bullet is shot with a velocity of 458 m/s out of a 1.4 kg gun. What is the speed of the recoil of the gun?
2. A 25 kg child dives off of a boat into the water. The child dives with a speed of 7 m/s and the boat has a mass of 3023 kg. How fast and in what direction does the boat move after the child dives off?
3. You (mass = 67 kg) are stuck in the middle of a frozen lake. In order to get to the shore due east, you decide to throw your 0.369 kg shoe due west with a velocity of 15 m/s. How fast and in what direction do you move?

Predictions in Collisions

1. Describe the type of collision.
2. Model the before, middle and after of the collision and note the velocities and masses.
3. Describe why the collision ended this way.

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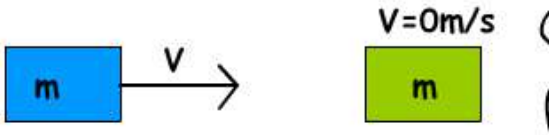
1. before collision



2. before collision

3. before collision

Determine the “after” for the collision and why. Feel free to use the simulations to help you!

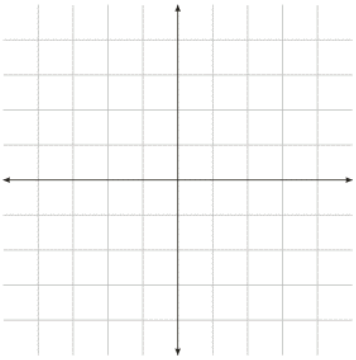
EXTENSION- 2D Motion

https://www.youtube.com/watch?v=XTBrAiuCaKU

https://www.youtube.com/watch?v=br3gPJkK8t0&t=28s

Part I: Vectors

1. Starting at the origin, I walk 5 meters east and 7 meters north. What is my displacement from start? What is my distance? Graph it.



Magnitude of displacement:

_____

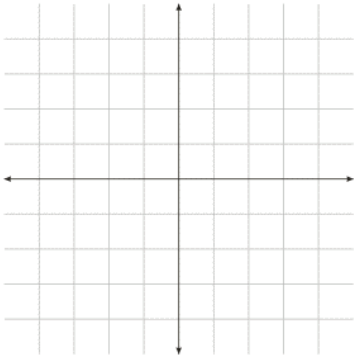
Direction (from +x axis):

_____

Distance:

_____

2. If I walk 10 meters east and 7 meters south, what is my displacement from start? Graph it.



Magnitude of displacement:

_____

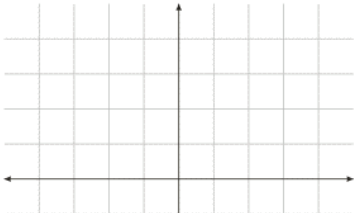
Direction (from +x axis):

_____

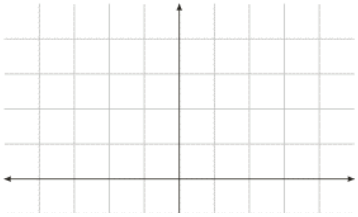
Distance:

_____

3. A vector has a magnitude of 17 at an angle of 135°. Find the x and y components. Graph it.



4. A vector has a magnitude of 17 at an angle of 225°. Find the x and y components. Graph it.



Part II: Velocity Vectors

1. Donavan is running on a treadmill at 5 m/s. He set the treadmill to -6 m/s.
    a. Using only vectors, sketch a vector diagram that explains what is happening as Donovan runs on the treadmill.

    b. Using only words (no numbers), describe what happens to Donovan as he runs on the treadmill.

Problems: Read the word problem, draw a diagram that illustrates your givens and what you are solving for, and then solve showing all of your work and equations. Do not forget your direction and units.

2. Chris, during aviation training, is flying a fighter plane west at 100 km/h. He experiences a wind blowing toward the north at 65 km/h. What is the magnitude and direction of the resulting velocity of the plane?

3. While training for the Ironman, Alex decides to swim across a river. He swims directly across at a rate of 6 m/s, but there is a current flowing to the east at 2 m/s. What is Alex's resultant velocity?

4. A soccer ball is rolling east with a velocity of 6 m/s when Eli kicks it to the north with an additional 7 m/s.
    a. Does the soccer ball lose the original 6 m/s?

    b. What is the soccer ball's resultant velocity?

Problems: Follow the italics (if given) and write your answer WITH UNITS on the line provided at the end.

Part 2: Half Projectile Problems:

1. Rose accidentally throws her car keys horizontally at 8.0 m/s from a cliff 64 m high. How far from the base of the cliff should she look for the keys?

   This is a half projectile problem because the keys are thrown horizontally; all of the velocity is directed in the x-direction and there is no y-component. Draw a diagram and write down your givens:

Diagram	*Variables in the x-direction*	*Variables in the y-direction*

The time in the air depends on how long the keys have to fall. "Falling" refers to motion in the y-direction. Solve for time by solving equations in the y-direction.

The time it takes to fall is how long the ball has to travel in the x-direction. Use that time to find out "how far from the base of the cliff you should look for your keys."

2. Isabelle dives from a cliff that is 61 m high, but there are rocks that extend horizontally from the base of the cliff for 23 meters. What is the minimum horizontal velocity Isabelle must have to clear the rocks?

   This is a half projectile problem because the Isabelle runs horizontally off the cliff; all of the velocity is directed in the x-direction and there is no y-component. Draw a diagram and write down your givens:

Diagram	*Variables in the x-direction*	*Variables in the y-direction*

a) How long is she in the air?

b) What is her final velocity in the y direction?

c) What is the initial horizontal velocity? (Hint set v initial and velocity final as the same variable)

3. Nick throws a baseball horizontally with a speed of 25 m/s from a height of 2 meters. How far does the ball go before it hits the ground?

4. Nate is so mad about all of his homework he has to do tonight that he decides to crumple it up and throw it from the top of the school. If he throws it horizontally with an initial velocity of 13 m/s and he is 10 meters high off of the ground, how far does the homework go so he can go retrieve it and do his homework anyways?

Part 3: Full Projectile Problems:

5. Matt kicks a football for a field goal from ground level with an initial velocity of 27.0 m/s, 30.0° above the horizontal. How far does the football go?

   This is a full projectile problem because our ball is kicked at an angle and the height does not change ("level ground"). Because our initial velocity is at an angle, we're gonna have to break it up into x- and y- components. Draw a diagram and write down your givens:

Diagram	*Variables in the x-direction*	*Variables in the y-direction*

a) How long is the ball in the air?

b) What is the horizontal distance the ball traveled?

6. Lilly shoots an arrow at 30.0° above the horizontal. Its initial velocity is 49 m/s and it hits the target which is at the same height at which the arrow was shot.

   This is a full projectile problem because our arrow is shot at an angle and the height does not change ("same height"). Because our initial velocity is at an angle, we're gonna have to break it up into x- and y- components. Draw a diagram and write down your givens:

Diagram	*Variables in the x-direction*	*Variables in the y-direction*

a. How far away is the target?

b. How long is the arrow in the air?

c. What is the maximum height of the arrow? (Set up a new y chart)

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7. Emily throws a wadded up paper ball into the trashcan at an angle of 37° with a speed of 6 m/s. How far away is the trashcan? (Assume she makes it into the trashcan).

8. Sai decides to take up BMX biking. On a particularly dangerous stunt, she has to jump over a gorge that is 60 meters wide gorge using a ramp. If the ramp is 45° and her bike can go at a maximum velocity of 23 m/s, does Sai make it over the gorge or does she die?

Extension- 2D Momentum Problems
https://www.youtube.com/watch?v=9YRgHikdcqs

Set A: Inelastic, No Angles

1) Tina (40 kg) runs towards Julia (45 kg) with a speed of 3 m/s moving South. Julia runs towards Tina with a speed of 1.4 m/s moving West. They collide and move together. What is their final velocity?
2) Car A (1000 kg) is moving at 10 m/s North and Car B (4000 kg) is moving 15 m/s East. The two cars collide and move together. What is their final velocity?
3) Ally (60 kg) is sitting meditating in her room (at rest). Her cat Felix (10 kg) runs at her at 2 m/s North and her other cat Hank (5 kg) runs at her West at 2.5 m/s. They all collide and move together. What is their final velocity?

Set B: Inelastic, Initial Angles

1) Hank the cat (5kg) runs towards a mouse (2.2 kg) that is at rest. They cat runs at 3.4m/s at 60 degrees North of East. The cat and mouse collide and move together. What is their final velocity?
2) Car A (1000 kg) is moving at 10 m/s 35 degrees North of East and Car B (4000 kg) is at rest. The two cars collide and move together. What is their final velocity?
3) Ally (60 kg) is sitting meditating in her room (at rest). Her cat Felix (10 kg) runs at her at 2 m/s 30 degrees North of East and her other cat Hank (5 kg) runs at her North at 2.5 m/s. They all collide and move together. What is their final velocity?