

Welcome to Physics First I Cycle 2

Lesson 3

OBJECTIVE: Describe the motion of an object in free fall. Calculate speed and distance for an object in free fall.

VOCAB: free fall, acceleration due to gravity, velocity

CLASSWORK:

Section 2.3 “Understanding Vocabulary” (p. 54 #8-10)

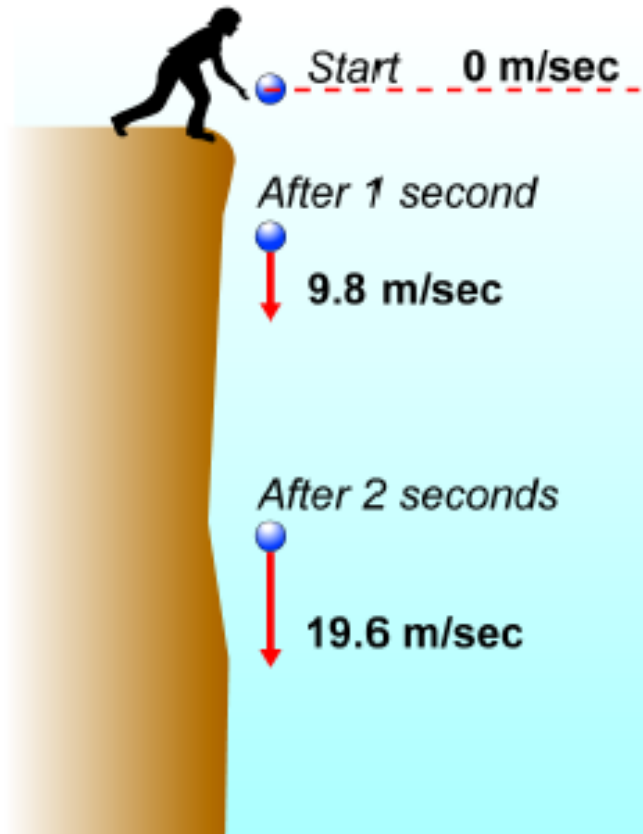
Section 2.3 “Reviewing Concepts” (p. 54 #13-15, p. 55 #16-17)

Section 2.3 “Solving Problems” (p. 55 #9 (a,b,c))

What happens to a falling object?

- An object in **Free Fall** has constant _____
- Imagine you drop something. At the instant you drop it, is it moving?
- When it hits the floor, is it moving?
- Now describe the motion using terms we have learned. Change in velocity is _____

An object in Free Fall



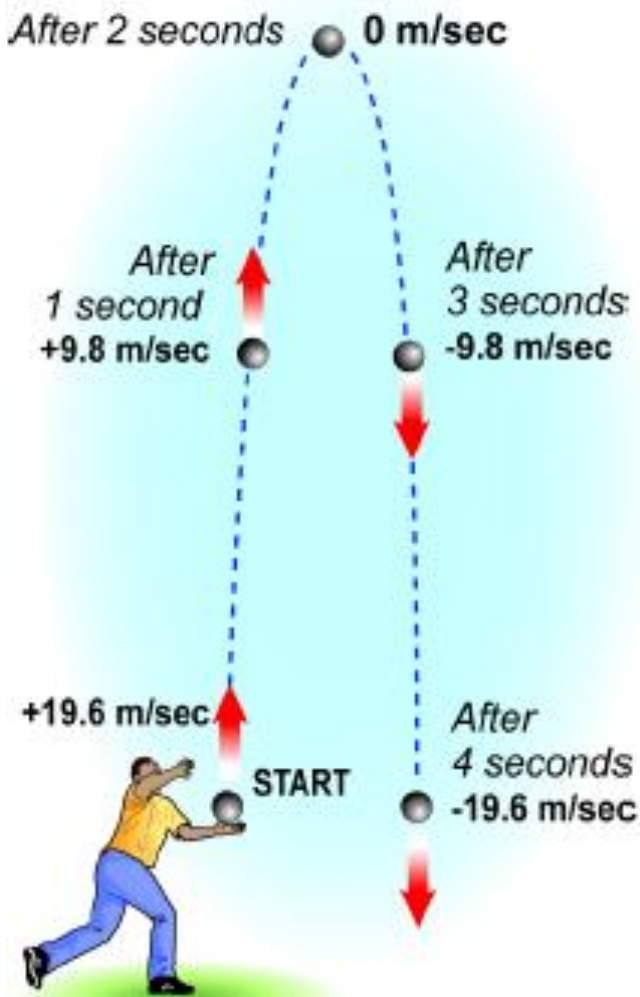
An object is in **free fall** if it is accelerating due to the force of gravity and no other forces are acting on it.

Objects in **free fall** on Earth accelerate downward at 9.8 m/sec^2 , the **acceleration due to gravity**.

A dropped baseball is in free fall from the instant it leaves your hand until it reaches the ground.

DISCUSSION: What happens if you toss a baseball straight upward? Is it in free fall at any time?

Upward Launch of a Projectile



Time (sec)	Velocity (m/sec)
0.0	19.60
1.0	9.80
2.0	0.00
3.0	-9.80
4.0	-19.60

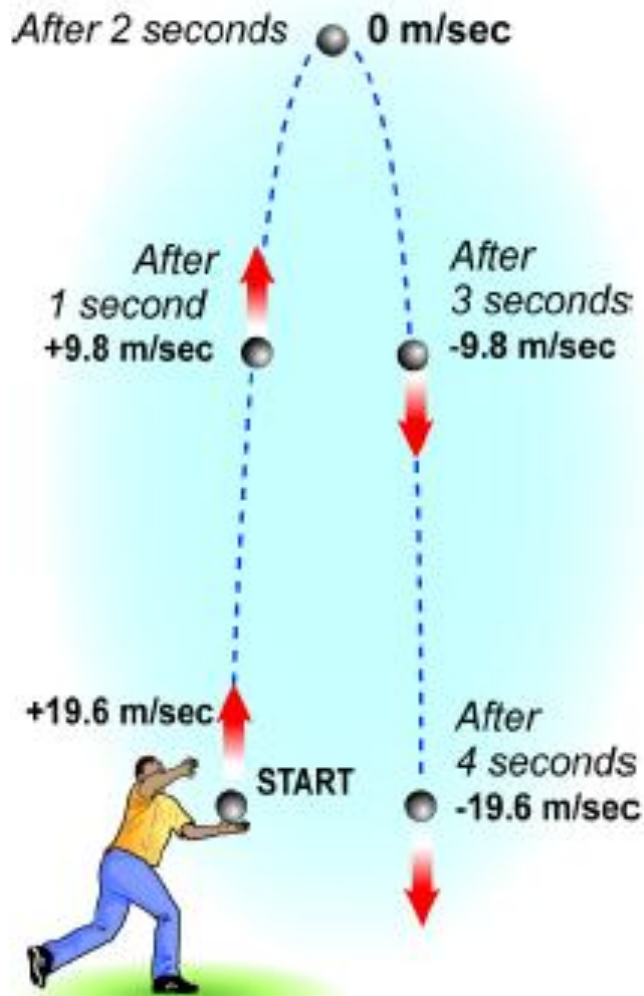
The ball slows down as it rises and speeds up as it falls, but the acceleration is **constant**.

The whole time the ball is in the air, it accelerates downward at 9.8 m/sec^2 , the **acceleration due to gravity**.

The ball appears motionless at the top of the trajectory.

DISCUSS: What is zero at the top? Velocity, or acceleration?

The Acceleration of Gravity, 'g'



Time (sec)	Velocity (m/sec)
0.0	19.60
1.0	9.80
2.0	0.00
3.0	-9.80
4.0	-19.60

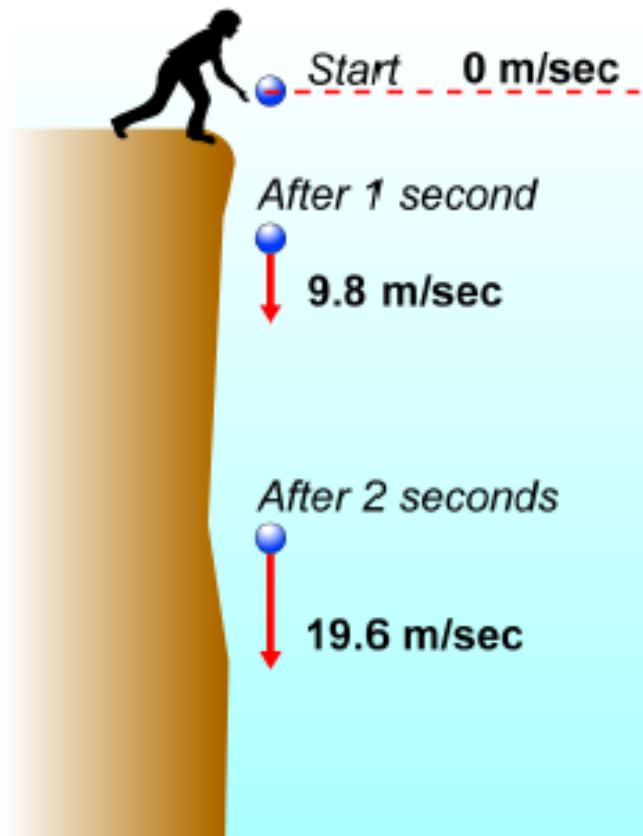
'g' is the **acceleration due to gravity**.

'g' = **9.8 m/sec² (or about 32 ft/sec²)**

Earth's gravity varies from place to place but this is mostly accurate.

DISCUSS: Every second that an object is in free fall, the velocity changes by ???

Formula for Velocity of a Falling Object



If an object is dropped starting from **rest** (speed of 0 m/sec), the velocity can be found by:

FREE FALL SPEED
(starting at rest)

$$\text{Speed (m/sec)} \rightarrow v = gt \leftarrow \text{Time (sec)}$$

Acceleration due to gravity (m/sec²)

$$V = gt$$

@ 1 second, $V = 9.8 \text{ m/sec}^2 * 1 \text{ sec} = 9.8 \text{ m/sec}$

@ 2 sec, $V = 9.8 \text{ m/sec}^2 * 2 \text{ sec} = 19.6 \text{ m/sec}$

What if object is launched at original velocity V_i ?
Then $V = gt + V_i$

DISCUSS: How long must an object fall to obtain a speed of 100 m/sec?

Average Velocity of a Falling Object

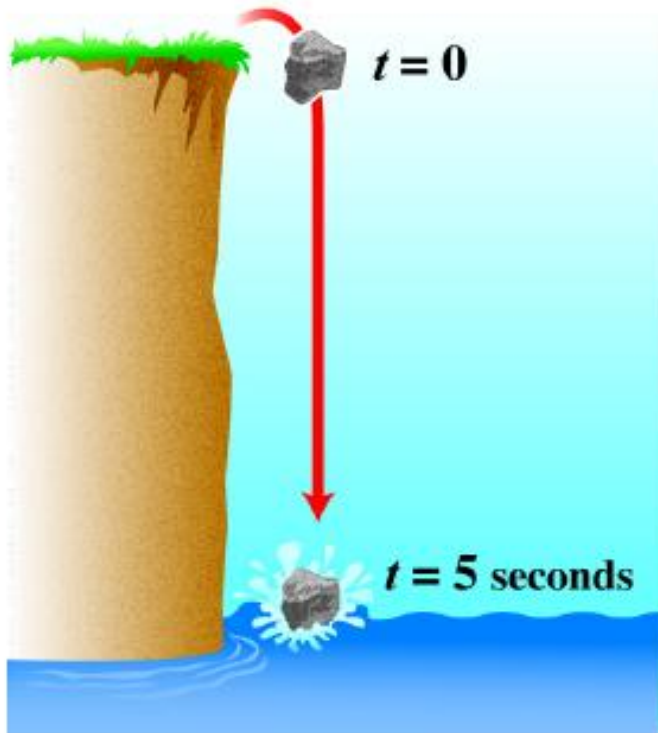


Figure 2.13: What is the average speed of a rock that falls for 5 seconds?

AVERAGE SPEED

$$\text{Average speed (m/sec)} \rightarrow V_{avg} = \frac{\overset{\text{Final speed (m/sec)}}{v_f} + \overset{\text{Initial speed (m/sec)}}{v_i}}{2}$$

$$V_{avg} = (V_f + V_i) / 2$$

Find the average velocity of this rock.

V_i is the initial velocity. Assuming the rock is dropped from rest,

$$V_i = 0 \text{ m/sec}$$

V_f is the final velocity. By $V = gt$,

$$V_f = 5 \text{ sec} * 9.8 \text{ m/sec}^2 = 49 \text{ m/sec}$$

$$V_{avg} = (V_f + V_i) / 2 = (49 \text{ m/sec} - 0) / 2$$

$$V_{avg} = 24.5 \text{ m/sec}$$

Average Velocity of a Falling Object

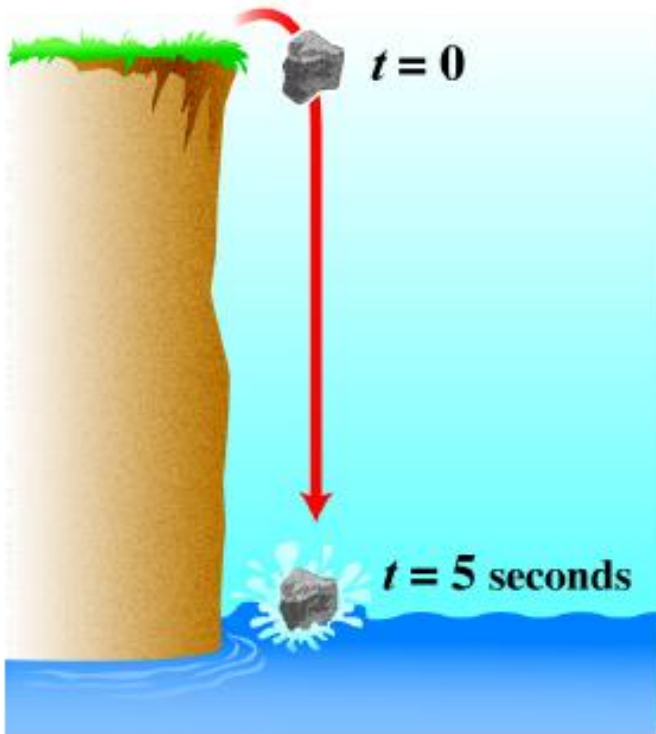


Figure 2.13: What is the average speed of a rock that falls for 5 seconds?

AVERAGE SPEED

$$\text{Average speed (m/sec)} \rightarrow V_{avg} = \frac{v_f + v_i}{2}$$

Final speed (m/sec)
Initial speed (m/sec)

What is the average speed of a baseball dropped from rest that falls for 2 seconds?

9.8 m/sec

What is the average speed of a ball with an initial downward speed of 10 m/sec that falls for 2 seconds?

14.8 m/sec

Distance Travelled by a Falling Object

FREE FALL DISTANCE

$$\text{Distance (m)} \rightarrow d = \overset{\text{Average speed (m/sec)}}{v_{avg}} \overset{\text{Time (sec)}}{t}$$

Formulas: $V_f = gt$ $V_{avg} = (V_f + V_i) / 2$ $d = V_{avg}t$

A skydiver falls for 6 seconds before opening her parachute. Calculate her actual speed at the 6-second mark and the distance she has fallen in this time.

$$V_f = 9.8 \text{ m/sec}^2 * 6 \text{ sec} = 58.8 \text{ m/sec}$$

$$V_i = 0 \text{ m/sec (why?)}$$

$$V_{avg} = (58.8 \text{ m/sec} - 0 \text{ m/sec}) / 2 = 29.4 \text{ m/sec}$$

$$d = 29.4 \text{ m/sec} * 6 \text{ sec} = 176.4 \text{ m}$$

Distance Travelled by a Falling Object

FREE FALL DISTANCE

$$\text{Distance (m)} \rightarrow d = \overset{\text{Average speed (m/sec)}}{v_{avg}} \overset{\text{Time (sec)}}{t}$$

Formulas: $v_f = gt$ $v_{avg} = (v_f + v_i) / 2$ $d = v_{avg}t$

Calculate the final speed and the total distance fallen by a skydiver who waits only 4 seconds to open their parachute.

39.2 m/sec , 78.4 m

An apple falls from the top branch of a tree and lands on the ground 1 second later. How tall is the tree?

4.9 m