

Falling Balls

Question:

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

Observations About Falling Balls

- A dropped ball:
 - Begins at rest, but acquires downward speed
 - Covers more and more distance each second
- A tossed ball:
 - Rises to a certain height
 - Comes briefly to a stop
 - Begins to descend, much like a dropped ball

Type of Force

- Weight – earth's gravitational force on object

Weight and Mass

- Object's weight is proportional to its mass
 - weight \propto mass
 - weight = constant \cdot mass
- On the Earth's surface, that constant is
 - 9.8 newtons/kilogram
 - called *acceleration due to gravity*

Acceleration Due to Gravity

- Why this strange name?
 - force = mass \cdot acceleration (Newton's 2nd law)
 - 1 newton \equiv 1 kilogram-meter/second² (definition)
 - 9.8 newtons/kilogram = 9.8 meter/second²
 - 9.8 meter/second² is an acceleration!
 - *Acceleration due to gravity* actually is an acceleration!
- On Earth's surface, all falling objects accelerate downward at *the acceleration due to gravity*!

Why Things Fall Together

- Increasing an object's mass
 - increases the downward force on it
 - makes it need more force to accelerate
- These effects balance out perfectly

A Falling Ball

- Falling ball accelerates downward steadily
 - Acceleration is constant and downward
 - Velocity increases in the downward direction
- Falling from rest (stationary):
 - 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

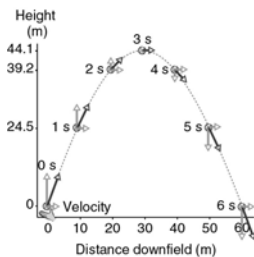
- A falling ball can start by heading upward!
 - Velocity starts in the upward direction
 - Velocity becomes less and less upward
 - Altitude increases at an ever slower rate
 - At some point, velocity is momentarily zero
 - Velocity becomes more and more downward
 - Altitude decreases at ever faster 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	$\uparrow 29.4 \text{ m/s}$	$\downarrow 9.8 \text{ m/s}^2$

Throws and Arcs

- Gravity only affects vertical motion
- A ball can coast horizontally while falling vertically



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Summary About Falling Balls

- A free ball experiences only gravity
 - Its inertia tends to make it go straight
 - But its weight makes it accelerate downward
 - Its velocity becomes increasingly downward
- Whether going up or down, it's still falling
- Horizontal motion is independent of falling