Making Sense of Projectile Motion

WhiteBoarding
B2-CT24: Toy Trucks with Different Speeds Rolling from Identical Tables—Time

Two toy trucks roll off the ends of identical tables. The speeds and masses of the trucks are given.

Will Truck A be in the air for (i) a longer time, (ii) a shorter time, or (iii) the same time as Truck B before it reaches the floor? _____

Explain your reasoning.
Two toy trucks roll off the ends of identical tables. The speeds and masses of the trucks are given.

Will Truck A be in the air for (i) a longer time, (ii) a shorter time, or (iii) the same time as Truck B before it reaches the floor? _____

Explain your reasoning.

Answer: the same time because they have the same distance to fall. Both trucks are acted on by gravity, so they will both accelerate downward with the same acceleration $g$. Both trucks have no initial vertical velocity. The time they are in the air depends only on initial height. Mass and horizontal velocity don’t affect the time the trucks are in the air.
Announcement

- Homework 1 is live. It is due Monday at 11:59PM

- Please message me through remind for hw questions during the weekend

- Tips: 1. Do not approximate anything to avoid sig-fig issues. 2. Rationalize denominators (no radicals in the denominator)

- Assessment 2 is next Friday (every 2 weeks; lowest exam, lab report, and hw grades are dropped)
Link to Quest homework: https://quest.cns.utexas.edu/student/courses/list (Please bookmark!)

Unit 1: Kinematics

- Physics Classroom Worksheets - Unit 1
  Download File

- 1-D Kinematics Review Problem Set
- 1-D Kinematics Review Problem Set answers

- Relative Velocity
  Download File

- Relative Motion 2
  Download File

- Horizontal Projectile Motion - Quantitative
  Download File
WhiteBoarding

• Grab two markers
• Grab a towel (eraser)
• Grab a whiteboard
8 Problems
A marble rolls off a table from a height of 0.8 m with a velocity of 3 m/s. Then another marble rolls off the same table with a velocity of 4 m/s. Which values are the same for both marbles?

Justify your answer qualitatively, with no equations or calculations.

A  The final speeds of the marbles.
B  The time each takes to reach the ground.
C  The distance from the base of the table where each lands.
Answers

• A) Not the same. Horizontal velocities are different; Vertical final velocities are the same. Resultant would be different

• B) It takes the same time for both of them to fall (time depends on height, not horizontal motion)

• C) Not the same. After 1 second, ball 1 travels 3m + ball 2 travels 4m, after 2 seconds, ball 1 travels 6m + ball 2 travels 8m, after 3 seconds ball 1 travels 9m + ball 2 travels 12m and so on… Ball 1 is always traveling 3/4 of the distance that Ball 2 is traveling.
B2-WWT08: FALLING ROCK AND THROWN ROCK—VELOCITY-TIME GRAPHS

Rock A is dropped from the top of a cliff at the same instant that Rock B is thrown horizontally away from the cliff. The rocks are identical. A student draws the following graphs to describe part of the motion of the rocks, using a coordinate system in which the positive vertical direction is up, the positive horizontal direction is away from the cliff, and the origin of the coordinate system is the point the rocks were released from.

What, if anything, is wrong with these graphs for the motions of the two rocks? If something is wrong, identify it and explain how to correct it. If the graphs are correct, explain why.
What, if anything, is wrong with these graphs for the motions of the two rocks? If something is wrong, identify it and explain how to correct it. If the graphs are correct, explain why.

The horizontal velocity graphs need to be switched, because Rock A has no horizontal velocity, and Rock B has a constant horizontal velocity. The vertical graph for Rock B is correct for both rocks.
A baseball is thrown from point $S$ in right field to home plate. The dashed line in the diagram shows the path of the ball. Use a coordinate system with up as the positive vertical direction and to the right as the positive horizontal direction, with the origin at the point the ball was thrown from (point $S$).

On the axes below, sketch graphs for the indicated quantities:
(a) The horizontal velocity versus time and the vertical velocity versus time.
**B2-QRT09: Projectile Motion—Velocity-Time and Acceleration-Time Graphs**

A baseball is thrown from point $S$ in right field to home plate. The dashed line in the diagram shows the path of the ball. Use a coordinate system with up as the positive vertical direction and to the right as the positive horizontal direction, with the origin at the point the ball was thrown from (point $S$).

**Explain your reasoning.**

*Answer: Since the positive horizontal direction is to the right, the horizontal velocity will be negative. Since up is the positive vertical direction the ball has a positive initial vertical velocity, which decreases to zero and then becomes negative.*

[Diagram showing velocity-time graphs for horizontal and vertical directions]
A baseball is thrown from point $S$ in right field to home plate. The dashed line in the diagram shows the path of the ball. Use a coordinate system with up as the positive vertical direction and to the right as the positive horizontal direction, with the origin at the point the ball was thrown from (point $S$).

On the axes below, sketch graphs for the indicated quantities:

(b) The horizontal acceleration versus time and the vertical acceleration versus time.
**Explain your reasoning.**

*Answer: Since there is no force in the horizontal direction there will be no horizontal acceleration. The vertical acceleration is negative and equal in magnitude to g.*
B2-QRT10: Projectile Motion for Two Rocks—Velocity-Time and Acceleration-Time Graphs

Two identical rocks are thrown horizontally from a cliff, with Rock A having a greater velocity at the instant it is released than Rock B. Use a coordinate system with down as the positive vertical direction, away from the cliff as the positive horizontal direction, and with the origin of the coordinate system at the bottom of the cliff directly below the release point.

(a) Sketch the velocity versus time graphs for each of the rocks.

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**Rock A (faster)**

- **v (horizontal)**
- **v (vertical)**
- **time**

**Rock B (slower)**

- **v (horizontal)**
- **v (vertical)**
- **time**
Rock A (faster)

- $v$ (horizontal)
- $v$ (vertical)

Rock B (slower)

- $v$ (horizontal)
- $v$ (vertical)
Two identical rocks are thrown horizontally from a cliff, with Rock A having a greater velocity at the instant it is released than Rock B. Use a coordinate system with down as the positive vertical direction, away from the cliff as the positive horizontal direction, and with the origin of the coordinate system at the bottom of the cliff directly below the release point.

(b) Which rock hits the ground first? Explain your reasoning.

(c) Which rock lands farthest from the base of the cliff? Explain your reasoning.
(b) Which rock hits the ground first?

*Explain your reasoning.*

*Both hit at the same time. Both rocks have the same vertical acceleration and travel the same vertical distance.*

(c) Which rock lands farthest from the base of the cliff?

*Explain your reasoning*

*Rock A, the faster rock.*

*There are no forces in the horizontal direction (ignoring air resistance) so both rocks will have a constant horizontal velocity. Since Rock B is slower than Rock A, it will have a smaller horizontal velocity. Both rocks are thrown horizontally, so they have no initial vertical velocity. Both are acted on by gravity, so the slopes of their vertical velocity graphs are constant and equal to g, and both are positive because gravity is acting down and the positive direction is defined as down. Both rocks hit at the same time but rock A hits farther from the cliff since it travels faster in the horizontal direction.*
B2-QRT11: BASEBALL PROJECTILE MOTION—VELOCITY-TIME AND ACCELERATION-TIME GRAPHS
A baseball is thrown from point $S$ in right field to home plate. The dashed line shows the path of the ball.

Use a coordinate system with up as the positive vertical direction and to the left as the positive horizontal direction, and with the origin at home plate.

Sketch the graph for the following:
(i) horizontal velocity versus time graph. Explain your reasoning.
(ii) horizontal acceleration versus time graph. Explain your reasoning.
(iii) vertical velocity versus time graph. Explain your reasoning.
(iv) vertical acceleration versus time graph. Explain your reasoning.
Answer: (1) A; (2) C; (3) I; and (4) B.
There are no horizontal forces (neglecting air resistance) and the ball will have no horizontal acceleration, so the horizontal velocity will be constant. The positive direction is to the left, so the horizontal velocity will be positive. Since up is positive, the initial vertical velocity is positive, and the final vertical velocity is negative. The only vertical force is gravity acting downward, and so the acceleration is constant, negative, and equal in magnitude to g. Since the acceleration is constant, the slope of the velocity must be constant, so the vertical velocity must be a straight line sloping downward from its initial positive value to its final negative value.
B2-CRT12: PROJECTILE MOTION FOR TWO ROCKS—VELOCITY-TIME GRAPHS

Two students throw two rocks horizontally from a cliff with different velocities. Both rocks hit the water below at the same time, but Rock B hits farther from the base of the cliff. Use coordinates where up is the positive direction, away from the cliff is the positive horizontal direction, and the origin is at the top of the cliff at the point of release.

Sketch below the velocity versus time graphs for each rock.

Rock A (closer)

Rock B (farther)

Explain your reasoning.
Explain your reasoning.

Answer: There are no forces in the horizontal direction (ignoring air resistance) so both rocks will have a constant horizontal velocity. Since Rock B lands farther away from the cliff than Rock A, it must have had a larger horizontal velocity. Both rocks are thrown horizontally, so they have no initial vertical velocity. Both are acted on by gravity, so the slopes of their vertical velocity graphs are constant equal to g, and both slopes are negative because gravity is acting down and the positive direction is defined as up.
B2-CRT13: PROJECTILE MOTION FOR TWO ROCKS—ACCELERATION-TIME GRAPHS

Two students throw two rocks horizontally from a cliff with different velocities. Both rocks hit the water below at the same time, but Rock B hits farther from the base of the cliff. Use coordinates where up is the positive direction, away from the cliff is the positive horizontal direction, and the origin is at the top of the cliff at the point of release.

Sketch the acceleration versus time graphs for each rock.

**Rock A** (closer)
- **a** (horizontal)
- **a** (vertical)

**Rock B** (farther)
- **a** (horizontal)
- **a** (vertical)

Explain your reasoning.
Answer: There are no forces in the horizontal direction (ignoring air resistance) so both rocks will have zero horizontal acceleration. Both are acted on by gravity, so both have a constant downward (negative, since the positive direction is defined as up) acceleration equal to $g$. 
**B2-LMCT14: Dropped Practice Bomb—Horizontal Distance Traveled**

An airplane is flying 1200 m above the ground at a speed of 200 m/s. It drops a practice bomb that hits the ground after traveling a horizontal distance of 3130 m.

For each of the changes below, use the choices below (i)-(v) to identify what will happen to the horizontal distance the bomb travels while falling compared to the situation above.

(i) The horizontal distance will be **greater than** 3130 m.
(ii) The horizontal distance will be **less than** 3130 m but not zero.
(iii) The horizontal distance will be **equal** to 3130 m.
(iv) The horizontal distance will be **zero** (the bomb will drop straight down).
(v) **We cannot determine** how this change will affect the horizontal distance.

For each of the following changes, only the feature(s) identified is(are) modified from the given situation above.

(a) The plane’s speed is tripled. ____  
(b) The plane is climbing straight up at the release point. ____  
Explain your reasoning.

(c) The plane is flying in level flight at an altitude of 1,100 m. ____  
(d) The mass of the bomb is increased. ____  
Explain your reasoning.

(e) The bomb is thrown from the plane with a vertical downward velocity of 15 m/s. ____  
Explain your reasoning.
(a) The plane’s speed is tripled. _____
Explain your reasoning.
   A: The time it takes to hit the ground is the same, but the bomb has a greater horizontal velocity.

(b) The plane is climbing straight up at the release point. _____
Explain your reasoning.
   D: Since there is no horizontal velocity it will come straight back down if it misses the plane.

(c) The plane is flying in level flight at an altitude of 1,100 m. _____
Explain your reasoning.
   B: It will take less time to reach the ground from a lower height, and the horizontal speed is the same.

(d) The mass of the bomb is increased. _____
Explain your reasoning.
   C: The vertical acceleration is still g and is independent of the mass, so the path the bomb takes will remain the same.

(e) The bomb is thrown from the plane with a vertical downward velocity of 15 m/s. _____
Explain your reasoning.
   B: The acceleration of the bomb is the same, but with an initial downward vertical velocity it will reach the ground faster, and so will travel less horizontal distance.
B2-CT23: Toy Trucks Rolling from Tables with Different Heights—Time
Two toy trucks roll off the ends of tables. The heights of the tables, the speeds of the trucks, and the masses of the trucks are given.

Will Truck A be in the air for (i) a longer time, (ii) a shorter time, or (iii) the same time as Truck B before it reaches the floor? ______

Explain your reasoning.
B2-CT23: TOY TRUCKS ROLLING FROM TABLES WITH DIFFERENT HEIGHTS—TIME

Two toy trucks roll off the ends of tables. The heights of the tables, the speeds of the trucks, and the masses of the trucks are given.

Will Truck A be in the air for (i) a longer time, (ii) a shorter time, or (iii) the same time as Truck B before it reaches the floor?

Explain your reasoning.

Answer: a shorter time because it has a smaller distance to fall. Both trucks are acted on by gravity, so they will both accelerate downward with the same acceleration g. Both trucks have no initial vertical velocity. The time they are in the air depends only on initial height. Mass and horizontal velocity don’t affect the time the trucks are in the air.