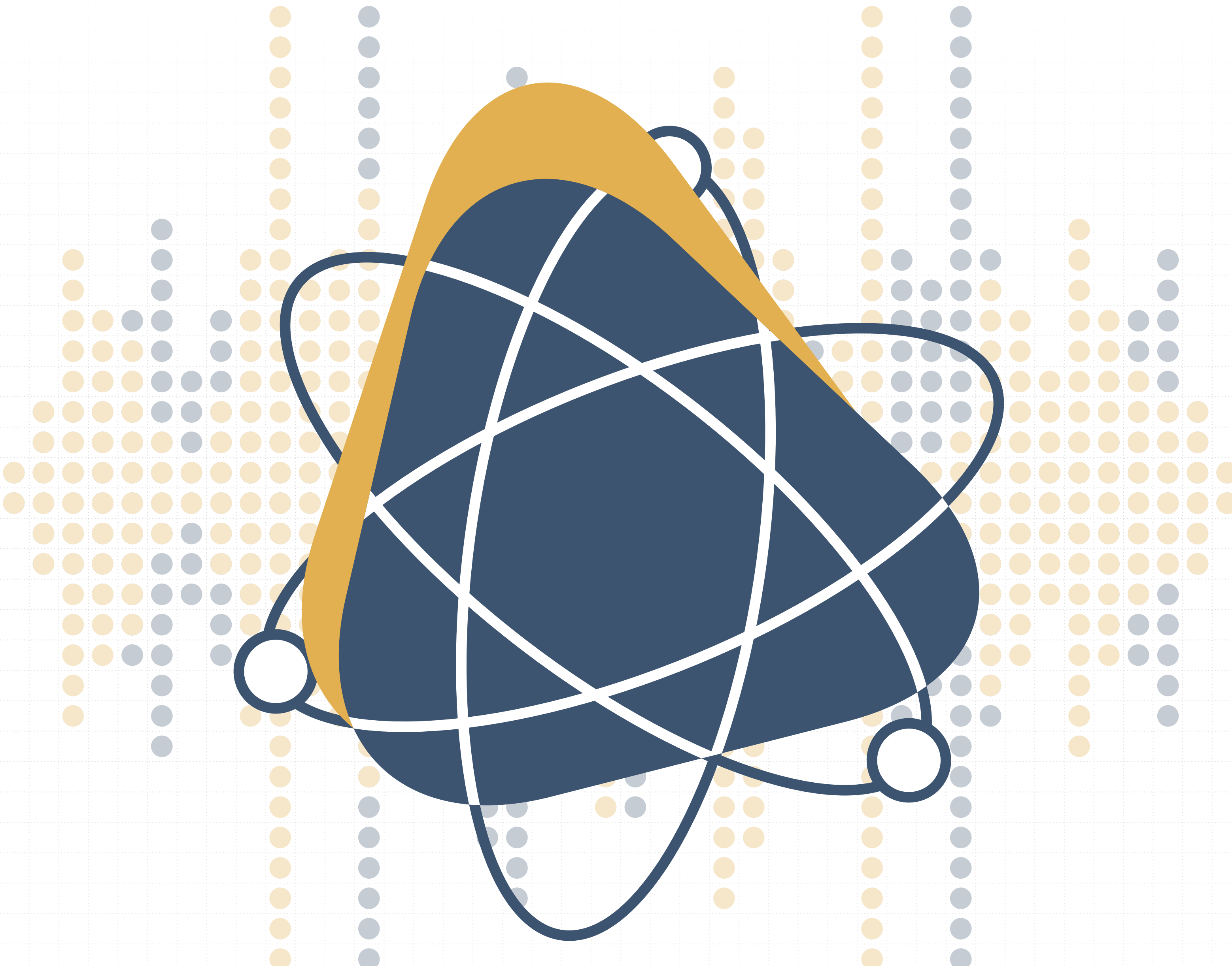

DISCOVER PHYSICS

STUDENT GUIDEBOOK

Luke & Trisha Gilkerson
with Ryan Westcott

Discover Physics: Student Guidebook

Journey Homeschool Academy

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WELCOME TO DISCOVER PHYSICS

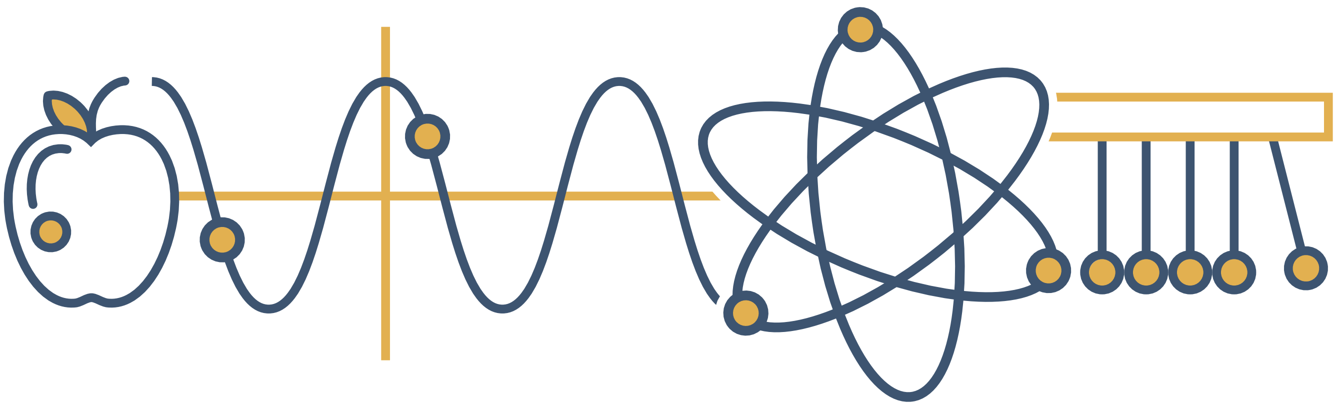
This Student Guidebook was designed for students in the Discover Physics online course. Simply follow along with the weekly lecture videos and fill in the blanks as you go. Sections for extra notes have been provided as well: use these to draw helpful diagrams or take extra notes you find particularly useful during the lecture. At the beginning of each lesson, you'll find a list of terms that might be unfamiliar to you. Be sure to familiarize yourself with these terms and use them as you spend time studying each week.

Along the way, you'll also find study guides for the quarterly exams. Each exam covers material from that quarter only, and these study guides will provide you with terms, questions, and concepts you should be familiar with before taking your exams.

We're excited to have you join the adventure as we explore the world God made!

We'll see you inside the course!

Trisha Gilkerson



LESSON 13

TWO-DIMENSIONAL MOTION

In the real world, motion doesn't happen along conveniently straight lines but in several dimensions all at once: up and down, left and right, back and forth. This lesson explores how we can predict and account for these kinds of motions using the basic math you've already learned.

Vocabulary

Pythagorean theorem

Vectors

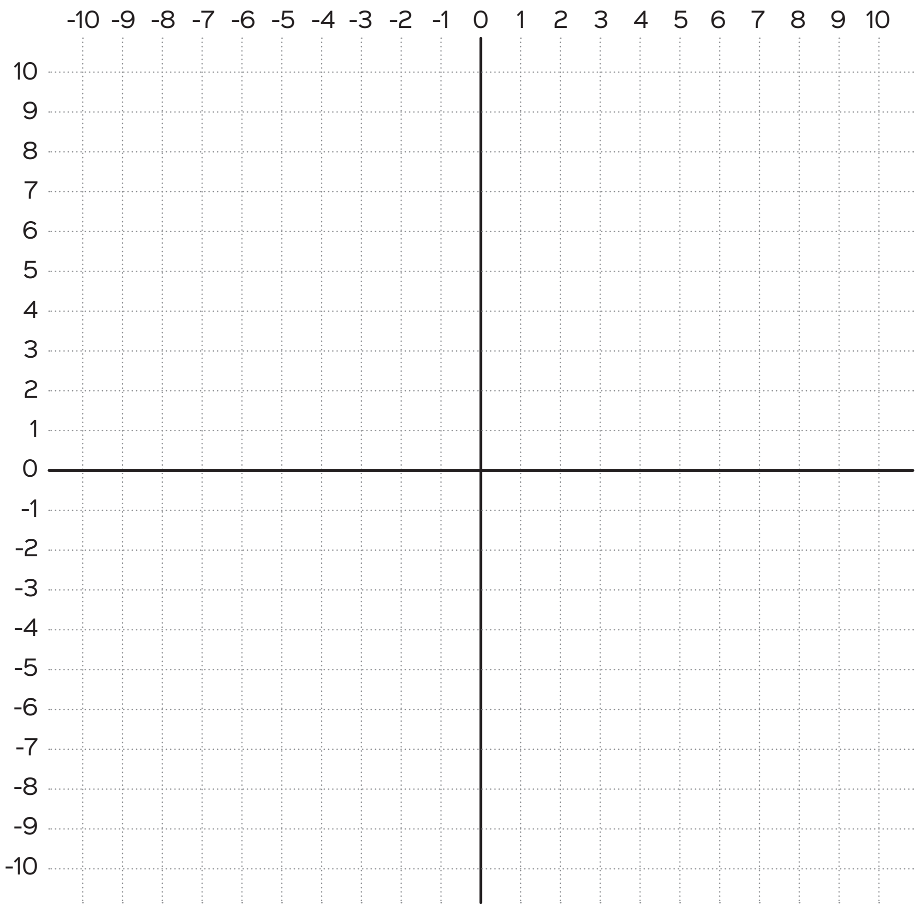
OUTLINE & NOTES

LESSON 13A: TWO-DIMENSIONAL MOTION

I. Two-Dimensional Motion

A. Vectors describe motion in ____________________ and ____________________

B. Example: A treasure map tells you to take 10 steps north, 6 steps east, 5 steps south, then 8 steps west.



1. How many steps would you walk? ____
2. If you wanted a shortcut, could you figure out the endpoint before you took all of the steps?
   a. Treat ________________________ as one dimension of movement, with north being ____________________ movement and south being ____________________ movement

b. Treat ______________________ as a second dimension of movement, with east being __________________ movement and west being __________________ movement

c. Add your north-south movements together: 10 steps north and the 5 steps south:

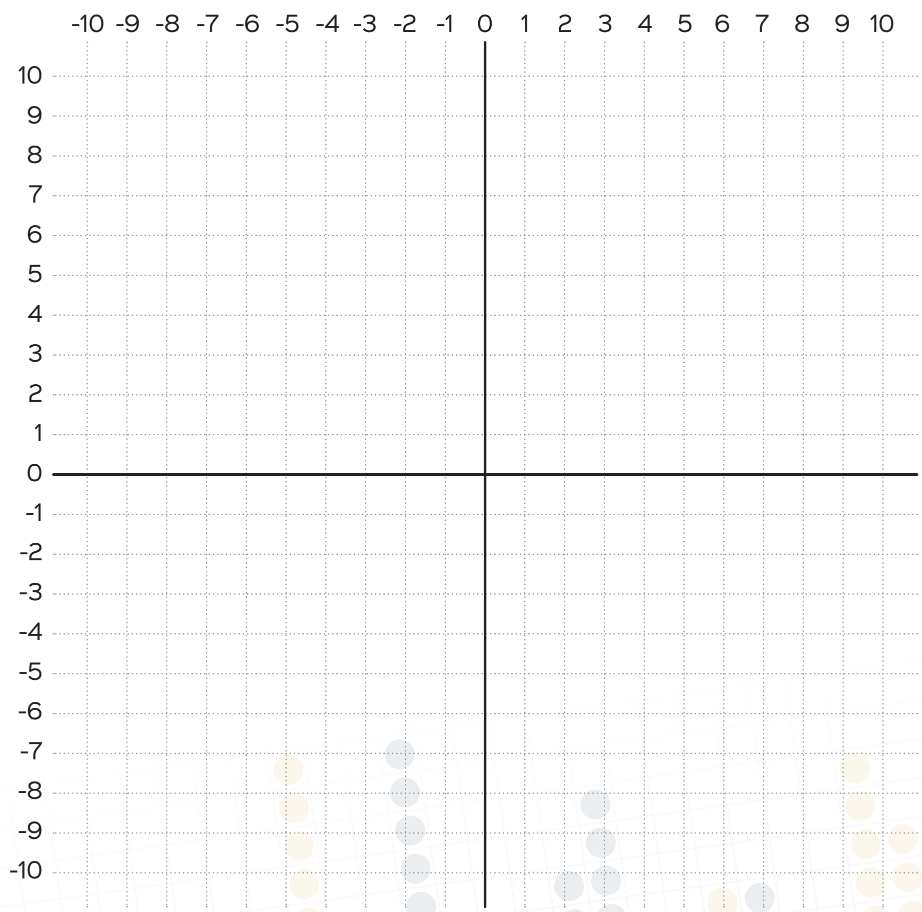
____

d. Add your east-west movements together: 6 steps east and 8 steps west:

____

e. Endpoint: _____ steps ______________ and _______ steps ______________

3. What is the overall diagonal distance when walking 5 steps north and 2 steps west?



a. Find the exact direction using ____________________

b. Find the exact distance using the ______________________________________

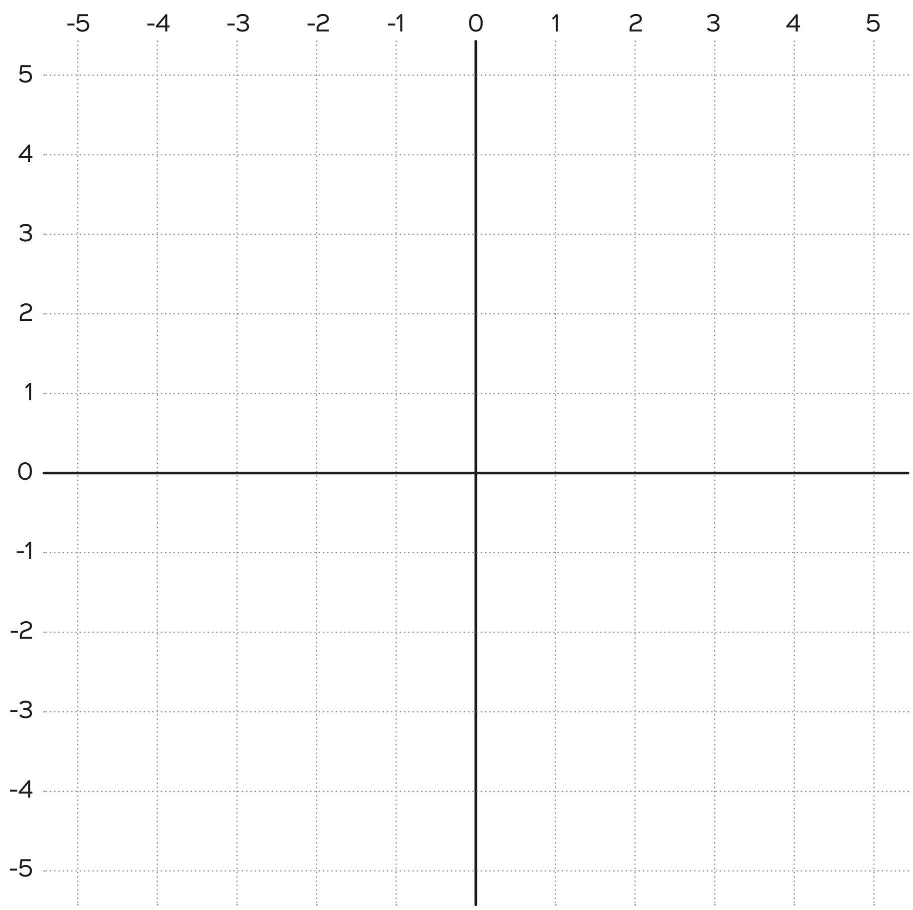
(1) Formula to tell us the length of a diagonal line in a right triangle

(2) Equation: ____________________________________

(3) Solve for c =

II. Velocity Vectors

A. Example: What is the average velocity of someone who walks 5 steps north and 2 steps west at the same time, in a diagonal within 2 seconds?



1. Find the speed in each direction:

   a. Northward speed

   b. Westward speed

2. Use the Pythagorean theorem to determine velocity of the northwest movement

B. Example: A plane flies south at 182 miles per hour, and a cross wind adds 40 miles per hour of westward speed. What is the total speed of the plane?

C. Example: A screen logo is 3 in away from the right-hand edge of the screen. It has a velocity vector with a horizontal component of 5 in/s. If its vertical velocity component is -4 in/s, how far will it travel down by the time it reaches the right-hand edge of the screen?

OUTLINE & NOTES
LESSON 13B: TWO-DIMENSIONAL MOTION

I. Two-Dimensional Motion

A. Each dimension's motion is ____________________ of the other

B. Only ____________________ influences can change horizontal motion, and only ____________________ influences can change vertical motion

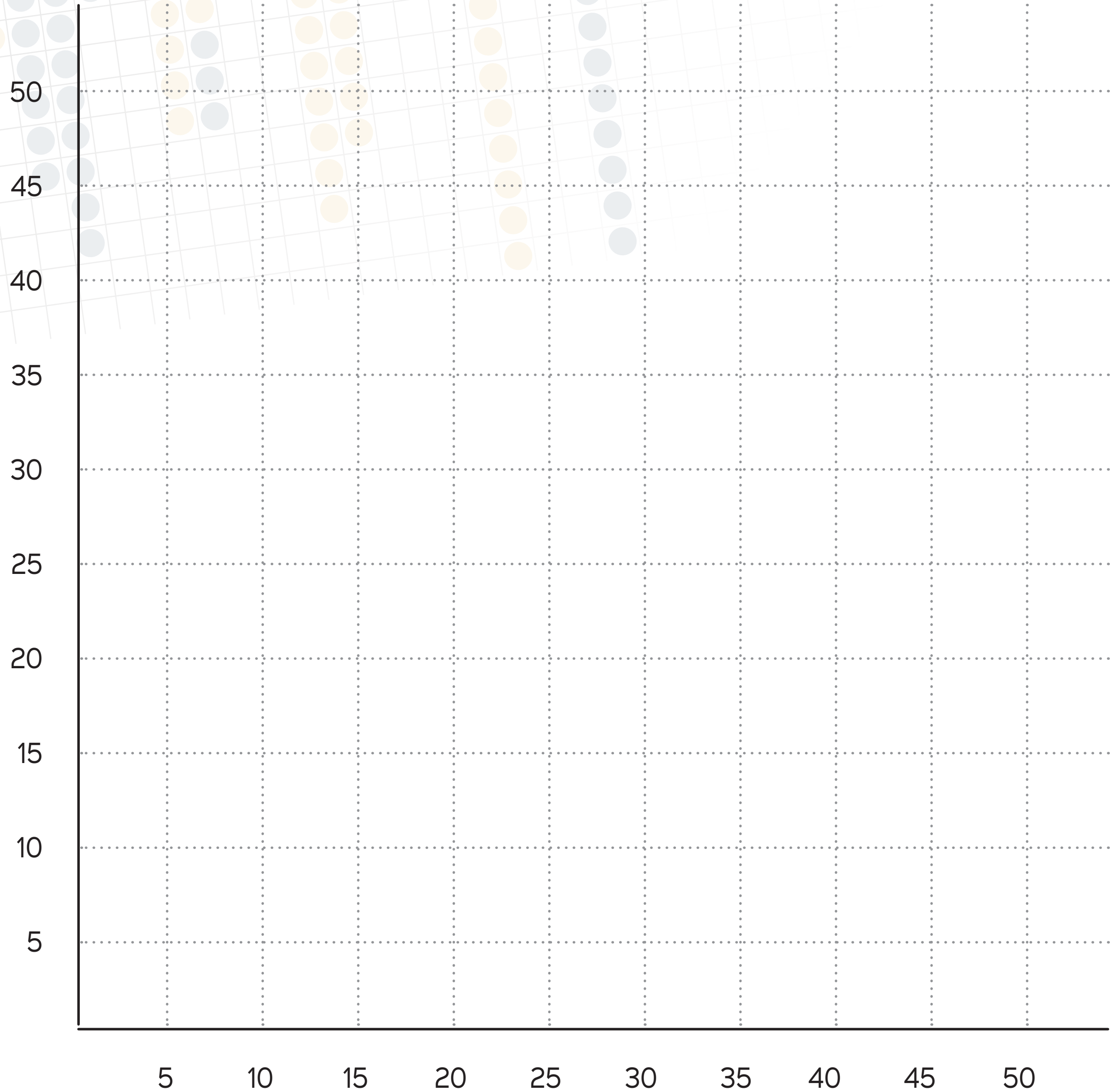
II. Acceleration Vectors

A. Vectors can be used to help us understand ______________________ in two ____

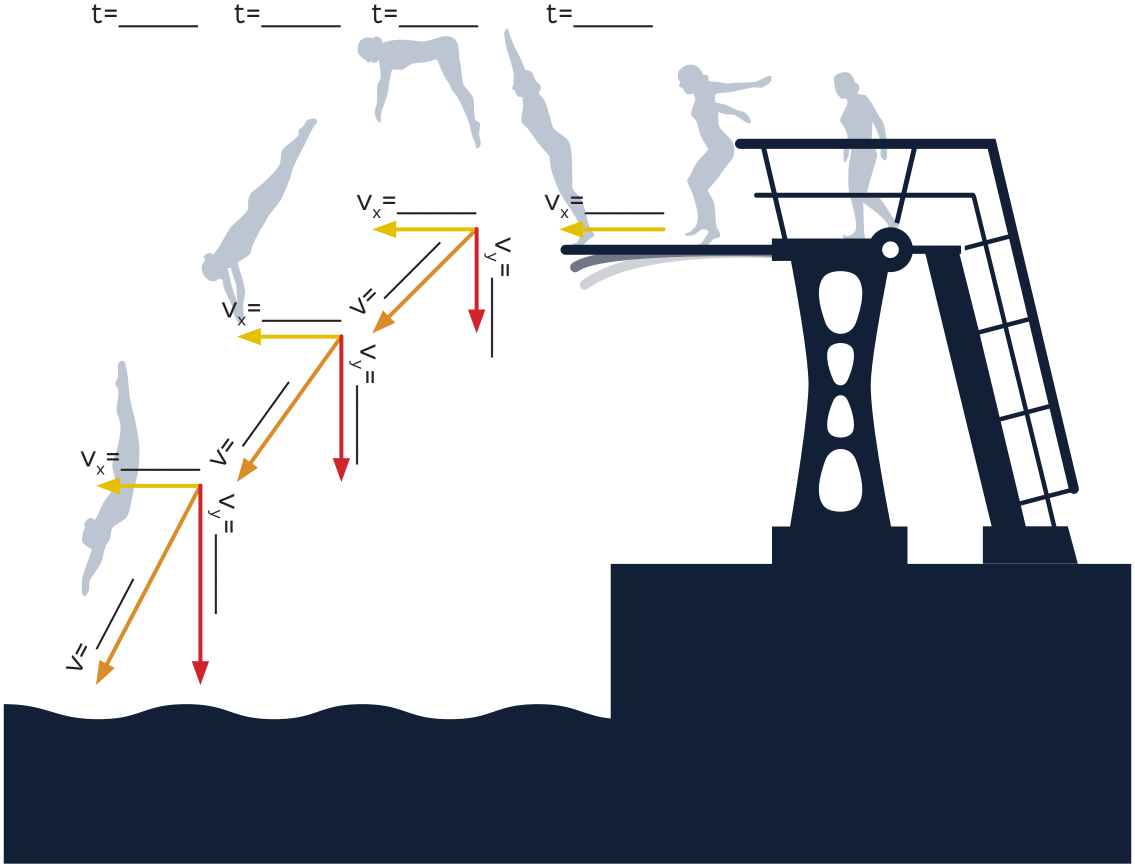
B. Example: A car gradually and steadily follows a curved road going 45 miles per hour, without changing its speed. The car starts facing north and the road makes a simple 90 degree turn, a quarter circle, to the east.

1. Has the car accelerated?
   a. Eastward
      (1) Before the turn, how fast was it proceeding eastward? ______________________
      (2) After the turn, how fast is it proceeding eastward? _________________________
      (3) Its eastward velocity has experienced a ____________________ acceleration from ______ to ______ mph
   b. Northward
      (1) Before the turn, how fast was it proceeding northward? ____________________
      (2) After the turn, how fast was it proceeding northward? _____________________
      (3) Its northward velocity has experienced a ____________________ acceleration from ______ to ______ mph

2. What would the acceleration vectors look like?



C. Example: A high diver runs at 5 m/s to the end of a platform where she dives into the pool. What is her overall velocity?



1. t = 0s

____

2. t = 1s

3. t = 2s

4. t = 3s

D. Example: If a diving board is 10 m above the water and our diver was traveling at 5 m/s as they ran off the diving board, how far sideways will she move before splashing into the pool?

E. Example: A long jumper runs sideways at a speed of 8 m/s along the track, and at takeoff his launch motion adds an additional 5 m/s of vertical speed to the 8 m/s of horizontal speed. How far will the jumper travel?

NOTES

DISCOVER PHYSICS

STUDENT LAB GUIDE

Luke & Trisha Gilkerson
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LESSON 13

PREDICTING PROJECTILE MOTION

When an object flies through the air and is influenced only by gravity's acceleration, we call this projectile motion. In this lab, we will be launching a metal ball with a horizontal starting velocity, and using what we learned about two-dimensional motion to make predictions about projectile motion.

Supplies

- Shelving track
- Support stand
- Ring support
- Meterstick
- Stopwatch
- Video camera
- 1" steel ball
- Masking tape
- 8.5x11" paper
- Pencil

Instructions

1. Read through the instructions completely before beginning your lab. Your hypothesis will be completed halfway through the lab, after you've gathered enough measurements to make a prediction of where you believe the ball will land.
2. Set up your steel ball ramp.
    a. Carefully bend the shelving track upwards into an L-shape around the halfway point, so the two sides are at an angle of about 120 degrees. This will serve as the ramp for the 1" steel ball.
    b. Secure the bottom end of the track to a flat table top with a loop of masking tape. Line up the end of the track with the edge of the table.
    c. Using masking tape, secure the end that is bent upwards to the ring support and secure the ring support to the support stand at an appropriate height to keep the ramp stable.
    d. Set up the meterstick along the horizontal end of the track so it is clearly visible. It does not have to line up directly with the end of the track.
    e. Set the stopwatch nearby.
    f. Set up a video camera so it can see the stopwatch, the meterstick, and the ball as it rolls on the ramp.

3. Choose a starting point on the upper part of the ramp that will give the ball significant speed as it rolls down the ramp. Mark this starting point carefully so it can be reused.
4. Start the video and the stopwatch, then roll the ball from the starting point on the ramp so it rolls down onto the flat part of the ramp and past the meterstick. Catch the ball before it hits the ground. If it hits the ground and unfairly biases your hypothesis, choose a different starting point and repeat step 6 again.
5. Repeat step 4 for a total of five trials, recording two distance and two time measurements for each trial in Data Table 1.
    a. Pause the video recording at two different moments during each trial. Note where the ball is next to the ruler and the corresponding time shown on the stopwatch.
    b. These measurements do not need to be any particular location on the track, and they do not need to remain consistent from one trial to the next.
    c. For instance, during Trial 1, the steel ball might be at 55 cm when the stopwatch shows 5.58 s and at 25 cm when the stopwatch shows 6.02 s. These would be values for d_1, t_1, d_2, and t_2.
6. Calculate your hypothesis:
    a. Use the distances and times for each trial to calculate an average velocity for each trial, then average these to find an overall average velocity for the steel ball. Record these averages in Data Table 1.
    b. Measure the height of the table, from the bottom end of the ramp to the ground in Data Table 2.
    c. Using the height measurement (x) from the table to the floor, calculate the time in seconds it should take an object influenced by gravity's acceleration to fall that distance along the x-axis. Record this in Data Table 2.
    d. This time will also be the time the ball will move horizontally (along the y-axis) before it hits the ground. Using the time and overall average velocity, find the horizontal distance (y) it will travel and record in Data Table 2.
    e. To find the 10% overestimate distance, multiply the hypothesis distance by 1.1 and record in Data Table 2.
    f. To find the 10% underestimate distance, multiply the hypothesis distance by 0.9 and record in Data Table 2.

7. Mark your paper and place it where you hypothesize the ball will land.

   a. Place a pencil mark on the center of the paper.

   b. Place a pencil mark at the 10% overestimate and the 10% underestimate locations.

   c. From the point on the ground directly below the end of the ramp, measure along the floor the hypothesized horizontal distance. Tape the piece of paper on the ground so its center is where you predict the ball will land.

8. Launch the ball again from the marked starting position on the ramp. Note where it lands, measure the actual landing distance, and record in Data Table 3. If the ball lands to the side of your target, you may move the target sideways (parallel to the edge of the table) in order to recalibrate.

9. Repeat step 8 for five trials, using the dents it makes in the paper to measure the actual landing distance.

Data Table 1: Velocity of the Steel Ball

Trial	d_1	t_1	d_2	t_2	Avg Vel.
1					
2					
3					
4					
5					
				Overall Average Velocity	

Data Table 2: Hypothesis

Height of table (x)	
Time you believe it will take for the ball to hit the floor	
Horizontal distance (y) you believe the ball will move away from the table before it hits the floor	
10% Overestimate	
10% Underestimate	

Data Table 3: Results

Launch trial	Hypothesized distance	Actual distance	Percent error	|Percent error|
1				
2				
3				
4				
5				
			Overall % Error	

LAB REPORT

LESSON 13

Write a lab report and include each of the parts listed in your Lab Report Guide. Be sure to form your hypothesis where indicated on your lab instructions. Answer the discussion questions in the conclusion of your lab report.

Results

Evaluate your hypothesis.

1. Calculate the percent error for each trial in Data Table 3.
2. Write down the absolute value of the percent error.
3. Average these absolute values to find the overall percent error from the hypothesis.

Discussion Questions

1. How accurate was your hypothesis? Were any individual landing points outside of the 10% overestimates or underestimates? Was the overall percent difference within 10% of the expected value? Was it within 5%?
2. What do you think accounts for the accuracy or inaccuracy of this experiment?
3. We were able to accurately calculate the motion of a ball that was flying diagonally to the floor by using the time for a ball that drops vertically from a table. Why is this possible?
4. Did the accuracy of this experiment prove that using the vertical drop time to determine the diagonal motion of the ball is a valid approach?

NOTES