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
  \[ \text{weight/mass} = \text{constant} \]
- On earth’s surface,
  \[ \text{weight/mass} = 9.8 \text{ newtons/kilogram} \]
  - is the same for all balls (or other objects)
  - is called “acceleration due to gravity”

Acceleration Due to Gravity
- Why this strange name?
  \[ \text{weight/mass} \rightarrow \text{force/mass} = \text{acceleration} \]
- Acceleration due to gravity is an acceleration!
  \[ 9.8 \text{ newtons/kilogram} = 9.8 \text{ meter/second}^2 \]
- On earth’s surface, all falling balls accelerate downward at 9.8 meter/second^2
- 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

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

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