Preview

- Objectives
- One Dimensional Motion
- Displacement
- Average Velocity
- Velocity and Speed
- Interpreting Velocity Graphically

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Objectives

- **Describe** motion in terms of frame of reference, displacement, time, and velocity.
- **Calculate** the displacement of an object traveling at a known velocity for a specific time interval.
- **Construct** and **interpret** graphs of position versus time.

End of Slide

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One Dimensional Motion

- To simplify the concept of motion, we will first consider motion that takes place in **one direction.**
- One example is the motion of a commuter train on a straight track.
- To measure motion, you must choose a **frame of reference.** A frame of reference is a system for specifying the precise location of objects in space and time.

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Frame of Reference

Click below to watch the Visual Concept.

Visual Concept

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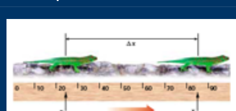
Displacement

- **Displacement** is a **change in position.**
- Displacement is not always equal to the distance traveled.
- The SI unit of displacement is the **meter, m.**



$$\Delta x = x_f - x_i$$

displacement = final position – initial position

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Displacement

Click below to watch the Visual Concept.

Visual Concept

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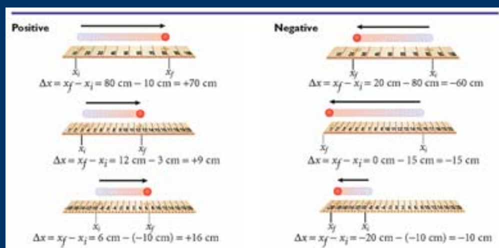
Positive and Negative Displacements



Average Velocity

- **Average velocity** is the total **displacement** divided by the **time interval** during which the displacement occurred.

$$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$$

$$\text{average velocity} = \frac{\text{change in position}}{\text{change in time}} = \frac{\text{displacement}}{\text{time interval}}$$

- In SI, the unit of velocity is **meters per second,** abbreviated as **m/s.**

End Of Slide

Average Velocity

Click below to watch the Visual Concept.

Visual Concept

Velocity and Speed

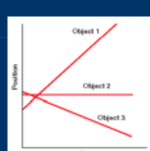
- **Velocity** describes motion with both a **direction** and a **numerical value** (a magnitude).
- **Speed** has no direction, only magnitude.
- **Average speed** is equal to the total **distance traveled** divided by the **time interval.**

$$\text{average speed} = \frac{\text{distance traveled}}{\text{time of travel}}$$

End Of Slide

Interpreting Velocity Graphically

- For any **position-time graph,** we can determine the **average velocity** by drawing a straight line between any two points on the graph.
- If the velocity is **constant**, the graph of position versus time is a **straight line.** The slope indicates the velocity.
  - **Object 1:** positive slope = positive velocity
  - **Object 2:** zero slope= zero velocity
  - **Object 3:** negative slope = negative velocity



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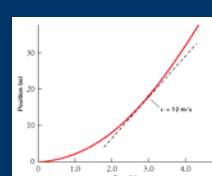
Interpreting Velocity Graphically, *continued*

The **instantaneous velocity** is the velocity of an object at some instant or at a specific point in the object's path.

The instantaneous velocity at a given time can be determined by measuring the slope of the line that is tangent to that point on the position-versus-time graph.



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Sign Conventions for Velocity

Click below to watch the Visual Concept.

Visual Concept

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Preview

- Objectives
- Changes in Velocity
- Motion with Constant Acceleration
- Sample Problem

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Objectives

- **Describe** motion in terms of changing velocity.
- **Compare** graphical representations of accelerated and nonaccelerated motions.
- **Apply** kinematic equations to **calculate** distance, time, or velocity under conditions of constant acceleration.

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Changes in Velocity

- **Acceleration** is the rate at which velocity changes over time.

$$a_{avg} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}$$

$$\text{average acceleration} = \frac{\text{change in velocity}}{\text{time required for change}}$$

- An object accelerates if its **speed, direction, or both** change.
- Acceleration has direction and magnitude. Thus, acceleration is a **vector** quantity.

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Acceleration

Click below to watch the Visual Concept.

Visual Concept

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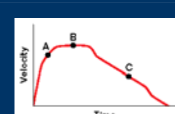
Changes in Velocity, *continued*

- Consider a train moving to the right, so that the displacement and the velocity are positive.
- The slope of the velocity-time graph is the average acceleration.
  - When the velocity in the positive direction is increasing, the **acceleration is positive**, as at **A.**
  - When the velocity is constant, there is **no acceleration**, as at **B.**
  - When the velocity in the positive direction is decreasing, the **acceleration is negative**, as at **C.**



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Graphical Representations of Acceleration

Click below to watch the Visual Concept.

Visual Concept

Velocity and Acceleration

v_i	a	Motion
+	+	speeding up
−	−	speeding up
+	−	slowing down
−	+	slowing down
− or +	0	constant velocity
0	− or +	speeding up from rest
0	0	remaining at rest

Motion with Constant Acceleration

- When velocity changes by the same amount during each time interval, **acceleration is constant.**
- The relationships between **displacement, time, velocity,** and **constant acceleration** are expressed by the equations shown on the next slide. These equations apply to any object moving with constant acceleration.
- These equations use the following symbols:
  - Δx = displacement
  - v_i = initial velocity
  - v_f = final velocity
  - Δt = time interval

End of Slide

Equations for Constantly Accelerated Straight-Line Motion

Form to use when accelerating object has an initial velocity	Form to use when accelerating object starts from rest
$\Delta x = \frac{1}{2}(v_i + v_f)\Delta t$	$\Delta x = \frac{1}{2}v_f\Delta t$
$v_f = v_i + a\Delta t$	$v_f = a\Delta t$
$\Delta x = v_i\Delta t + \frac{1}{2}a(\Delta t)^2$	$\Delta x = \frac{1}{2}a(\Delta t)^2$
$v_f^2 = v_i^2 + 2a\Delta x$	$v_f^2 = 2a\Delta x$

Sample Problem

Final Velocity After Any Displacement

A person pushing a stroller starts from rest, uniformly accelerating at a rate of 0.500 m/s². What is the velocity of the stroller after it has traveled 4.75 m?

End of Slide

Sample Problem, *continued*

1. Define

Given:

v_i = 0 m/s

a = 0.500 m/s^2

Δx = 4.75 m

Unknown:

v_f = ?

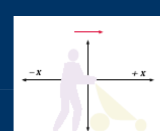

Diagram: Choose a coordinate system. The most convenient one has an origin at the initial location of the stroller, as shown above. The positive direction is to the right.

End of Slide

Sample Problem, *continued*

2. Plan

Choose an equation or situation: Because the initial velocity, acceleration, and displacement are known, the final velocity can be found using the following equation:

$$v_f^2 = v_i^2 + 2a\Delta x$$

Rearrange the equation to isolate the unknown: Take the square root of both sides to isolate v_f .

$$v_f = \pm\sqrt{v_i^2 + 2a\Delta x}$$

Sample Problem, *continued*

3. Calculate

Substitute the values into the equation and solve:

$$v_f = \pm\sqrt{(0 \text{ m/s})^2 + 2(0.500 \text{ m/s}^2)(4.75 \text{ m})}$$

$$\boxed{v_f = +2.18 \text{ m/s}}$$

Tip: *Think about the physical situation to determine whether to keep the positive or negative answer from the square root. In this case, the stroller starts from rest and ends with a speed of 2.18 m/s. An object that is speeding up and has a positive acceleration must have a positive velocity. So, the final velocity must be positive.*

4. Evaluate

The stroller's velocity after accelerating for 4.75 m is 2.18 m/s to the right.

Preview

- Objectives
- Free Fall
- Free-Fall Acceleration
- Sample Problem

Objectives

- **Relate** the motion of a freely falling body to motion with constant acceleration.
- **Calculate** displacement, velocity, and time at various points in the motion of a freely falling object.
- **Compare** the motions of different objects in free fall.

Free Fall

Click below to watch the Visual Concept.

Visual Concept

Free Fall

- **Free fall** is the motion of a body when only the force due to gravity is acting on the body.
- The acceleration on an object in free fall is called the **acceleration due to gravity,** or **free-fall acceleration.**
- Free-fall acceleration is denoted with the symbols $\boldsymbol{a_g}$ (generally) or $\boldsymbol{g}$ (on Earth's surface).

Free-Fall Acceleration

Click below to watch the Visual Concept.

Visual Concept

Free-Fall Acceleration

- Free-fall acceleration is the same for all objects, regardless of mass.
- This book will use the value **g = 9.81 m/s²**.
- Free-fall acceleration on Earth's surface is –9.81 m/s² at **all points** in the object's motion.
- Consider a ball thrown up into the air.
  - **Moving upward:** velocity is decreasing, acceleration is –9.81 m/s²
  - **Top of path:** velocity is zero, acceleration is –9.81 m/s²
  - **Moving downward:** velocity is increasing, acceleration is –9.81 m/s²

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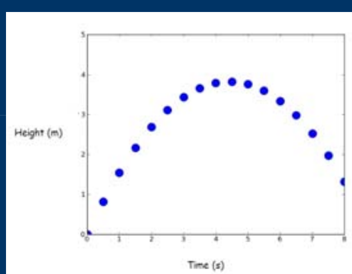
Fill in v and a



Notes on Free-fall

Acceleration *always* = g ($-9.81 \, {}^{m}/_{s}{}^{2}$)

$v_{top} = 0$

If the trip starts and ends at the same height $v_f = -v_i$ (for the trip)

Because…

Notes on Free-fall

Acceleration *always* = g ($-9.81 \, {}^{m}/_{s}{}^{2}$)

$v_{top} = 0$

If the trip starts and ends at the same height $v_f = -v_i$ (for the trip)

Because…

Sample Problem

Falling Object

Water leaving Old Faithful geyser in Yellowstone park reaches a height of 120 ft. How fast is it travelling when comes out?

End of Slide

Sample Problem – II

Falling Object

Jason hits a volleyball so that it moves with an initial velocity of 6.0 m/s straight upward. If the volleyball starts from 2.0 m above the floor, how long will it be in the air before it strikes the floor?

End of Slide

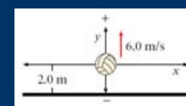
Sample Problem, *continued*

1. Define

Given:
v_i = +6.0 m/s
$a = -g$ = –9.81 m/s²
Δy = –2.0 m

Unknown:
Δt = ?

Diagram:
Place the origin at the Starting point of the ball (y_i = 0 at t_i = 0).



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Sample Problem, *continued*

2. Plan

Choose an equation or situation:
Both Δt and v_f are unknown. Therefore, first solve for v_f using the equation that does not require time. Then, the equation for v_f that does involve time can be used to solve for Δt.

$$v_f^2 = v_i^2 + 2a\Delta y \qquad v_f = v_i + a\Delta t$$

Rearrange the equation to isolate the unknown:
Take the square root of the first equation to isolate v_f. The second equation must be rearranged to solve for Δt.

$$v_f = \pm\sqrt{v_i^2 + 2a\Delta y} \qquad \Delta t = \frac{v_f - v_i}{a}$$

End of Slide

Sample Problem, *continued*

3. Calculate

Substitute the values into the equation and solve:
First find the velocity of the ball at the moment that it hits the floor.

$$v_f = \pm\sqrt{v_i^2 + 2a\Delta y} = \pm\sqrt{(6.0\ \text{m/s})^2 + 2(-9.81\ \text{m/s}^2)(-2.0\ \text{m})}$$

$$v_f = \pm\sqrt{36\ \text{m}^2/\text{s}^2 + 39\ \text{m}^2/\text{s}^2} = \pm\sqrt{75\ \text{m}^2/\text{s}^2} = -8.7\ \text{m/s}$$

***Tip:** When you take the square root to find v_f, select the negative answer because the ball will be moving toward the floor, in the negative direction.*

End of Slide

Sample Problem, *continued*

Next, use this value of v_f in the second equation to solve for Δt.

$$\Delta t = \frac{v_f - v_i}{a} = \frac{-8.7\ \text{m/s} - 6.0\ \text{m/s}}{-9.81\ \text{m/s}^2} = \frac{-14.7\ \text{m/s}}{-9.81\ \text{m/s}^2}$$

$$\boxed{\Delta t = 1.50\ \text{s}}$$

4. Evaluate

The solution, 1.50 s, is a reasonable amount of time for the ball to be in the air.

End of Slide