Chapter Menu

Chapter Introduction

Lesson 1  Describing Motion

Lesson 2  Graphing Motion

Lesson 3  Forces

Chapter Wrap-Up
What is the relationship between motion and forces?
What do you think?

Before you begin, decide if you agree or disagree with each of these statements. As you view this presentation, see if you change your mind about any of the statements.
Do you agree or disagree?

1. If an object’s distance from a starting point changes, the object is in motion.

2. Speed describes how fast something is going and the direction which it is moving.

3. You can show the path an object takes using a graph of distance and time.
Do you agree or disagree?

4. You can tell how fast objects are moving if you look at a graph of speed and time.

5. To apply a force, one object must be touching another object.

6. If an object is at rest, there are no forces acting on it.
Describing Motion

Key Concepts

• How do you describe an object’s position?
• How do you describe an object’s motion?
• How do speed and velocity differ?
• What is acceleration?
Describing Motion

Vocabulary

- reference point
- position
- displacement
- motion
- speed
- velocity
- acceleration
Describing Position

A **reference point** is the starting point used to locate another place or thing.

**WORD ORIGIN**

*reference*

from Latin *referre*, means “to carry or direct back”
Describing Position (cont.)

**Position** describes an object’s distance and direction from a reference point.

**Key Concept Check**

How would you describe an object’s position?
Displacement is the difference between the initial, or starting, position and the final position.

An object’s displacement and the distance it travels are not always equal.
If the girl runs from position D to position C and then to position B, the distance she runs is 51.2 m. Her displacement is 40 m.
Motion

**Motion** is the process of changing position.

**Key Concept Check**

Why does the description of an object’s motion depend on a reference point?
Speed

• **Speed** is the distance an object moves in a unit of time.

• When an object moves the same distance over a given unit of time, it is said to have a constant speed.
The bus maintains a constant speed of 10 m/s from positions 1 to 4.
When the distance an object covers increases or decreases over a given unit of time, the object is said to be changing speed.
The bus is changing speed from positions 4 to 7.
Speed (cont.)

Average speed is equal to the total distance traveled divided by the total time.

\[
\text{average speed} = \frac{\text{total distance}}{\text{total time}}
\]
Speed (cont.)

The bus travels a total of 80 m in 30 s. Therefore, the average speed of the bus is $80 \text{ m}/30 \text{ s}$ or $2.7 \text{ m/s}$.
Velocity

**Velocity** is the speed and the direction of a moving object.

**Science Use** v. **Common Use**

**speed**

*Science Use* the distance an object covers in a given unit of time

*Common Use* the sense of going fast or to go fast
Velocity (cont.)

You can use arrows to show the velocity of an object. The longer the arrow, the faster the object is moving.
Velocity (cont.)

**Key Concept Check**

How do speed and velocity differ?
Velocity (cont.)

Constant velocity means that an object moves with constant speed and its direction does not change.
Velocity changes when either the speed or the direction of motion of an object changes.
Acceleration

- **Acceleration** is a measure of how quickly the velocity of an object changes.

- When the velocity of an object changes, it accelerates.

- When an object’s acceleration is in the same direction as its motion, this is called positive acceleration.

- The action of slowing down is called negative acceleration.
When the roller-coaster car increases speed, decreases speed, or changes direction, it accelerates. Acceleration takes place whenever velocity changes.
Describe three ways an object can accelerate.
The position of an object is described by a reference point, a reference direction, and a distance. Motion is a change of position.
• Speed is the distance traveled by an object during a unit of time. Velocity includes both speed and direction of motion.
• Acceleration is a change in velocity. Velocity changes when either the speed or the direction changes.
1. If an object’s distance from a starting point changes, the object is in motion.

2. Speed describes how fast something is going and the direction which it is moving.
Lesson 2

Graphing Motion

Key Concepts

• How can you graph an object’s motion?

• How can a graph help you understand an object’s motion?
Lesson 2

Graphing Motion

Vocabulary

• distance-time graph

• speed-time graph
Describing Motion with Graphs

• A graph that shows how distance and time are related is a **distance-time graph**.

• The $y$-axis shows the distance an object travels from a reference point, and time is on the $x$-axis.

• If the angle of the line on a distance-time graph changes, you know that the speed changes.
The line on this distance-time graph represents an object traveling at a constant speed.
In order to better understand how sea turtles migrate through the oceans, marine biologists attach satellite-tracking devices to turtles’ shells.

**WORD ORIGIN**

biologist

from Greek *bios* and *logia*, meaning “to study life”
This table shows satellite-tracking data that was gathered for a green sea turtle off the coast of Florida.

<table>
<thead>
<tr>
<th>Time (days)</th>
<th>Distance (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>32</td>
</tr>
<tr>
<td>3</td>
<td>48</td>
</tr>
<tr>
<td>4</td>
<td>64</td>
</tr>
<tr>
<td>5</td>
<td>80</td>
</tr>
<tr>
<td>6</td>
<td>96</td>
</tr>
</tbody>
</table>
Use the following steps to make a distance-time graph:

1. Draw $x$- and $y$-axes.

2. Label the $x$-axis for time measured in days. Label the $y$-axis for distance measured in kilometers.
3. Make tick marks on the axes and number them. Be sure the values you choose allow you to plot all the data.
4. Plot the data from each row of your data table. Move across the x-axis to the correct time and up the y-axis to the correct distance. Draw a small circle.
5. Connect data points with a line.
• An object moving the same distance in the same amount of time moves at constant speed.

• An object moves with constant speed if the line representing its motion on a position-time graph is straight.
You can use distance-time graphs to compare the motion of two different objects.

Steeper lines on distance-time graphs mean that the average speed is greater.
Each change in the steepness of the line means that the average speed of the object changed during that time interval.
How can a graph show you how the motion of an object is changing?
Speed-Time Graphs

• A **speed-time graph** shows the speed of an object on the $y$-axis and time on the $x$-axis.

• A speed-time graph shows how the speed of the object changes during each interval of time.
Speed-Time Graphs (cont.)

- The speed-time graph for an object at rest is a horizontal line at $y = 0$.
- On a speed-time graph, an object moving with constant average speed is a horizontal line.
A line on a speed-time graph that shows the motion of an object with increasing speed slopes upward from left to right.
Negative acceleration is indicated on a speed-time graph as a line that slopes downward from left to right.
Speed-Time Graphs (cont.)

**Key Concept Check**

What is the difference between an upward-slanting line on a speed-time graph and one on a distance-time graph?
The slanting line on a distance-time graph shows the motion of an object traveling at a constant speed.
A horizontal line on a speed-time graph shows the motion of an object moving at a constant speed.
• An upward-slanting line on a speed-time graph shows the motion of an object that is speeding up. A downward-slanting line shows the motion of an object that is slowing down.
What do you think NOW?
Do you agree or disagree?

3. You can show the path an object takes using a graph of distance and time.

4. You can tell how fast objects are moving if you look at a graph of speed and time.
Forces

Key Concepts

• What are different types of forces?
• What factors affect the force of gravity?
• What happens when forces combine?
• How are balanced and unbalanced forces related to motion?
Lesson 3

Forces

Vocabulary

• force
• contact force
• noncontact force
• gravity
• friction

• air resistance
• Newton’s first law of motion
• Newton’s second law of motion
• Newton’s third law of motion
What is force?

- A **force** is a push or a pull on an object.
- Force has both size and direction.
- You can use arrows to show the size and direction of a force.
- The unit for force is the newton (N).
What is force? (cont.)

- A **contact force** is a push or a pull on one object by another object that is touching it.

- A force that one object can apply to another object without touching it is a **noncontact force**.
What is force? (cont.)

**Key Concept Check**

What are some examples of contact and noncontact forces you have experienced today?
Gravity—A Noncontact Force

• **Gravity** is an attractive force that exists between all objects that have mass.

• The size of a gravitational force depends on the masses of the objects and the distance between them.
Gravity—A Noncontact Force (cont.)

If the mass of an object increases, the gravitational force increases between it and another object.

The distances between the marbles in diagrams A and B are the same. The force of attraction between the marbles in B is greater than in A because the marbles in B have more mass.
Gravity—A Noncontact Force (cont.)

As two objects move apart, the gravitational force between them decreases.

The masses of the marbles in diagrams C and D are the same. The force of attraction between the marbles in D is less than in C because the distance between the marbles is greater.
Gravity—A Noncontact Force (cont.)

**Key Concept Check**

What factors affect the force of gravity?
Gravity—A Noncontact Force (cont.)

- Weight is a measure of the gravitational force acting on an object’s mass.

- The weights of objects on the Moon are smaller than objects on Earth because the mass of the Moon is smaller.
Friction—A Contact Force

**Friction** is a contact force that resists the sliding motion of two surfaces that are touching.

**WORD ORIGIN**

friction

from Latin *fricare*, means “to rub”
Friction—A Contact Force (cont.)

• The force of friction acts in the opposite direction of an object’s motion.

• The heavier an object, the more it is affected by friction than a lighter one.

• **Air resistance** is the frictional force between air and objects moving through it.
Combining Forces

• When more than one force acts on an object, the forces combine and act as one force.

• The sum of all the forces acting on an object is called the net force.

• When two forces act on the same object in opposite directions, you must include the direction of the forces when you add them to calculate net force.
Combining Forces (cont.)

- If the net force on an object is 0 N, the forces acting on the object are called balanced forces.
- When the net force on an object is not 0 N, the forces acting on the object are unbalanced.
Combining Forces (cont.)

**KEY CONCEPT CHECK**

What can happen when forces combine?
When unbalanced forces act on an object, the object’s velocity changes.

Unbalanced forces can change either the speed or the direction of motion.
Unbalanced Forces $\Rightarrow$ Acceleration

Changing speed

Friction from rails $\Rightarrow$ Force of engine

Changing direction

Force of engine $\Rightarrow$ Force from track on wheels
Balanced Forces and Constant Motion

• When balanced forces act on an object, the motion is constant.

• The object is either at rest or moving at a constant velocity.
Balanced Forces $\rightleftharpoons$ Constant Motion

Resting

Constant velocity

Gravity

Force of track

Friction from rails $\rightleftharpoons$ Force of engine
Balanced Forces and Constant Motion (cont.)

Key Concept Check

How do balanced and unbalanced forces affect motion?
Forces and Newton’s Laws of Motion

• According to **Newton’s first law of motion**, if the net force acting on an object is zero, the motion of the object does not change.

• Inertia is the tendency of an object to resist a change in its motion.
Forces and Newton’s Laws of Motion (cont.)

**WORD ORIGIN**

*inertia*

from Latin *inertia*, means “idle” or “inactive”
According to **Newton’s second law of motion**, the acceleration of an object is equal to the net force exerted on the object divided by the object’s mass.

\[
\text{acceleration (} a \text{)} = \frac{\text{force (} f \text{)}}{\text{mass (} m \text{)}}
\]
Forces and Newton’s Laws of Motion (cont.)

The greater the mass, the greater the force needed to accelerate the object at the same rate.

**KEY CONCEPT CHECK**

What happens to the motion of an object as the unbalanced force acting on it increases?
Forces and Newton’s Laws of Motion (cont.)

- **Newton’s third law of motion** says that for every action there is an equal and opposite reaction.

- When one object exerts a force on a second object, the second object exerts a force of the same size but in the opposite direction on the first object.

- Equal and opposite forces are called force pairs.
Summary

- Gravity is a noncontact force between two objects. Gravity depends on the mass of the objects and the distance between them.
• Balanced forces produce constant motion. Unbalanced forces produce acceleration.
Newton’s laws of motion describe relationships among forces and their effect on motion.
5. To apply a force, one object must be touching another object.

6. If an object is at rest, there are no forces acting on it.
The motion of an object is changed by a pushing or a pulling force. The force that moves an object can be either in physical contact with the object or at a distance.
Lesson 1: Describing Motion

- An object’s position depends on a reference point, a distance and a direction.
- An object’s motion can be described using speed, velocity, or acceleration.
- Speed is how fast an object moves. Velocity describes an object’s speed and the direction it moves.
- Acceleration is how fast an object’s velocity changes.
Lesson 2: Graphing Motion

- Motion data can be plotted as points on a graph. The line connecting the points shows changes in the motion of the object.

- The line on a distance-time graph allows you to calculate an object’s speed at any moment in time. A speed-time graph helps you understand both how fast an object moves and how fast the object’s speed changes.
Lesson 3: Forces

- Contact forces include friction and air resistance. Noncontact forces include gravity, electricity, and magnetism.
- Mass and distance affect gravitational force.
- Both the size and direction of forces must be used when combining forces to determine the net force acting on an object.
- Newton’s laws of motion describe the relationships among forces, mass, and motion.