2D MOTION

VECTORS
There are times when being a whiz at physics can be a definite drawback.
Use trigonometry to find the different components of the vectors drawn below.

<table>
<thead>
<tr>
<th>27 m</th>
<th>22 m</th>
<th>31.9 m</th>
<th>32°</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Component</td>
<td>North Component</td>
<td>North Component</td>
<td>North Component</td>
</tr>
<tr>
<td>South Component</td>
<td>South Component</td>
<td>South Component</td>
<td>South Component</td>
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<tr>
<td>East Component</td>
<td>East Component</td>
<td>East Component</td>
<td>East Component</td>
</tr>
<tr>
<td>West Component</td>
<td>West Component</td>
<td>West Component</td>
<td>West Component</td>
</tr>
</tbody>
</table>

In these spaces add up the vectors using the head to tail method. Measure the result!

Check your answer by adding all the north and south components followed by the east and west components in the space below. How close did you come?
Canoes and other boaters must pay attention to currents and wind to be certain that they stay on course. For example, if the canoe shown moving at a rate of 8.3 m/s while moving in the direction of 32.7° (as read from the compass), and a wind was blowing at 182°, at a rate of 5.4 m/s which way would the canoe actually go and how fast would it move? Make components of each contributing factor and show this below.

What if there was a current of 2.3 m/s at 282° also affecting the canoe? What would be the final result?
1) Above left: A pig is dropped from a cliff. Calculate and draw the position it has fallen at 1 s intervals. Do this until the pig has safely hit the ground and use the scale provided.

2) Above right: Now the pig is shot horizontally out of a cannon. The pictures shown are if gravity was not acting on the pig. First, calculate the horizontal distance the pig will travel if it is launched with an initial $V_x = 10 \text{ m/s}$. Second, if gravity is turned back on, calculate and draw the position it has fallen for each picture. Redraw the pig at this position, then connect the pigs with a smooth curve to show the true path of flight.

No pigs were injured in the making of this worksheet.
4) Use the rulers and draw the correct positions of the pig at each second
determine the pig's gone. Do this for the first 8
3) Use the Y's found in part one. Use this as your initial velocity and calculate the vertical
first 8.
2) Use the Y's found in part I. Find the horizontal distance the pig has gone. Do this for the
1) Find Y, and Y.
two parts: horizontal and vertical.
Now the pig is shot at an angle or at an angle. For this you must draw the motion of the pig into

\[ \alpha = 76^\circ \]
\[ v = 4.2 \text{ m/s} \]

Use 50 cm = 5 m

Scale 1 cm = 5 m
1. A ball is thrown with an angle of 12.0 ° to the horizon with a speed of 15.0 m/s. What are its horizontal and vertical components?

2. A frog falls from its rainforest tree. If we ignore wind resistance, (a) how much time does it take the frog to fall a distance of 12.0 m? (b) how fast is the frog falling at this point?

3. A cannon shoots a large cannonball. The cannonball has a speed of 125 m/s when it leaves the barrel. If the elevation angle was 32.0°, what is the horizontal distance that the cannonball travels?

I don't want to get to the end of my life and find that I lived just the length of it. I want to have lived the width of it as well. -- Diane Ackerman
4. A ball is thrown at some angle. The ball is in the air for 4.50 seconds before it hits. If it travels 45.0 meters before it hits the ground, what was the initial velocity of the ball (magnitude and direction please)?

5. A crow flies aloft carrying a shiny rock in its beak. The crow reaches an altitude of 65.0 m and is flying at 34.5 km/h. It releases the rock. Find: (a) the time it will take the rock to hit the ground below, (b) the horizontal distance the rock will travel before it hits, and (c) the speed of the rock when it hits the ground.

6. A ball rolls across a table at constant velocity. The ball is traveling at speed \( v \). The table is a distance \( h \) above the deck below. How far from the edge of the table does the ball travel before it hits the deck?
1. A ball is thrown straight up with a speed of 12.5 m/s. (a) How high does it go and (b) how much time does it take to get there?

2. A Volkswagen runs straight off a cliff. The Volkswagen is traveling at a speed of 34.5 m/s when it leaves the road. If the cliff is 12.5 m high, how far horizontally does the car travel before it smashes into the ground below?

3. A stealth bomber on a training mission drops one of its bombs from a height of 3,500 m during level flight. The bomb travels a horizontal distance of 1.25 km. What was the plane’s horizontal speed?
4. An arrow is launched with a velocity of 88.7 m/s at an angle of 33.0° to the horizontal. How far does the arrow travel?

5. A brick is thrown upward from the top of a building at an angle of 25° to the horizontal and with an initial speed of 15 m/s. It strikes the ground below. If the brick is in flight for 3.0 s, how tall is the building?

6. A ball is thrown at an angle of 43° to the horizontal. It travels a distance of 75 m in 2.3 s. (a) What was its original velocity? (b) How high did it go?
7. Observe the distance Vs time graph for the motion of a toy car. From the graph, determine the following: (a) the speed at time $t = 2.5\, \text{s}$. (b) The speed at time $t = 17\, \text{s}$. (c) parts of the curve when the speed is increasing in magnitude. (d) What will be total displacement at $t = 14\, \text{s}$.

8. A truck is out on the highway cruising along. It goes by a marker that says “125\, \text{km}”. 12 minutes later it travels past a marker that says “88\, \text{km}”. What is the average speed of the truck?

9. The USS Theodore Cleaver fires a projectile at an angle of $25.0^\circ$. The time of flight for the projectile is 48.4\, \text{s}. What was the horizontal distance of the shot?
Vital papers will demonstrate their vitality by spontaneously moving from where you left them to where you can't find them. -- Anonymous

1. A ball is at rest on a ramp as shown. If the ramp makes an angle of 11.0° to the horizontal, what is the acceleration component down the ramp? If the ball rolls down the ramp a distance of 1.2 m, how much time did it take? As you can see, \( \mathbf{g} \) is the resultant of the acceleration down the ramp and normal to the ramp.

![Diagram of a ramp with angle and acceleration components]

2. A kid runs straight off a diving board. The diving board is 3.0 m above the water. If the kid travels 2.5 m horizontally from the edge of the board when he hits the water, what was his horizontal speed?
3. The nose wheel falls off of a 767 when it is flying at an altitude of 12 500 m. Okay, (a) how much time for it to hit the ground? (b) If the plane has an air speed of 885 km/h, what is the horizontal distance that the wheel travels before it hits the ground.

4. A 5 inch projectile is fired with a velocity of 288.7 m/s at an angle of 18.0° to the horizontal. How far does the projectile travel?

5. An aircraft launches a bomb. The plane is flying upward at an angle of 55° to the horizon. When the bomb is launched, de plane has a speed of 745 km/h. At the time of launch, the bomb is 8 750 m above the ground. So (a) how high does the bomb go from where it was launched? (b) How far horizontally does it travel? (c) How much time till it hits?
1. Draw the velocity vectors onto the balls below:

2. A projectile is launched with an initial speed of 60.0 m/s and an angle of 30.0° above the horizontal. The projectile lands on a hillside 4.00 s later. Neglect air friction. (a) What is the projectile's velocity at the highest point of its trajectory? (b) What is the straight-line distance from where the projectile was launched to where it hits?
3. A gigantic roc (the mythical bird that gave Sinbad a real bad time) picks up a boat and flies off with it. The bird releases the boat. The boat travels 235 m in the horizontal direction before it hits the water. The bird was flying at a speed of 23.5 m/s. So how high was the bird flying when it dropped the boat?

4. A speedy destroyer's 5 inch gun fires a projectile at some angle to the horizontal. If the thing travels a distance of 23,500 m in 135 s, what was the projectile's initial velocity?

5. A car is parked on a cliff overlooking the ocean on an incline that makes an angle of 24.0° below the horizontal. The negligent driver leaves the car in neutral, and the emergency brakes are defective. The car rolls from rest down the incline with a constant acceleration of 4.00 m/s² for a distance of 50.0 m to the edge of the cliff. The cliff is 30.0 m above the ocean. Find (a) the car's position relative to the cliff when the car lands in the ocean, and (b) the length of time the car is in the air.
6. An overpaid (really overpaid) baseball player hits a homerun. The ball is caught by one of the few baseball fans left under the age of 50 in the stands in the cheap seats. It is caught 7.50 m above the point from which it was hit. At the moment it was caught (or an instant before if you prefer) it had a velocity of 36.0 m/s at an angle of $28.0^\circ$ below the horizontal. Ignoring air resistance, find the initial velocity of the ball when it was hit.

7. A basketball hoop is 3.05 m above the playing surface. A basket is made. The ball reached a maximum height that was 2.00 m above the height of the basket hoop. The basketball was launched from a height of 1.95 m. If the ball traveled a horizontal distance of 5.20 m in 2.00 seconds, what was the initial velocity of the basketball?
Basic idea: A steel ball will roll down a ramp and into a pan set on the deck.

Required Gear: 1. Steel ball (supplied by the beloved General Physics on request)
2. Aluminum channel
3. Meter stick
4. Protractor
5. Metal pan (supplied by the beloved General Physics on request)

Discussion: The ball is placed at point $A$ some distance $d$ from the lower end of the ramp ($B$). When released, the ball will accelerate along the ramp from point $A$ to point $B$ a distance of $d$. From point $B$ to point $C$ it will travel at, for all practical purposes, a constant speed, at $C$ it will begin to fall.
You need to determine the distance $d$ up the ramp that you want to use as the start point. This can be any value that you desire. General Physics suggests that it should not be a short distance (this would require a very steep angle). Anyway, based on that position, you will then calculate the angle $\theta$ needed so that the ball will land in a pan placed on the deck. The center of this pan will be set 65 cm from the top edge of the lab tabletop.

Once you have determined your point $A$, calculated the angle, and set up the ramp, notify the General that you are ready to make your try. The General will then issue you a steel ball, observe your attempt, and see if the balls do land in the pan.

You get one shot at the pan, so do your calculations carefully.

Good luck.
AP Physics B – Projectile motion

Materials: Dart Gun, Black Paper, Meter stick, Chalk

Pre-lab: CONSIDER THE FORMULA BELOW: This is one of three equations

1. \[ x = v_{ox} t + \frac{1}{2} at^2 \]

In the box, re-write this equation so that it represents the vertical direction.

2. What is the magnitude and direction (just a sign +/- will suffice) of gravity?

3. Is it ever zero, in this direction?

4. Does gravity work horizontally?

5. Is gravity, an acceleration or a force?

6. According to your answer in #4 and #5, the **NUMERICAL** value for acceleration in the x-direction must be what?

7. Substitute your answer from #6 in the equation below and rewrite the equation in the box provided.

\[ x = v_{ox} t + \frac{1}{2} at^2 \]

8. According to your answer, once again, in #6: What can you say conceptually about the horizontal velocity?

9. What does the **VERTICAL** velocity do as the dart approaches the ground?

10. If the dart begins **HORIZONTALLY**, what do you think the **INITIAL VERTICAL VELOCITY** is equal to?

11. Out of all the different variables, which one is the same for BOTH the “x” and “y” directions?

12. If 2 equations share an identical variable, what can you do?

13. Take your advice in #12 and show below one formula for a projectile.
14. Notice in your formula the "y" is on one side and "x^2" is on the other. Is this true?

15. What is left over if we ignore the "x^2" and "y"?

16. If "y" was the rise of a graph and "x^2" was the run, this left over part is considered the what?

**Purpose:** To graphically determine the horizontal velocity of a dart and then use that velocity to predict a range.

1. Place a lab table a certain "x" displacement away from the wall.
2. Tape a large sheet of dark colored paper against the wall.
3. Mark the Height (Y(0)) of the lab table on the dark paper.
4. Measure and record the horizontal displacement away from the wall.

5. Shoot a chalk tipped dart horizontally off the edge of the table so that it strikes the paper. You may want to shoot the dart more than once at this setting for accuracy.

6. Measure and record the vertical displacement from where the dart hit to the top of the table mark.

7. Repeat this procedure using five other horizontal displacements.

<table>
<thead>
<tr>
<th>Trial</th>
<th>ΔY</th>
<th>ΔX</th>
<th>(ΔX)^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>2</td>
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<td>6</td>
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</tbody>
</table>

8. Using Graphical Analysis, make a Y vs. X^2 graph and find the slope.

Slope = _______________
Calculations
Using the slope of your graph, set it equal to the part of the equation mentioned in pre-lab #15 and solve for the horizontal velocity of your dart below. Show all work!

Measure and record the complete height of the table below this sheet of paper. Using this height and the vertical formula from the front, calculate the amount of time a projectile would be in the air using your gun. Show all work!

Calculate the horizontal displacement of the dart using your time and your calculated horizontal velocity.

Part II
1. Shoot the dart horizontally from the table and record the horizontal displacement from the table to the point where it lands. Do this three times to get an average.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Horizontal Displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>AVERAGE</td>
<td>=</td>
</tr>
</tbody>
</table>

Calculate a % difference between the calculated displacement and the measured displacement

\[
\%\text{difference} = \frac{|\text{Calculated} - \text{Average}|}{|\text{Average}|} \times 100 =
\]

Describe and explain some types of experimental error that may have occurred here.