

Falling Balls

Introductory Question

- Suppose I throw a ball upward into the air. After the ball leaves my hand, is there any force pushing the ball upward?

- A. Yes
- B. No

Observations about Falling Balls

- When you drop a ball, it
 - begins at rest, but acquires downward speed
 - covers more and more distance each second
- When you tossed a ball straight up, it
 - rises to a certain height
 - comes briefly to a stop
 - begins to descend, much like a dropped ball
- A thrown ball travels in an arc

5 Questions about Falling Balls

- Why does a dropped ball fall downward?
- Do different balls fall at different rates?
- Would a ball fall differently on the moon?
- Can a ball move upward and still be falling?
- Does a ball's horizontal motion affect its fall?

Question 1

- Why does a dropped ball fall downward?
 - What is gravity doing to the ball?

Gravity and Weight

- Gravity exerts a force on the ball
- That force is the ball's weight
- Since earth's gravity produces the ball's weight, that weight points toward the earth's center
- The ball's weight causes it to accelerate toward the earth's center (i.e., downward)

Question 2

- Do different balls fall at different rates?
 - If different balls have different weights and different masses, is there any relationship between their accelerations as they fall?

Weight and Mass

- A ball's weight is proportional to its mass
weight/mass = constant
- On earth's surface,
 - weight/mass = 9.8 newtons/kilogram
 - is the same for all balls (or other objects)
 - is called "acceleration due to gravity"

Acceleration Due to Gravity

- Why this strange name?
 - weight/mass → force/mass = acceleration
- Acceleration due to gravity is an acceleration!
9.8 newtons/kilogram = 9.8 meter/second²
- On earth's surface, all falling balls accelerate downward at 9.8 meter/second²
- Different balls fall at the same rate!

Clicker Question

- If we could eliminate air resistance, would a light sheet of paper and a heavy book fall at the same rate?
- A. Yes
B. No

Question 3

- Would a ball fall differently on the moon?
 - Yes!
 - Moon's acceleration due to gravity is different!

Question 4

- Can a ball move upward and still be falling?
 - How does falling affect a ball's
 - acceleration?
 - velocity?
 - position?

A Falling Ball (Part 1)

- A falling ball accelerates downward steadily
 - Its acceleration is constant and downward
 - Its velocity increases in the downward direction
- When falling from rest (stationary), its
 - velocity starts at zero and increases downward
 - altitude decreases at an ever faster rate

Falling Downward

Position	Fall time	Velocity	Acceleration
0 m	0 s	0 m/s	$\downarrow -9.8 \text{ m/s}^2$
-4.9 m	1 s	$\downarrow -9.8 \text{ m/s}$	$\downarrow -9.8 \text{ m/s}^2$
-19.6 m	2 s	$\downarrow -19.6 \text{ m/s}$	$\downarrow -9.8 \text{ m/s}^2$
-44.1 m	3 s	$\downarrow -29.4 \text{ m/s}$	$\downarrow -9.8 \text{ m/s}^2$

A Falling Ball (Part 2)

- A falling ball can start by heading upward!
 - Its velocity starts in the upward direction
 - Its velocity becomes less and less upward
 - Its altitude increases at an ever slower rate
 - At some point, its velocity is momentarily zero
 - Its velocity becomes more and more downward
 - Its altitude decreases at ever faster rate

Falling Upward First

Position	Fall time	Velocity	Acceleration
44.1 m	3 s	0 m/s	$\downarrow 9.8 \text{ m/s}^2$
39.2 m	2 s	$\uparrow 9.8 \text{ m/s}$	$\downarrow 9.8 \text{ m/s}^2$
24.5 m	1 s	$\uparrow 19.6 \text{ m/s}$	$\downarrow 9.8 \text{ m/s}^2$
0 m	0 s	$\downarrow 29.4 \text{ m/s}$	$\downarrow 9.8 \text{ m/s}^2$

Clicker Question

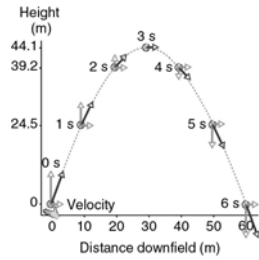
- You jump upward from a springboard and dive gracefully into the pool. At the peak of your jump, your velocity is
 - A. changing, but your acceleration is constant.
 - B. constant, and your acceleration is constant.
 - C. constant, but your acceleration is changing.
 - D. changing, and your acceleration is changing.

Question 5

- Does a ball's horizontal motion affect its fall?
- Why does a thrown ball travel in an arc?

Throws and Arcs

- Gravity only affects only the ball's vertical motion
- A ball coasts horizontally while falling vertically



Introductory Question (revisited)

- Suppose I throw a ball upward into the air. After the ball leaves my hand, is there any force pushing the ball upward?
- A. Yes
B. No

Summary About Falling Balls

- Without gravity, a free ball would coast
- With gravity, an otherwise free ball
 - experiences its weight,
 - accelerates downward,
 - and its velocity becomes increasingly downward
- Whether going up or down, it's still falling
- Its horizontal coasting motion is independent of its vertical falling motion