Minds•On Physics Activity

AT•9

Reasoning About Projectile Motion

Purpose and Expected Outcome

In this activity you will reason about the motion of objects undergoing projectile motion. You will learn more about how to relate the initial position and velocity of an object to its maximum height, time of flight, and range. You will also confront some common points of confusion about projectile motion.

Prior Experience / Knowledge Needed

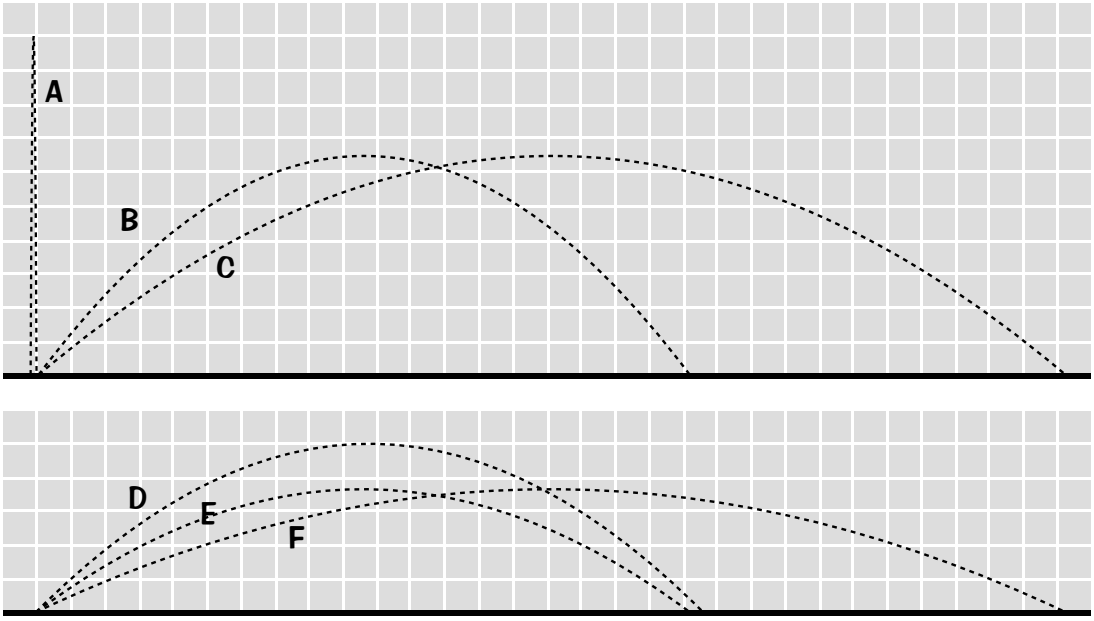
You should have some experience with motion in two dimensions. You should be familiar with the relationships for position and velocity in terms of time, acceleration, initial velocity, and initial position. You should be able to manipulate algebraic expressions.

Explanation of Activity

There are two parts in this activity. In the first part, you will compare six trajectories with each other. In the second part, you will create scenarios to fit given conditions.

PART A: Comparing Trajectories

Shown below are six trajectories, labeled A through F. All six were prepared assuming motion in a gravitational field with no air resistance. The maximum height of A is about 5m. Objects B and C have the same maximum height. Objects E and F also have the same maximum height. Objects B and E land at the same distance from the start, as do objects C and F. Trajectory D has an initial angle of 45°. Use these six trajectories to answer all the questions. Be prepared to discuss your answers with your classmates.



A1. (a) Which object has the larger x-component of initial velocity: B or C? E or F?

(b) Which of the six objects has the largest x-component of initial velocity?

A2. (a) Which object has the larger y-component of initial velocity: B or C? D or E? E or F?

(b) Which of the six objects has the largest y-component of initial velocity?

A3. (a) Which object is in the air longer, or are they the same: B or C? E or F? D or E?

(b) Which of the six objects is in the air the longest?

A4. (a) Which object has the larger initial speed, or are they the same: A or B? C or F?

(b) Which has the larger initial speed: B or C? B or E? E or F?

A5. (a) Which object most likely has an initial velocity of (6m/s, 8m/s)? Explain why you think so.

(b) Which object most likely has an initial velocity of (7m/s, 7m/s)? Explain why you think so.

Summary of Part A

Three quantities are particularly relevant for identifying, distinguishing, and analyzing trajectories: *range*, *maximum altitude*, and *time of flight*. The range is the horizontal distance traveled by the projectile from the time it is fired until it lands. The maximum altitude is the height of the highest point in the trajectory. The time of flight is the amount of time the projectile spends in the air between when it is fired and when it lands.

In the next part we will examine these three quantities and learn how they can be used to analyze situations.

PART B: Creating and Analyzing Scenarios

B1. If two projectiles have the same *range*, must they have the same initial speed? Explain. If not, create a situation in which two objects travel the same horizontal distance, but they have different initial speeds.

B2. If the *maximum altitudes* of two projectiles are the same, must they have the same initial speed? Explain. If not, create a situation in which two objects have the same maximum height but different initial speeds.

B3. If two projectiles have the same range, must they have the same time of flight? Explain. If not, create a situation in which two objects cover the same horizontal distance, but they spend different amounts of time in the air.

B4. Two people are standing on the edge of a cliff. One throws a ball straight up, and the other throws an identical ball straight down. The initial speeds of the two balls are the same.

(a) Which ball will have the larger speed when it lands? Explain.

(b) Which ball will have the larger average speed for the time interval it is in the air? Explain.

B5. Two projectiles have the same initial speed and spend the same amount of time in the air. What other features of their trajectories must be the same also? Explain.

B6. Create a situation in which the initial positions, initial speeds and the ranges of two projectiles are the same, but the maximum altitudes are different. What else about the two trajectories is different?

Reflection

R1. Does a large range mean that the projectile is in the air a long time? Explain why or why not. If possible, give an example of a situation in which the range is large, but the projectile does not spend very much time in the air.

R2. Does a large maximum altitude mean that the projectile is in the air a long time? Explain why or why not. If possible, give an example of a situation in which the maximum height is large, but the projectile does not spend very much time in the air.

R3. Does a large maximum height mean that the projectile also has a large range? Explain why or why not. If possible, give an example of a situation in which the maximum height is large, but the projectile does not have a very large range.

R4. What kinds of drawings and sketches did you use to help answer the questions in part B? Which were the most helpful?

R5. How far away from its initial position does an object land when it has an initial velocity of (10m/s, 0m/s)? Explain.