Graphing Projectiles Launched at Angles

A – Mild: Constructing Graphs

1. A ball is launched upward with an initial velocity of 23.0 m/s at 58.5° above the horizontal. It lands 5.0 m below its launch elevation.

   a) Sketch the projectile's trajectory, identifying the launch, maximum height, and landing.

   b) Calculate the initial horizontal and vertical velocity components.

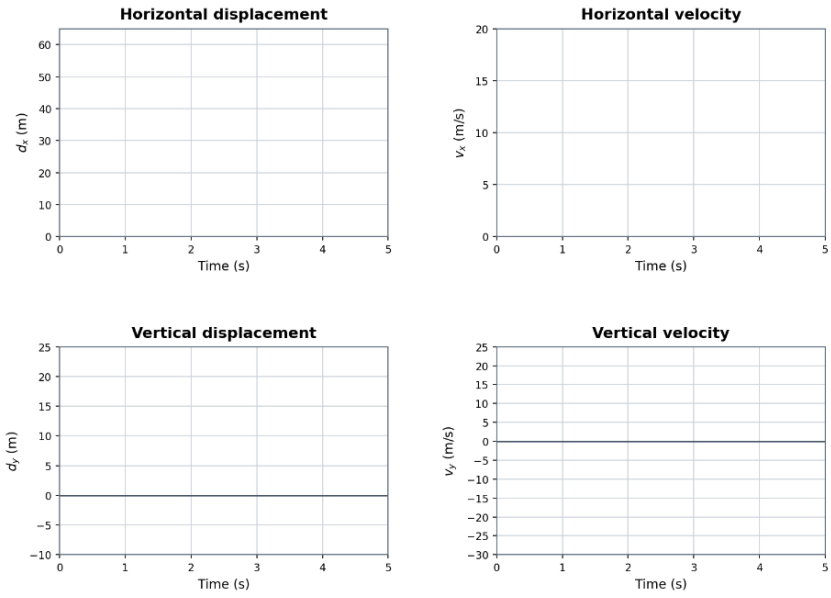
   c) Complete the table for the first 4.00 seconds of flight. The ball will land before 5.00 s.

Time (s)	$d_x = v_i t + \frac{1}{2}at^2$	$v_x = v_i + at$	$d_y = v_i t + \frac{1}{2}at^2$	$v_y = v_i + at$
0	0		0	
1				
2				
3				
4				

   d) Plot all four displacement–time and velocity–time relationships using your calculated values from 0 to 4.00 s.

   e) Extend the vertical displacement graph until it reaches −5.0 m. Estimate the total time of flight.

   f) Use your horizontal displacement–time graph to estimate how far the ball travels horizontally before landing.



   g) Label the launch, maximum height, and landing on both vertical graphs.

   h) Explain how vertical displacement and vertical velocity are related at the apex.

   i) Calculate the slope of the vertical velocity–time graph. What does the slope represent?

j) Find the area from 0 to 2.00 s. What physical displacement does it represent?

k) Find the area from 2.00 s to 4.00 s. Why is it negative?

l) The ball has the same displacement at 1.00 s and 3.00 s. Use both vertical graphs to explain why.

2. Two balls leave the same 40.0 m-high platform simultaneously. During the first 2.00 s of flight, both move horizontally at 12.0 m/s. Ball H is launched horizontally; Ball V is launched upward with an initial vertical velocity of 19.6 m/s.

Ball H

Time (s)	$d_x = v_i t + \frac{1}{2}at^2$	$v_x = v_i + at$	$d_y = v_i t + \frac{1}{2}at^2$	$v_y = v_i + at$
0	0		0	
1				
2				
3				
4				

Ball V

Time (s)	$d_x = v_i t + \frac{1}{2}at^2$	$v_x = v_i + at$	$d_y = v_i t + \frac{1}{2}at^2$	$v_y = v_i + at$
0	0		0	
1				
2				
3				
4				

a) Which two of the four motion graphs would be identical for the balls over these 2.00 s? Explain.

b) At launch, what would the vertical velocity graph show for each ball?

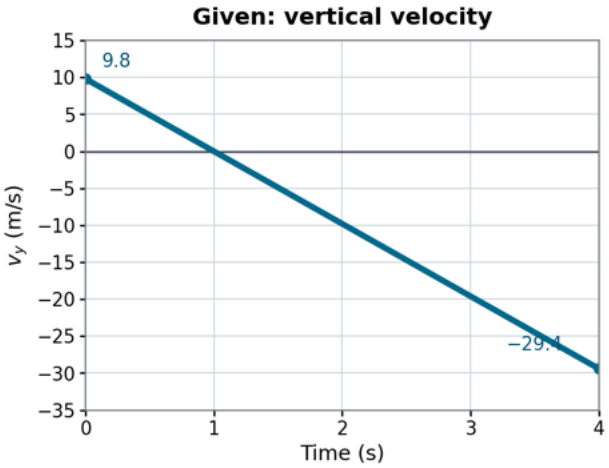
c) After 2.00 s, determine the vertical velocity of each ball and explain which ball is at its highest point.

d) How do the slopes of their vertical velocity graphs compare?

e) Explain how the vertical displacement–time graph of Ball V differs from that of Ball H.

C – Spicy: Different Launch and Landing Heights

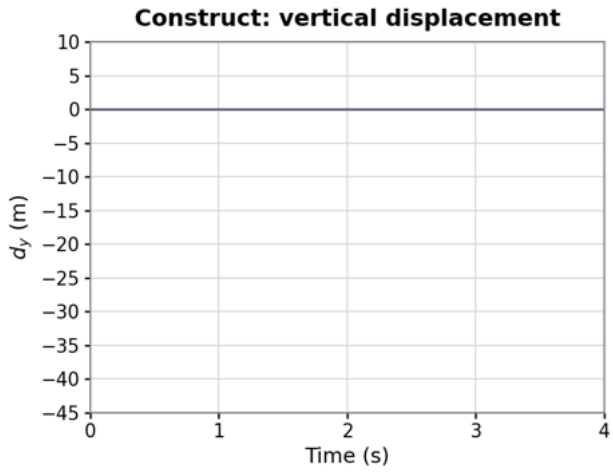
3. A projectile is launched from a cliff 39.2 m above the ground with horizontal velocity 12.0 m/s and initial vertical velocity 9.8 m/s upward. It hits the ground 4.00 s after launch. The vertical velocity graph is given.



a) From the velocity graph, identify the time at maximum height.

b) Calculate vertical displacement at 0, 1, 2, 3, and 4 s, then plot the corresponding displacement graph.

Time (s)	$d_y = v_i t + \frac{1}{2} a t^2$
0	0
1	
2	
3	
4	



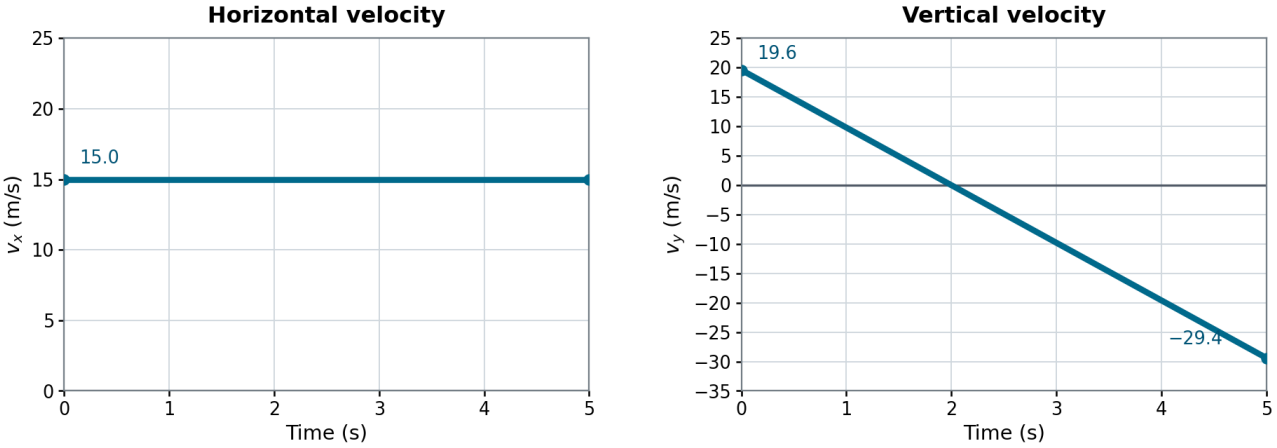
c) Determine the maximum height above the release point and the maximum height above the ground.

d) Compare the time spent rising with the time spent falling.

e) Why does the vertical displacement graph end below zero even though the velocity–time graph has the same constant slope throughout?

D – Extra Spicy: Reconstructing Motion

4. A projectile launches upward at an angle from an elevated position and strikes the ground after 5.00 s. The two velocity–time graphs describe its entire flight.



a) Determine the initial horizontal and vertical velocities, then calculate the launch angle.

b) Calculate vertical acceleration from the slope of the vertical velocity graph.

c) Find when the projectile reaches maximum height

d) Use the area under the vertical velocity-time graph to determine its rise above the release point.

e) Find the total horizontal displacement from the horizontal velocity graph.

f) Determine the net vertical displacement from the signed areas under the vertical velocity graph.

g) How high above the ground was the launch point?

h) Determine the magnitude and direction of impact velocity.