Motion

Chapter 11

What Produces Motion?

WARM-UP

THINK ABOUT IT

A sprinter was timed running “all out” over three distances as shown in the data table. Calculate the speed for each trial and then make a statement about the velocities:

Distance (m)	Time (s)	Speed (d/t) in m/s
3 m	1.5 s	
10 m	3.3 s	
20 m	4.0 s	

What Produces Motion?

WARM-UP

THINK ABOUT IT

A sprinter was timed running "all out" over three distances as shown in the data table. Calculate the speed for each trial and then make a statement about the velocities:

Distance (m)	Time (s)	Speed (d/t) in m/s
3 m	1.5 s	2.0 m/s
10 m	3.3 s	3.0 m/s
20 m	4.0 s	5.0 m/s

v = d/t = 3 m / 1.5 s = 2.0 m/s

v = d/t = 10 m / 3.3 s = 3.0 m/s

v = d/t = 20 m / 4.0 s = 5.0 m/s

Velocity was not constant, but increased with each distance.

What are the types of Velocity?

What are the types of Velocity?

Constant → no change in velocity (balanced force) e.g. cruise control

Instantaneous → velocity at a given point in time

Average → total distance / total time …
e.g. used in gps of vehicles

Focus Questions

LESSON QUESTION

1. Describe how motion is produced.
2. Explain what is meant by relative motion and factors involved.
3. Distinguish between speed and velocity and know how to calculate both. Describe the types of speed and velocity.
4. Define and calculate acceleration, acceleration due to gravity, and free fall.

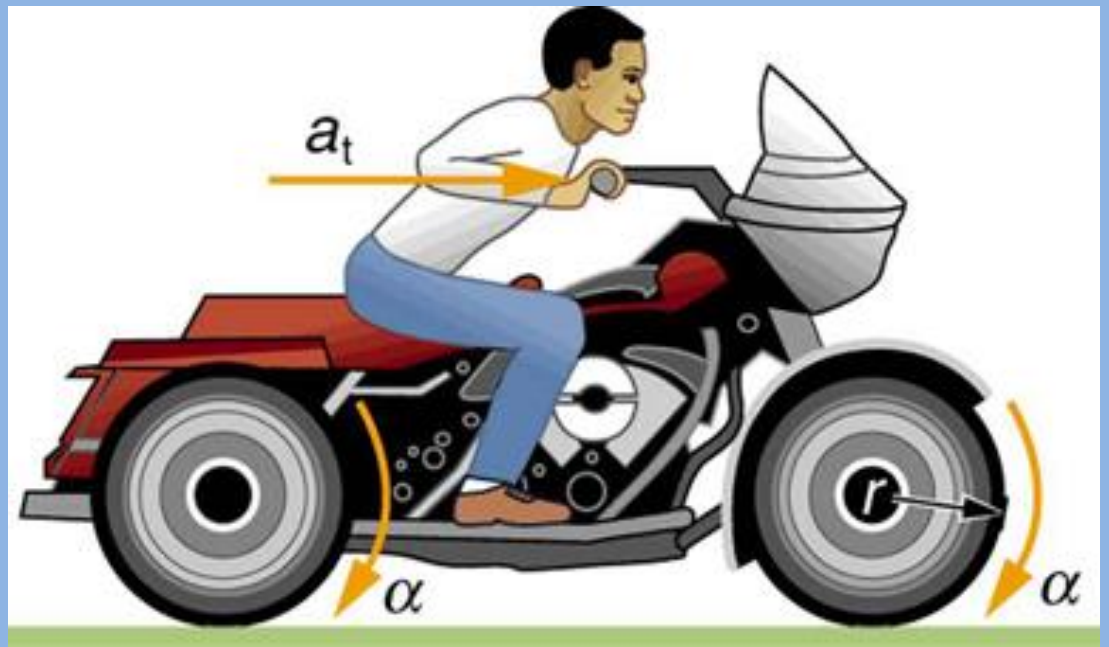
Acceleration

An unbalanced force produces a *change in motion*.

Motion is related to speed or velocity … therefore, an unbalanced force produces a ***change*** *in speed or velocity.*

This is called acceleration.

$$a = \Delta v/t$$



Acceleration

A change in speed over time → rate of change of motion

1. slowing down or speeding up
2. keeping the same speed but changing direction
3. circular / rotational motion (centripetal force)

   e.g. *going around a corner on a roller coaster*

Acceleration

A change in speed over time → rate of change of motion

1. slowing down or speeding up
2. keeping the same speed but changing direction
3. circular / rotational motion (centripetal force)

   e.g. *going around a corner on a roller coaster*

DEMO: roll a Hula hoop down the hall with "reverse acceleration" … it will return to you. (video)

Reverse spin a Hula hoop, meaning its velocity is in one direction while its acceleration is in a different direction. The circular motion, of the Hula hoop also causes an "inward" acceleration due to centripetal force.

http://somup.com/cFXh0in1ky

- Motion in Two Directions ctr (0:25)

Acceleration

Acceleration is a vector quantity, meaning you must designate DIRECTION as well as magnitude.

Force and motion (velocity) must be in the same direction, but acceleration and motion (velocity) do not have to be.

e.g. a car can be moving forward due to the engine's force (same direction), but if the break is applied it would decelerate or have negative acceleration (opposite direction).

Acceleration

Acceleration is a vector quantity, meaning you must designate DIRECTION as well as magnitude.

Force and motion (velocity) must be in the same direction, but acceleration and motion (velocity) do not have to be.

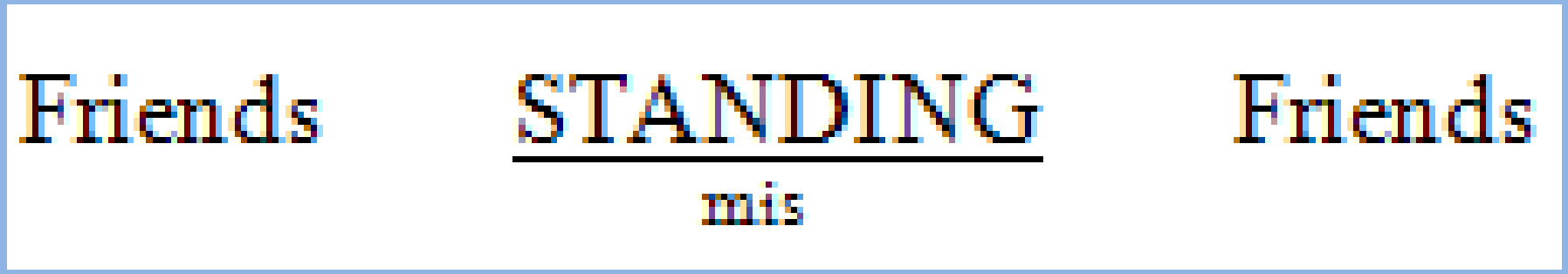
e.g. a car can be moving forward due to the engine's force (same direction), but if the break is applied it would decelerate or have negative acceleration (opposite direction).

http://somup.com/cFXh0Vn1kU

Motion in Different Directions (0:20)

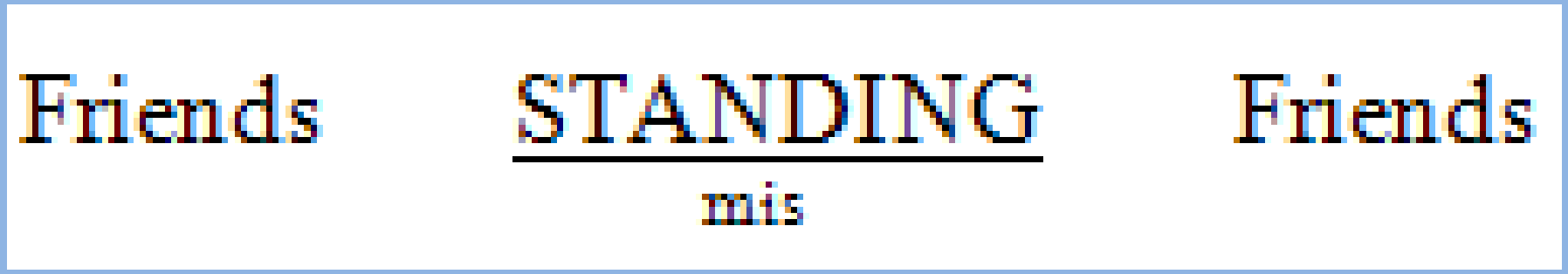
Velocity versus Acceleration

Handling Equations



You the past

Handling Equations



" A little misunderstanding between friends"

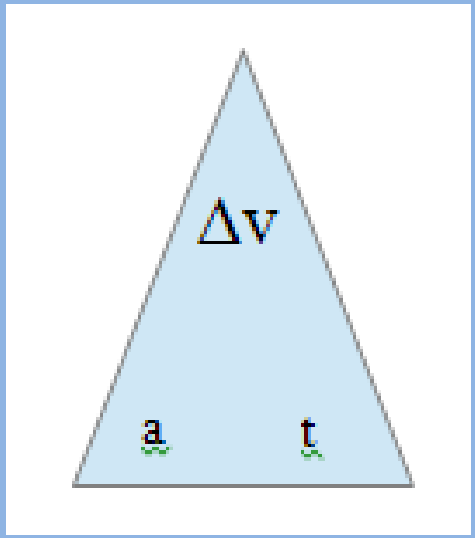
You the past

" put the past behind you"

EQUATIONS: Once you find the pattern, it's easy to figure out.

Calculating Acceleration

Acceleration (a), change in velocity (Δv), and time (t) can be calculated depending on the variable given.



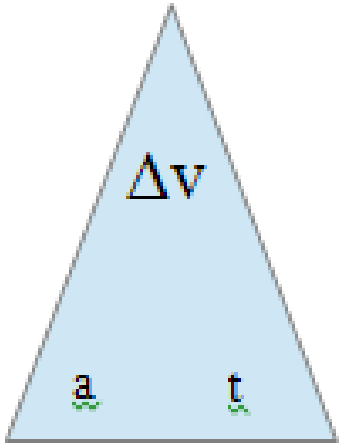
Calculating Acceleration

Acceleration (a), change in velocity (Δv), and time (t) can be calculated depending on the variable given.

$a = \Delta v / t$

$\rightarrow \Delta v = a\,t$

$\rightarrow t = \Delta v / a$



Acceleration (a) includes a change in velocity (Δv)

$$a = \frac{v_f - v_i}{t}$$

v_f = final velocity

v_i = initial velocity

Calculating Acceleration

An Indy 500 race car's velocity increases from +4.0 m/s to +36 m/s over a 4.0 s period. What is the acceleration?

$$a = \frac{v_f - v_i}{t}$$

Find the uniform acceleration that causes a car's velocity to change from 32 m/s to 96 m/s in an 8.0 s period.

Calculating Acceleration

An Indy 500 race car's velocity increases from +4.0 m/s to +36 m/s over a 4.0 s period. What is the acceleration?

$$a = \frac{\Delta v}{\Delta t} = \frac{(36\ \text{m/s} - 4.0\ \text{m/s})}{(4.0\ \text{s})} = 8.0\ \text{m/s}^2$$

$$a = \frac{v_f - v_i}{t}$$

Find the uniform acceleration that causes a car's velocity to change from 32 m/s to 96 m/s in an 8.0 s period.

$$a = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{\Delta t} = \frac{96\ \text{m/s} - 32\ \text{m/s}}{8.0\ \text{s}} = 8.0\ \text{m/s}^2$$

Acceleration Problems Worksheet

- Download the Acceleration Problems Worksheet
- Work on problems together

Gravity

TRY IT

Obtain a pen or pencil and wad up an 8.5 x 11” piece of paper into a tight ball.

Stand up and hold the objects at shoulder level and release them at exactly the same time.

PREDICT: which will hit the floor first?

OBSERVE: which did hit the floor first?

Gravity

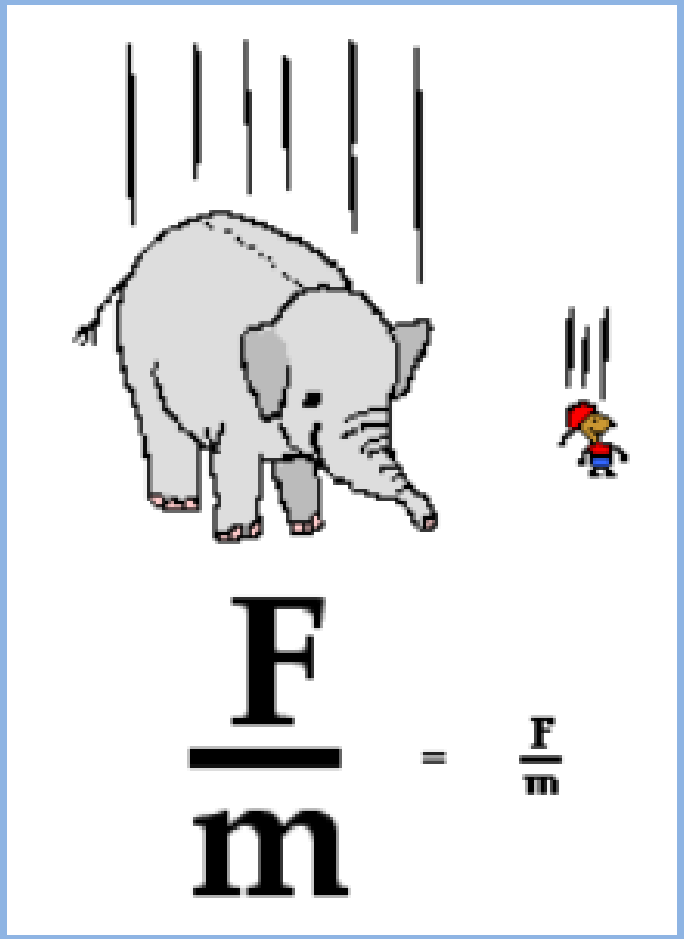
TRY IT

Obtain a pen or pencil and wad up an 8.5 x 11” piece of paper into a tight ball.

Stand up and hold the objects at shoulder level and release them at exactly the same time.

OBSERVE: which did hit the floor first?

They both land at the same time (assuming no air resistance)



Gravity

The acceleration due to the force of attraction that exists between all objects in the universe.

Gravity (g) = 9.8 m/s^2

on earth

Weight is mass times gravity

$W = mg$

Which falls first?

Previously, you dropped two objects from the same height and they landed pretty much at the same time because gravity acted on them. Let's predict & observe again!

Now obtain your textbook and an 8.5 x 11" sheet of paper.

1. Hold the paper & textbook parallel to the floor at waist level (one in each hand). Predict, then observe which lands first when you drop them at the same time.
2. Repeat the experiment, but place the paper directly underneath the textbook before dropping it.
3. Repeat the experiment, but place the paper directly on top of the textbook before dropping it.

Which falls first?

Now obtain your textbook and an 8.5 x 11” sheet of paper.

1. Hold the paper & textbook parallel to the floor at waist level (one in each hand). Drop them at the same time. Which lands first? (predict, then observe)

The textbook landed first due to air resistance.

2. Repeat the experiment, but place the paper directly underneath the textbook before dropping it.

Both landed at the same time … no air resistance

3. Repeat the experiment, but place the paper directly on top of the textbook before dropping it.

Both landed at the same time … no air resistance

Free Fall

When an object is only influenced by the acceleration due to gravity, it is said to be in Free fall.

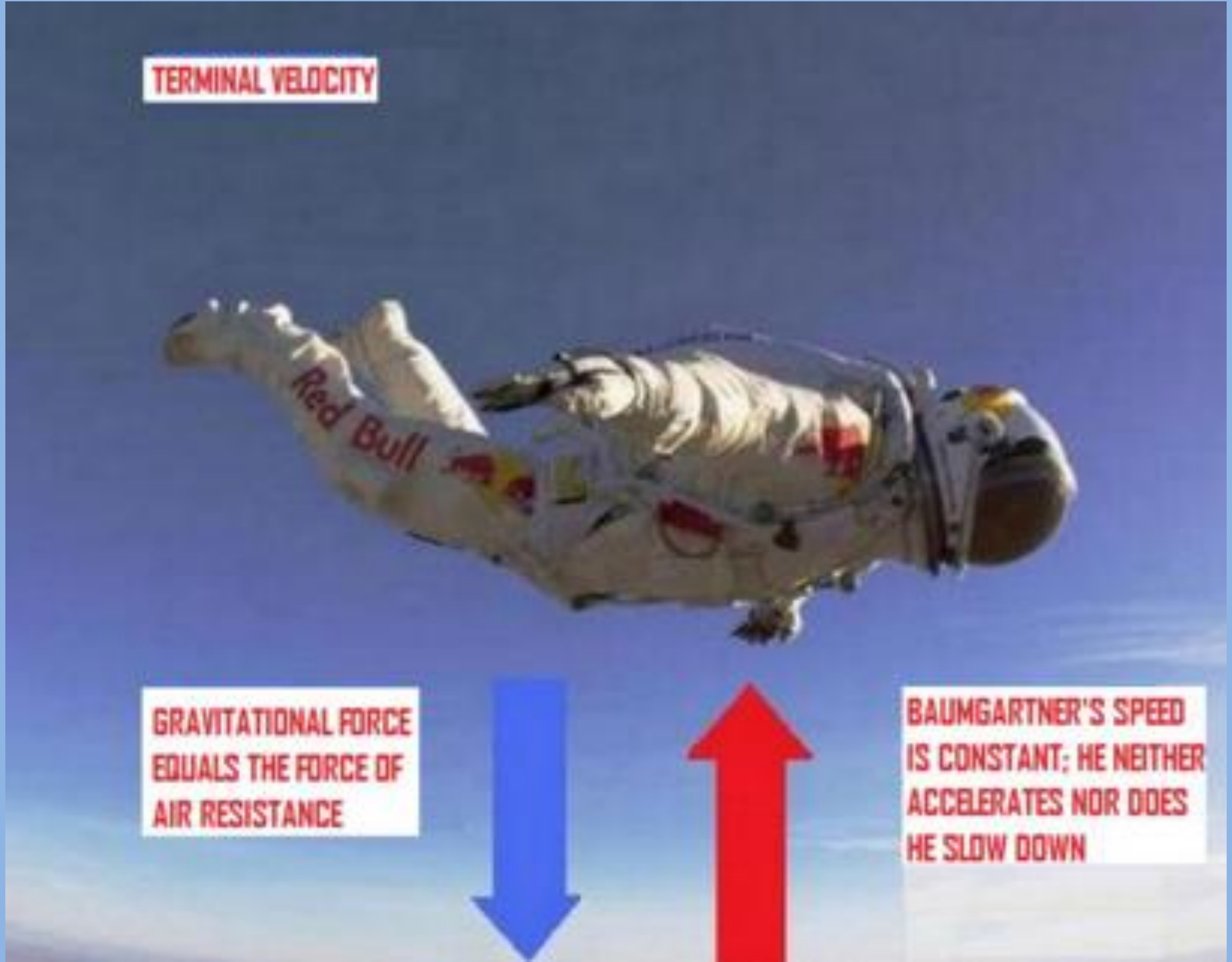
Air Resistance or drag (a form of fluid friction) opposes free fall.

Terminal Velocity

When objects free fall they continually gain speed because of the influence of acceleration due to gravity. HOWEVER, air resistance also comes into play. Eventually, a free falling object will reach its **terminal velocity**:

[1:22]

http://somup.com/cFXh38n1kO


TERMINAL VELOCITY
Red Bull
GRAVITATIONAL FORCE EQUALS THE FORCE OF AIR RESISTANCE
BAUMGARTNER'S SPEED IS CONSTANT; HE NEITHER ACCELERATES NOR DOES HE SLOW DOWN

Terminal Velocity

http://somup.com/cFXh3Mn1k0

Terminal Velocity ctr (0:59)

Suspending a ballon using a fan.

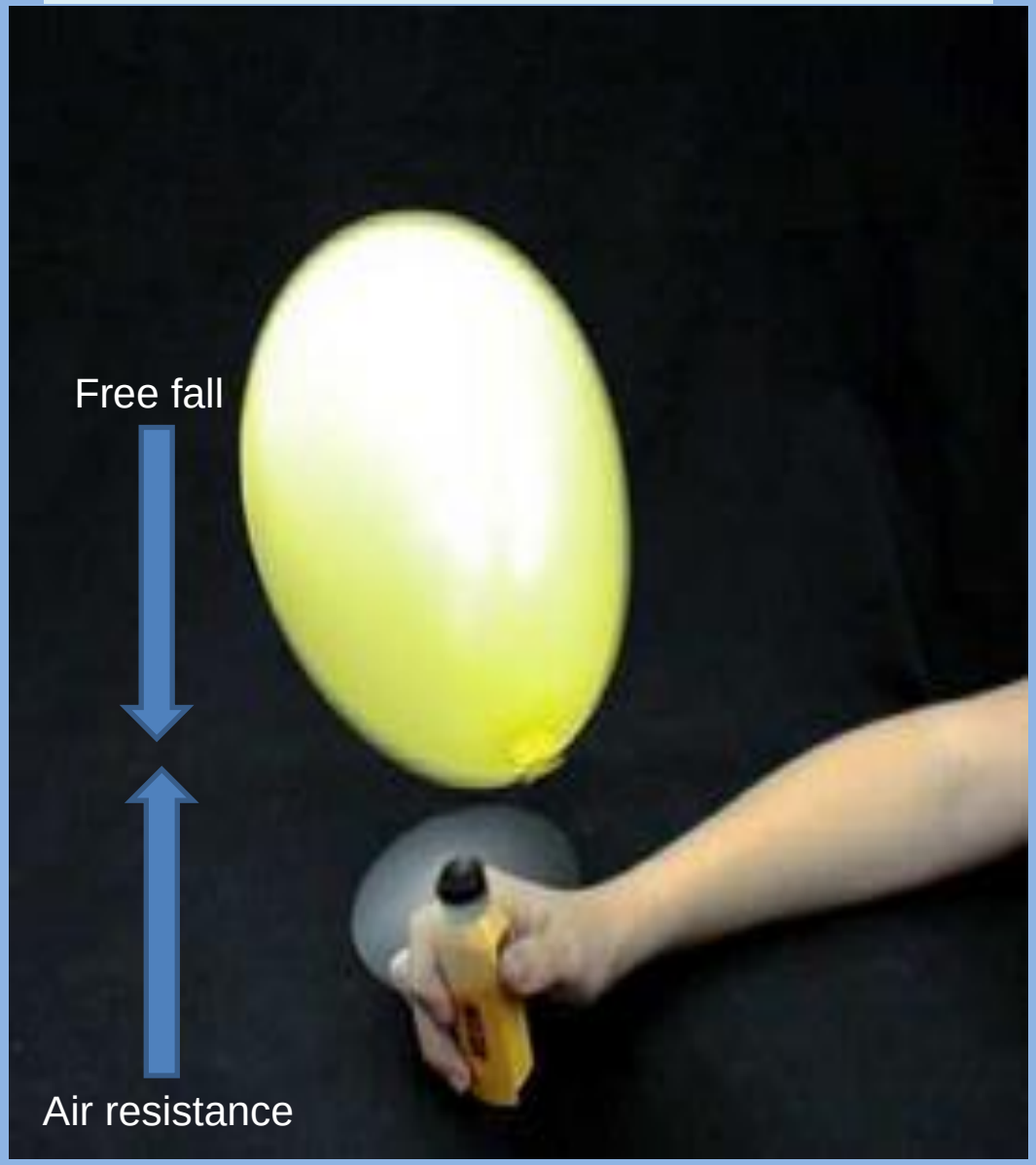
Terminal Velocity

TRY THIS

use a hair dryer and ping pong ball or a fan and a balloon.

You may need to add a paper clip to the tied end of the balloon if the fan is too strong.

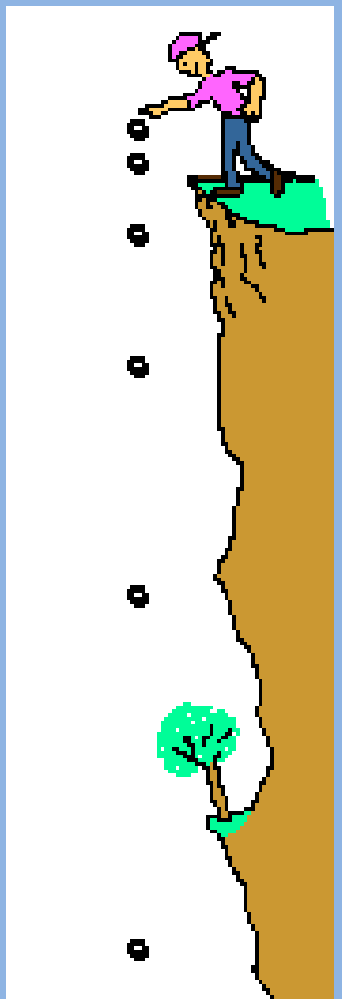
The balloon is in constant free fall, but the air resistance (drag) pushes it back up … appearing to stop the movement, but actually there is constant motion. (video)



TRY IT

Calculating Free Fall

For a freely falling object dropped from rest, how far will it fall after five seconds? How far will it fall after 10 seconds? $d = \frac{1}{2} gt^2$



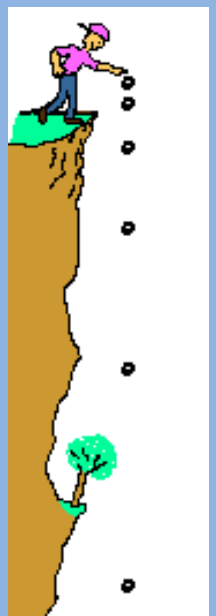
TRY IT

Calculating Free Fall

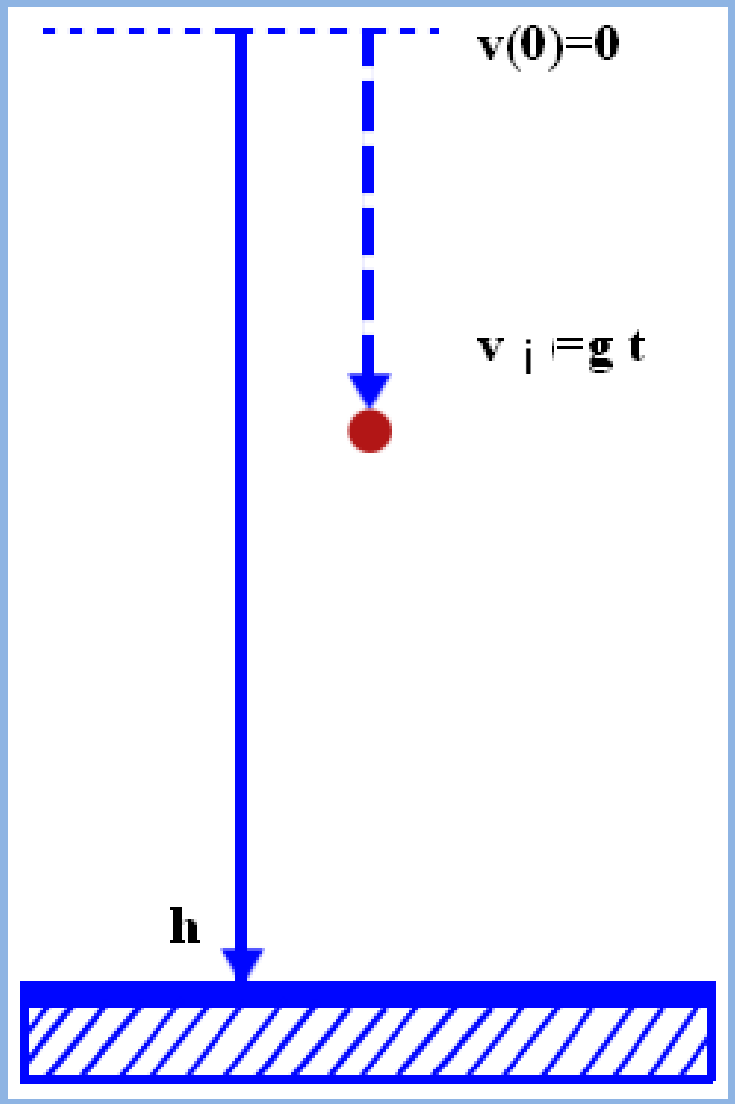
For a freely falling object dropped from rest, how far will it fall after five seconds? How far will it fall after 10 seconds?

$d = \frac{1}{2} gt^2 = \frac{1}{2} (10\ m/s^2)(5\ s)^2 = \underline{125\ m}$

$d = \frac{1}{2} gt2 = \frac{1}{2} (10\ m/s^2)(10\ s)^2 = \underline{500\ m}$



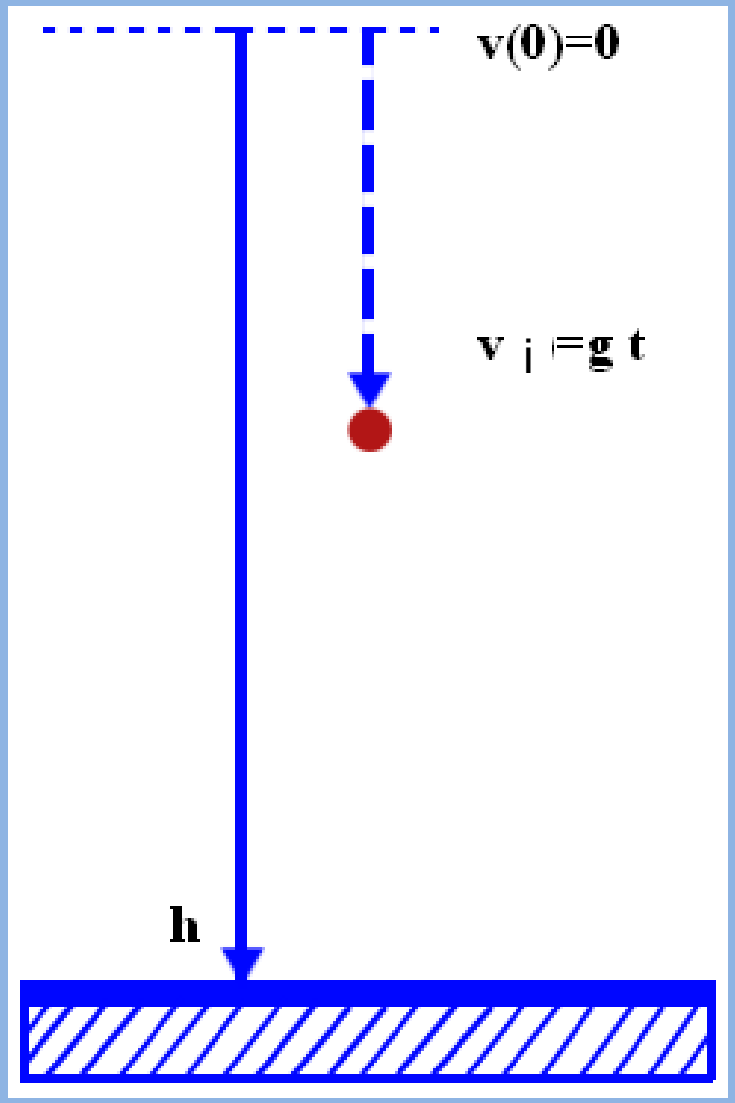
Calculating Instantaneous Speed at Impact



At the moment a freely falling object impacts the ground, the instantaneous velocity can be calculated by multiplying gravity by time:

$$V_i = gt$$

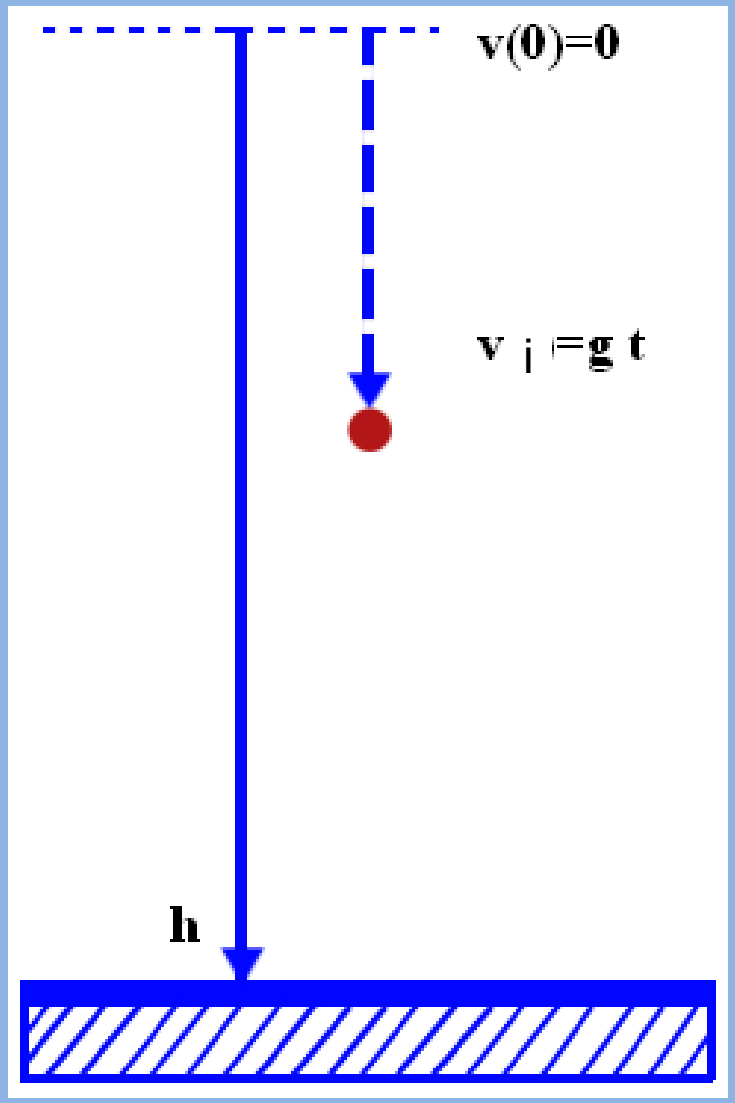
Calculating Instantaneous Speed at Impact



A person drops a quarter from a bridge and it takes 3 seconds to hit the water. What is the speed of the quarter upon impact?

$$V_i = gt$$

Calculating Instantaneous Speed at Impact



A person drops a quarter from a bridge and it takes 3 seconds to hit the water. What is the speed of the quarter upon impact?

$$V_i = gt$$

$$V_i = (9.8\ m/s^2)\ (3\ s)$$

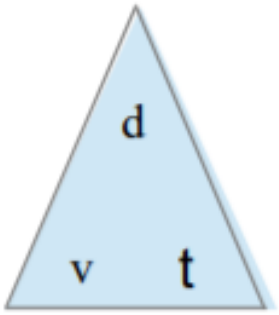
$$V_i = 29.4\ m/s$$

Free Fall Problems Worksheet

- Download the Free Fall & Graphing Problems Worksheet
- Work on problems together

Physical Science Formula Sheet

$s = d / t$ $v = d / t$

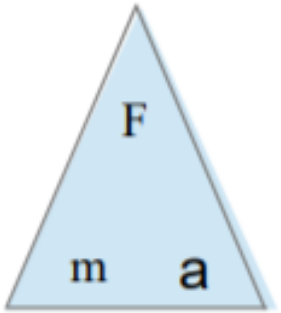


$a = \Delta v / t$

$PE = mgh$

$a = \frac{v_f - v_i}{t}$

$KE = \frac{1}{2} mv^2$



$F = m\,a$

$p = m \cdot v$

$d = \frac{1}{2} at^2$

$P = W / t$

Acceleration Problems

1. Distinguish between velocity and acceleration.

2. Can an automobile having a velocity toward the north have an acceleration in a different direction (i.e. south)? Explain your answer.

3. If you were standing on a bus moving at constant velocity, would you have to lean in some special way to compensate for the bus's motion? What if the bus were accelerating? Explain.

4. What is the acceleration of a vehicle that changes its speed from 100 km/h to a dead stop in 10 s? Is this acceleration (positive) or deceleration (negative)?

5. A car speeds up from 64 km/h to 112 km/h in 5 seconds. What is the car's acceleration in that time period?

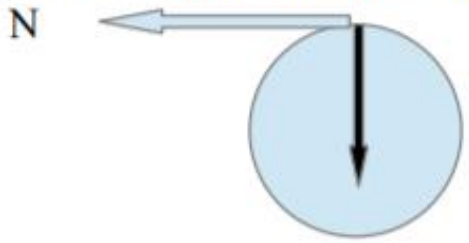
1. Distinguish between velocity and acceleration.

Velocity is motion produced by a force (energy). Acceleration ($\Delta v/t$) is the change in motion or velocity ($v = d/t$) over time. Both are vector quantities possessing magnitude and direction.

2. Can an automobile having a velocity toward the north have an acceleration in a different direction (i.e. south)? Explain your answer.

Yes, when the car is heading north, its velocity is north, but if it slows down or decelerates, its acceleration is negative or to the south (in the opposite direction).

With circular motion, a car can be heading north for a moment (while going in a circle) and its centripetal force will cause the car to accelerate towards the center of the circular motion.



Also with circular motion, a hockey puck rotates (towards the center) while heading north. This is rotational motion.

3. If you were standing on a bus moving at constant velocity, would you have to lean in some special way to compensate for the bus's motion? What if the bus were accelerating? Explain.

Constant velocity involves balanced forces, making it seem that one is not even moving. Acceleration involves unbalanced net force and would shift one's weight.

4. What is the acceleration of a vehicle that changes its speed from 100 km/h to a dead stop in 10 s? Is this acceleration (positive) or deceleration (negative)?

$a = (vf - vi) / t = (0 - 100\ km/h) / 10\ s = \underline{-10\ km/h/s} \rightarrow \underline{deceleration}$

5. A car speeds up from 64 km/h to 112 km/h in 5 seconds. What is the car's acceleration in that time period?

$a = (vf - vi) / t = (112\ km/h - 64\ km/h) / 5\ s = \underline{9.6\ km/h/s}$

$D = \frac{1}{2} g t^2$ or $D = \frac{1}{2} a t^2$

1. What is meant by a "freely falling" object?

2. The acceleration of free-fall is about 10 m/s^2. Why does the "seconds" unit appear twice?

3. For a freely falling object dropped from rest, how far will it fall after three seconds? How far will it fall after six seconds?

4. You throw a ball into the air and it reaches a height of 31.25 meters. It takes 2.5 seconds for the ball to fall back to the ground. What is the acceleration in m/s^2 of the ball from the highest point it reached to the ground?

5. An arrow is shot straight up in the air with an initial speed of 1.6×10^2 m/s. How high does it go if it takes 0.46×10^1 s to reach that point? (Neglect air resistance)

1. What is meant by a "freely falling" object?

   Only gravity acts on the object ... air resistance (a form of friction) can oppose the fall.

2. The acceleration of free-fall is about 10 m/s^2. Why does the "seconds" unit appear twice?

   $a = \Delta v/t$ = *m/s/s ... every second, the velocity of a falling object increases by 10 m/s. Therefore, after 1 s, the velocity is 10 m/s, after 2 s, the velocity is 20 m/s, and so forth.*

3. For a freely falling object dropped from rest, how far will it fall after three seconds? How far will it fall after six seconds?

   $d = \frac{1}{2} gt^2 = \frac{1}{2} (10\ m/s^2)(3\ s)^2 =$ <u>45 m</u>

   $d = \frac{1}{2} gt^2 = \frac{1}{2} (10\ m/s^2)(6\ s)^2 =$ <u>180 m</u>

4. You throw a ball into the air and it reaches a height of 31.25 meters. It takes 2.5 seconds for the ball to fall back to the ground. What is the acceleration in m/s^2 of the ball from the highest point it reached to the ground?

   $d = \frac{1}{2} at^2 \rightarrow a = 2d/t^2 = (2)(31.25\ m) / (2.5)^2 = 10\ m/s^2$

5. An arrow is shot straight up in the air with an initial speed of 1.6×10^2 m/s. How high does it go if it takes 0.46×10^1 s to reach that point? (Neglect air resistance)

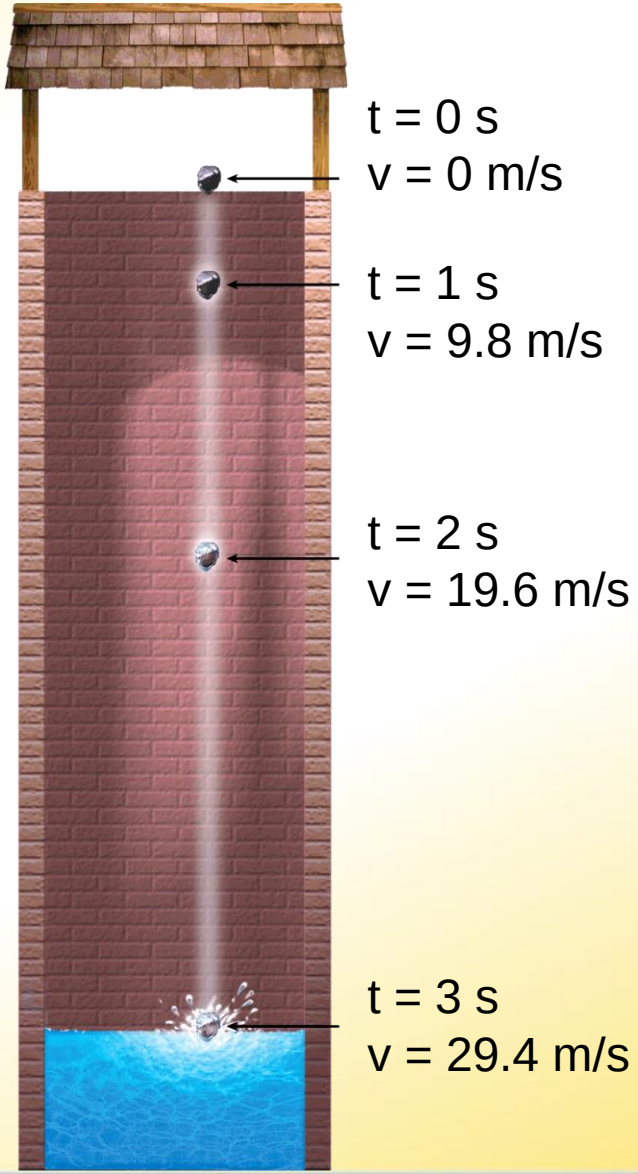
   The distance going up is the same as that returning to the ground. The acceleration is gravity.

   $d = \frac{1}{2} at^2 = \frac{1}{2} (10\ m/s^2)(4.6\ s)^2 =$ <u>105.8 m</u>

What Is Acceleration?

Each second an object is in free fall, its velocity increases downward by 9.8 meters per second.

The change in the stone's speed is 9.8 m/s^2, the acceleration due to gravity.



Describing Ionic Compounds

Math Practice

1. A car traveling at 10 m/s starts to decelerate steadily. It comes to a complete stop in 20 seconds. What is its acceleration?

Describing Ionic Compounds

Math Practice

1. A car traveling at 10 m/s starts to decelerate steadily. It comes to a complete stop in 20 seconds. What is its acceleration?

Answer:

$$a = (v_f - v_i)/t = (0 \text{ m/s} - 10 \text{ m/s})/20 \text{ s}$$
$$= -0.5 \text{ m/s}^2$$

Describing Ionic Compounds

Math Practice

2. An airplane travels down a runway for 4.0 seconds with an acceleration of 9.0 m/s^2. What is its change in velocity during this time?

Describing Ionic Compounds

Math Practice

2. An airplane travels down a runway for 4.0 seconds with an acceleration of 9.0 m/s^2. What is its change in velocity during this time?

Answer:

(vf – vi) = at = (9.0 m/s2)(4.0 s) = 36 m/s

Describing Ionic Compounds

Math Practice

3. A child drops a ball from a bridge. The ball strikes the water under the bridge 2.0 seconds later. What is the velocity of the ball when it strikes the water?

Describing Ionic Compounds

Math Practice

3. A child drops a ball from a bridge. The ball strikes the water under the bridge 2.0 seconds later. What is the velocity of the ball when it strikes the water?

Answer:

$v_i = 0$; $v_f = at = (9.8\ m/s2)(2.0\ s) = 20\ m/s$

Assessment Questions

5. The acceleration at a specific point on a distance-time graph is the
   a. instantaneous acceleration.
   b. momentary acceleration.
   c. positive acceleration.
   d. numerical acceleration.

Assessment Questions

5. The acceleration at a specific point on a distance-time graph is the
   a. instantaneous acceleration.
   b. momentary acceleration.
   c. positive acceleration.
   d. numerical acceleration.

   ANS: A