Name _____ Date _____ Period _____

ZornScience
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Projectile Motion Virtual Lab

Physics

Open **activities.zornscience.org/projectile-lab/** and follow each step. The simulation uses g = 9.80 m/s^2 and no air resistance. Show your work with units.

Objective

Use a launched ball and its velocity vectors to find how the **horizontal** and **vertical** parts of a projectile's motion change during a flight, and what sets its **time in the air** and **range**.

NGSS alignment: HS-PS2-1. Analyze data to support the claim that Newton's second law describes the relationship among the net force on an object, its mass, and its acceleration (here, a constant downward acceleration from gravity).
Practices and concepts: Analyzing and interpreting data; Using mathematics and computational thinking; Patterns; Cause and effect.

Meet the simulation

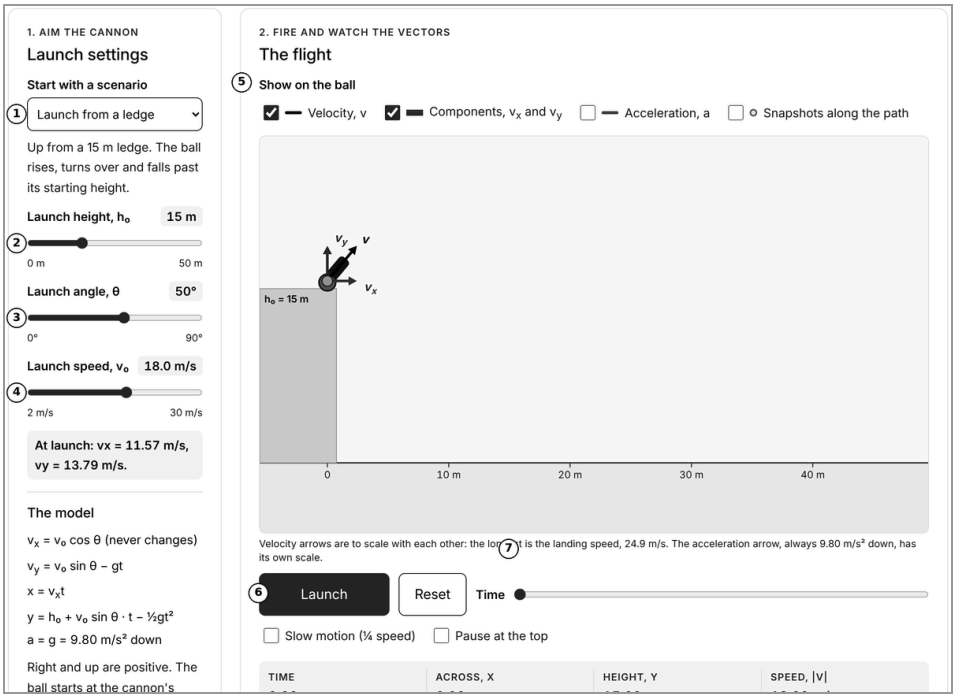


Figure 1. The Projectile Motion Vector Lab.

(1) Scenario menu: loads a ready-made launch.

(2) Launch height, h_0.

(3) Launch angle, θ, above horizontal.

(4) Launch speed, v_0.

(5) Check boxes for the velocity, component, acceleration and snapshot arrows.

(6) Fires the ball.

(7) Time slider: moves to any time. Click it, then use the arrow keys to step 0.05 s, or press End to jump to the landing.

Readouts and Flight results are below the scene.

Pre-lab

1. A ball is launched at 20 m/s, 45° above horizontal. Calculate its horizontal (v_x) and vertical (v_y) velocity components at launch.

2. Predict: at the very top of its path, what is the ball's velocity? What is its acceleration?

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Part A. Watch the components change

1. Choose the scenario **Ground to ground at 45°** (h_0 = 0 m, θ = 45°, v_0 = 20.0 m/s). Check **Acceleration, a** and select **Launch** to watch.
2. Move the Time slider to each time in the table and record the readouts. Write a velocity that says "down" as a **negative** number.

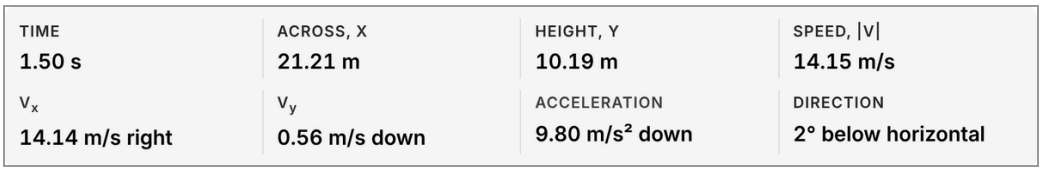
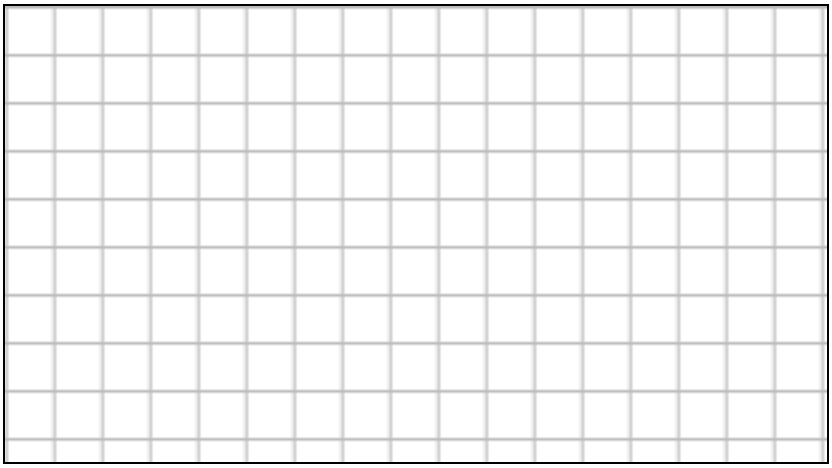


Figure 2. The readouts at 1.50 s.

Time (s)	x (m)	y (m)	v_x (m/s)	v_y (m/s)	Change in v_y since last row (m/s)
0.00					none
0.50					
1.00					
1.50					
2.00					
2.50					

3. Graph v_x and v_y against time on the same grid. Use a different symbol for each, and draw a best-fit line for each. Label both axes with units.



4. Find the slope of each line with units. What does each slope tell you about the acceleration in that direction?

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5. Press **End** on the Time slider. Record the Flight results: time in the air, highest point, range, and v_y at landing. How does v_y at landing compare with v_y at launch?

6. Look at the x column. The ball moves the same distance across every 0.50 s. Explain why, using the arrows you saw on the ball.

Part B. Horizontal launch from a cliff

1. Set h_0 = 40 m and θ = 0°. For each launch speed in the table, press End on the Time slider and record the Flight results.
2. For trial 4, change the height to h_0 = 10 m with v_0 = 12 m/s.

Trial	h_0 (m)	v_0 (m/s)	Time in the air (s)	Range (m)	v_y at landing (m/s)
1	40	6			
2	40	12			
3	40	18			
4	10	12			

7. Does launch speed change the time in the air for a horizontal launch? What does it change? Use trials 1 to 3.

8. Use $\Delta y = \frac{1}{2}gt^2$ to calculate the time to fall 40 m. Then calculate the range for trial 2 with $x = v_x t$. Compare with the simulation.

9. Compare trials 2 and 4. The height is 4 times larger in trial 2. How many times longer is the time in the air? Explain using $\Delta y = \frac{1}{2}gt^2$.

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Part C. Launch angle and range

1. Set h_0 = 0 m and v_0 = 20 m/s. For each angle, press End on the Time slider and record the Flight results.

Angle θ (°)	15	30	45	60	75
Time in the air (s)					
Highest point (m)					
Range (m)					

10. Which angle gives the longest range? Which pairs of angles give the same range? Why does a steep launch stay in the air longer but not go farther?

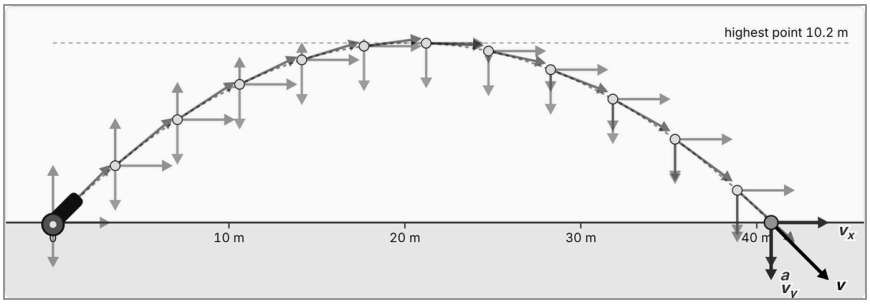


Figure 3. Snapshots every 0.25 s for the 45° launch at 20 m/s.

Set θ = 45°. Check **Snapshots along the path** and **Acceleration, a**, then press End on the Time slider.

11. In Figure 3, describe what the horizontal arrows, the vertical velocity arrows and the acceleration arrows each do from launch to landing.

12. A real ball moves through air. Would the real range at 45° and 20 m/s be longer, shorter or the same as 40.82 m? Explain.

Conclusion

13. Write a claim that answers the objective. Support it with specific numbers from Parts A and B, then explain your reasoning using the direction of the acceleration.

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