

**University of Virginia**

**Department of Physics**

Physics 606: How Things Work II

Lecture #3 Slides:

**Falling Balls II**

## Weight and Mass

- An 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/second<sup>2</sup> (definition)
  - 9.8 newtons/kilogram = 9.8 meter/second<sup>2</sup>
  - 9.8 meter/second<sup>2</sup> 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 steadily downward
  - Its acceleration is constant and downward
  - Its 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	↓ -9.8 m/s <sup>2</sup>
-4.9 m	1 s	↓ -9.8 m/s	↓ -9.8 m/s <sup>2</sup>
-19.6 m	2 s	↓ -19.6 m/s	↓ -9.8 m/s <sup>2</sup>
-44.1 m	3 s	↓ -29.4 m/s	↓ -9.8 m/s <sup>2</sup>

## A Falling Ball, Part 2

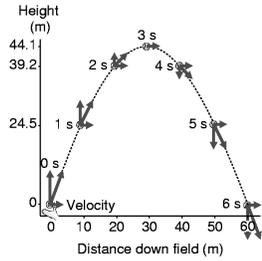
- A falling ball can start by heading upward!
  - Velocity starts in the upward direction
  - Velocity becomes less and less upward
  - Altitude increases at an ever slower rate
  - At some point, velocity is momentarily zero
  - Velocity becomes more and more downward
  - Altitude decreases at ever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

## Falling Upward First

44.1 m	3 s	0 m/s	9.8 m/s <sup>2</sup>
39.2 m	2 s	9.8 m/s	9.8 m/s <sup>2</sup>
24.5 m	1 s	19.6 m/s	9.8 m/s <sup>2</sup>
0 m	0 s	29.4 m/s	9.8 m/s <sup>2</sup>
Position	Fall time	Velocity	Acceleration

## Throws and Arcs

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



## Question:

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

## Ramps

## Question:

Can a ball ever push downward on a table with a force greater than the ball's weight?

## Observations About Ramps

- Lifting an object straight up is often difficult
- Pushing the object up a ramp is usually easier
- The ease depends on the ramp's steepness
- Shallow ramps require only gentle pushes
- You seem to get something for nothing
- How does distance figure in to the picture?

## Type of Force

- Support force
  - Prevents something from penetrating a surface
  - Points directly away from that surface

## Physics Concept

- Net Force
  - The sum of all forces on an object.
  - Determines object's acceleration.