# Falling Balls

Turn off all electronic devices



## Observations about Falling Balls

When you drop a ball, it
- begins at rest,
- soon acquires a considerable downward speed,
- and covers more and more distance each second

When you tossed a ball straight up, it
- rises to a certain height,
- comes momentarily to a stop,
- and then descends, much like a dropped ball

A thrown ball travels in an arc



## 6 Questions about Falling Balls

1. Why does a dropped ball fall downward?
2. How differently do different balls fall?
3. How would a ball fall on the moon?
4. How does a falling ball move after it is dropped?
5. How can a ball move upward and still be falling?
6. How does a ball's horizontal motion affect its fall?



## Question 1

Q: Why does a dropped ball fall downward?
A: The ball's downward weight causes it to accelerate downward

Earth's gravity exerts a downward force on the ball
- That force on the ball due to Earth's gravity is called the ball's weight
- The ball's weight points toward earth's center (it defines <u>downward</u>)

A falling ball experiences only one force: its weight

A falling ball's weight causes it to accelerate downward



## Question 2

Q: How differently do different balls fall?
A: Not differently. They all fall together!

A ball's weight is proportional to its mass
- When you divided a ball's weight by its mass, you always get the same value:

$$\frac{\text{weight of ball}}{\text{mass of ball}} = 9.8\ \frac{\text{newtons}}{\text{kilogram}}$$

- Near Earth's surface, every kilogram of mass weighs 9.8 newtons!



## Acceleration Due to Gravity

According to Newton's second law,

$$\text{acceleration of ball} = \frac{\text{net force on ball}}{\text{mass of ball}}$$

The only force acting on a falling ball is its weight,

$$\text{acceleration of falling ball} = \frac{\text{weight of ball}}{\text{mass of ball}} = 9.8\ \frac{\text{newtons}}{\text{kilogram}}$$

That ratio *is* the acceleration of *any* falling object near Earth's surface!

It is called the <u>acceleration due to gravity</u>

$$\text{acceleration due to gravity} = 9.8\ \frac{\text{newtons}}{\text{kilogram}} = 9.8\ \frac{\text{meters}}{\text{second}^2}$$

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## Question 3

Q: How would a ball fall on the moon?

A: It would fall more slowly.

Gravity depends on <u>mass of planet/moon</u> and <u>distance from its center</u>

- Moon's mass is small, but its radius is also small, so

$$\text{acceleration due to moon's gravity} = 1.6\ \frac{\text{meters}}{\text{second}^2}$$

Earth's gravity actually varies slightly with location

- You weigh slightly less at the Equator than at the North or South Pole
- You weigh very slightly less on a mountaintop than in a valley

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## Question 4

Q: How does a falling ball move after it is dropped?

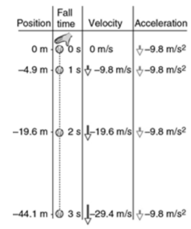
A: It accelerates downward, covering more distance each second

A falling ball experiences only its weight

- Acceleration is constant and downward
- Velocity increases in the downward direction

When dropped from rest,

- the ball's velocity starts at zero and increases in the downward direction
- the ball's altitude decreases at an ever faster rate

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## Question 5

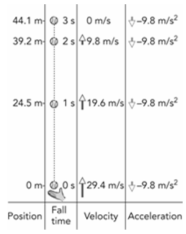
Q: How can a ball move upward and still be falling?

A: It may be moving upward, but it is still accelerating downward!

A falling ball accelerates downward, but its initial velocity can be anything, even upward!

When thrown upward,

- ball's velocity starts upward but increases downward
- ball's altitude increases at an ever slower rate until…
- velocity is <u>momentarily</u> zero
- and then ball falls downward…

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## Question 6

Q: How does a ball's horizontal motion affect its fall?

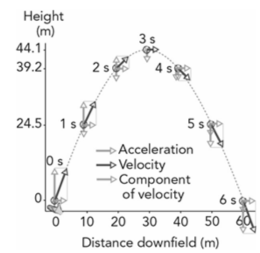
A: It doesn't. The ball falls vertically, but coasts horizontally.

Ball's acceleration is purely vertical (downward)

It falls vertically

It coasts horizontally

Its path is a parabolic arc

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## Summary About Falling Balls

Without gravity, an isolated ball would coast

With gravity, an isolated ball

- experiences its weight,
- accelerates downward,
- and its velocity becomes increasingly downward

Whether going up or down, it's still falling

It can coast horizontally while falling vertically