Strategy
Use the equation for acceleration.

Calculations
\[ a = \frac{v_f - v_i}{\Delta t} \]
\[ = \frac{+3.5 \text{ m/s} - (-4.0 \text{ m/s})}{3.0 \text{ s}} \]
\[ = \frac{7.5}{3.0} \text{ m/s}^2 \]
\[ = +2.5 \text{ m/s}^2 \]

The Indy race car’s acceleration is +8.0 m/s².

Validate
The units in the answer were m/s², which is correct for acceleration. The average acceleration is positive, since the velocity of the Indy car was increasing while traveling in the positive direction.

7. Frame the Problem
- Sketch and label a diagram of the motion.

- The equations of motion apply to the problem, since the acceleration was constant.

Identify the Goal
The car’s acceleration once the driver got it started

Variables and Constants
Involved in the problem Known Unknown

| \( v_i \) | \( a \) | \( v_f = -4.0 \text{ m/s} \) | \( a \) |
| \( v_f \) | \( \Delta t \) | \( v_f = +3.5 \text{ m/s} \) | \( \Delta t = 3.0 \text{ s} \) |

Strategy
- Use the equation for acceleration.
- Let uphill be the positive direction.

Calculations
\[ a = \frac{\Delta v}{\Delta t} \]
\[ = \frac{+3.5 \text{ m/s} - (-4.0 \text{ m/s})}{3.0 \text{ s}} \]
\[ = \frac{7.5}{3.0} \text{ m/s}^2 \]
\[ = +2.5 \text{ m/s}^2 \]

The car’s acceleration once the driver got it started was 2.5 m/s² [uphill].

Validate
The units in the answer were m/s², which is correct for acceleration. The acceleration is positive, since the velocity of the Indy car was increasing uphill.
8. Frame the Problem
- Sketch and label a diagram of the motion.

\[ V_i \quad \Delta t = 3.0 \text{s} \]

\[ \sigma = -8.0 \frac{\text{m}}{\text{s}^2} \]

- The equations of motion apply to the problem, since the acceleration was constant.
- The final velocity of the bus will be zero.

Identify the Goal
The velocity the bus was travelling when the brakes were applied

Variables and Constants

<table>
<thead>
<tr>
<th>Involved in the problem</th>
<th>Known</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>( t )</td>
<td>( a = -8.0 \frac{\text{m}}{\text{s}^2} )</td>
<td>( v_f = 0.0 \frac{\text{m}}{\text{s}} )</td>
</tr>
<tr>
<td>( v_i )</td>
<td>( \Delta t = 3.0 \text{s} )</td>
<td></td>
</tr>
</tbody>
</table>

Strategy
Select the equation that relates the initial velocity to the final velocity, acceleration, and time interval.

All of the needed quantities are known, so substitute them into the equation.

Simplify.

The bus was travelling at +24 \( \frac{\text{m}}{\text{s}^2} \) when the brakes were applied.

Validate
The units in the answer were \( \text{m/s}^2 \), which is correct for velocity. The initial velocity was positive, which is correct.

Practice Problem Solutions
Student Textbook page 84

9. Frame the Problem
- Make a diagram of the motion of the field hockey player that includes the known variables.

- The equations of motion apply to the problem, since the acceleration was constant.

Identify the Goal
(a) The distance she travelled
(b) Her acceleration
Variables and Constants

<table>
<thead>
<tr>
<th>Involved in the problem</th>
<th>Known</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>( v_i )</td>
<td>( v_i = 0.0 , \text{m/s} )</td>
<td>( \Delta d )</td>
</tr>
<tr>
<td>( v_f )</td>
<td>( v_f = 4.0 , \text{m/s} )</td>
<td>( a )</td>
</tr>
<tr>
<td>( \Delta t )</td>
<td>( \Delta t = 2.5 , \text{s} )</td>
<td></td>
</tr>
</tbody>
</table>

Strategy
Use the equation of motion that relates time, initial velocity, and final velocity to displacement.

All of the needed quantities are known, so substitute them into the equation.
Simplify.

(a) The distance was 5.0 m.
Use the information to find the acceleration.

\[
a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t} = \frac{4.0 \, \text{m/s} - 0.0 \, \text{m/s}}{2.5 \, \text{s}} = 1.6 \, \text{m/s}^2
\]

(b) Her acceleration is 1.6 m/s².

Validate
The units for displacement are metres and metres per second for acceleration, which are correct. Both displacement and acceleration are positive, as they should be.

10. Frame the Problem
- Let time zero be the moment that Michael begins to accelerate.
- At time zero, Michael is 75 m behind Robert and will thus must run 75 m further than Robert in order to catch up with him.
- When Michael catches up to Robert, they will have run for the same amount of time.
- Michael is travelling with uniform acceleration. Thus, the equation of motion that relates displacement, initial velocity, acceleration, and time interval describes Michael's motion.
- Robert travels with constant velocity or uniform motion. Robert's motion can therefore be described by using the equation that defines velocity.

Identify the Goal
Length of time it will take Michael to catch up with Robert in the race

Variables and Constants

<table>
<thead>
<tr>
<th>Involved in the problem</th>
<th>Known</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Delta d_R + 75 , \text{m} )</td>
<td>( \Delta t )</td>
<td>( \Delta t )</td>
</tr>
<tr>
<td>( \Delta d_M )</td>
<td>( v_R )</td>
<td>( \Delta d_M )</td>
</tr>
<tr>
<td>( v_{M0} )</td>
<td>( v_R = 4.2 , \text{m/s} )</td>
<td>( \Delta d_R + 75 , \text{m} )</td>
</tr>
<tr>
<td>( a_M )</td>
<td>( a_M = 0.15 , \text{m/s}^2 )</td>
<td></td>
</tr>
</tbody>
</table>
Strategy
Write a mathematical equation that states that the distance Michael runs is equal to the distance Robert runs during the time interval, plus the 75 m Michael has to make up.

Substitute the equation that defines the velocity for Robert for $\Delta d_R$. Substitute the equation of motion that relates displacement, initial velocity, acceleration, and the time interval for Michael for $\Delta d_M$.

The time interval from time zero is the same for the two runners when Michael catches up with Robert. Solve for $\Delta t$, the unknown, after substituting the known values into the equations.

Use the quadratic formula to solve for $\Delta t$, since it cannot be easily factored.

Calculations

\[
\Delta d_M = \Delta d_R + 75 \, \text{m}
\]

\[
v_M \Delta t + \frac{1}{2} a_M \Delta t^2 = 75 \, \text{m} + v_R \Delta t
\]

\[
3.8 \frac{\text{m}}{\text{s}} \Delta t + \frac{1}{2} (0.15 \frac{\text{m}}{\text{s}^2}) \Delta t^2
\]

\[
= 75 \, \text{m} + 4.2 \frac{\text{m}}{\text{s}} \Delta t
\]

\[
3.8 \frac{\text{m}}{\text{s}} \Delta t + (0.075 \frac{\text{m}}{\text{s}^2}) \Delta t^2
\]

\[
= 75 \, \text{m} + 4.2 \frac{\text{m}}{\text{s}} \Delta t
\]

\[
3.8 \frac{\text{m}}{\text{s}} \Delta t - 4.2 \frac{\text{m}}{\text{s}} \Delta t
\]

\[
+ (0.075 \frac{\text{m}}{\text{s}^2}) \Delta t^2 - 75 = 0
\]

\[
-0.4 \frac{\text{m}}{\text{s}} \Delta t + (0.075 \frac{\text{m}}{\text{s}^2}) \Delta t^2 - 75 = 0
\]

\[
(0.075 \frac{\text{m}}{\text{s}^2}) \Delta t^2 - 0.4 \frac{\text{m}}{\text{s}} \Delta t - 75 = 0
\]

\[
\Delta t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}
\]

\[
\Delta t = \frac{(-0.4) \pm \sqrt{(-0.4)^2 - 4(0.075)(-75)}}{2(0.075)}
\]

\[
\Delta t = 0.4 \pm \sqrt{0.16 + 22.5}
\]

\[
\Delta t = 0.4 \pm \sqrt{22.66}
\]

\[
\Delta t = 0.4 \pm 4.76
\]

\[
\Delta t = 0.4 \pm 4.76
\]

\[
\Delta t = \frac{0.4 \pm 4.76}{0.15}
\]

\[
\Delta t = \frac{0.4 \pm 4.76}{0.15}
\]

\[
\Delta t = \frac{0.4 - 4.76}{0.15}
\]

\[
\Delta t = \frac{0.4 - 4.76}{0.15}
\]

\[
\Delta t = \frac{5.16}{0.15}
\]

\[
\Delta t = \frac{5.16}{0.15}
\]

\[
\therefore \Delta t = 34.4 \, \text{s}
\]

\[
\therefore \Delta t = -29.07 \, \text{s}
\]

Exclude $-29.07$, since a negative time has no meaning in this situation.

It will take Michael 34 s to catch Robert.

Validate
The time is positive, and it seems to be reasonable.

11. Frame the Problem
- Sketch and label the situation.

\[
V_i = 200 \frac{\text{km}}{\text{h}} = 55.6 \frac{\text{m}}{\text{s}}
\]

\[
a = 5.0 \frac{\text{m}}{\text{s}^2}
\]

\[
\Delta t = 8.0 \, \text{s}
\]

- Since the acceleration of the race car is constant, the equation of motion that relates displacement, initial velocity, acceleration, and time interval describes its motion.

Identify the Goal
How far the car has travelled (its displacement) after 8 s.
Variables and Constants

Known

- \( v_i = 200 \text{ km/h} \)
- \( \Delta t = 8.0 \text{ s} \)
- \( a = 5.0 \text{ m/s}^2 \)

Unknown

- \( \Delta d \)

Strategy

First, convert 200 km/h to m/s, since acceleration and time are given in these units.

Select the equation of motion that relates the unknown variable, \( \Delta d \), to the three known variables, \( a \), \( v_i \), and \( \Delta t \).

All of the needed quantities are known, so substitute them into the equation.

Simplify.

The race car travelled \( 6.0 \times 10^2 \text{ m} \) during the 8.0 s time interval.

Calculations

\[
\Delta d = v_i \Delta t + \frac{1}{2} a \Delta t^2
\]

\[
\Delta d = 55.6 \text{ m} (8.0 \text{ s})
\]

\[
+ \frac{1}{2} (5.0 \text{ m/s}^2)(8.0 \text{ s})^2
\]

\[
\Delta d = 444.8 \text{ m} + 160 \text{ m}
\]

\[
\Delta d = 604.8 \text{ m} = 605 \text{ m}
\]

\[
\Delta d = 604.8 \text{ m} = 600 \text{ m}
\]

Validate

The units cancelled to give metres for displacement, which is correct, and the displacement seems to be reasonable.

12. Frame the Problem

- Sketch and label the diagram of motion.

Identify the Goal

(a) The acceleration of the car

(b) The speed of the car just as it passes the green light

Variables and Constants

<table>
<thead>
<tr>
<th>Involved in the problem</th>
<th>Known</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>( v_i ) ( a ) ( \Delta t ) ( \Delta d )</td>
<td>( v_i = 20 \text{ m/s} ) ( a ) ( \Delta t = 150 \text{ m} ) ( \Delta t = 10 \text{ s} )</td>
<td>( a ) ( v_i )</td>
</tr>
</tbody>
</table>
Strategy
Select the equation of motion that relates the unknown variable, acceleration, to the three known variables, time, initial velocity, and displacement. Substitute and simplify.

Calculations
Rearrange \( \Delta d = v_1 \Delta t + \frac{1}{2} a \Delta t \)
to solve for \( a \).
\[
\begin{align*}
\frac{\Delta d}{\Delta t} &= \frac{20}{100} - \frac{20}{10} \\
\frac{300}{100} &= \frac{40}{10} \\
\frac{30}{100} &= \frac{40}{10} \\
a &= \frac{10}{-10} \\
a &= -10 \, \text{m/s}^2
\end{align*}
\]
(a) The motorist's acceleration is \(-10 \, \text{m/s}^2\).
Select the equation that relates final velocity to the initial velocity, acceleration, and time interval.
\[
v_f = v_i + a \Delta t
\]
(b) The final velocity of the car just as it passes the green light is 10 m/s.

Validate
The negative value of the acceleration indicated the motorist slowed down to a reasonable final velocity of 10 m/s.

Solutions for Problems for Understanding
Student Textbook pages 86–87

15. (a) A car is moving in the frame of reference of the road.
    (b) A car is at rest in the frame of reference of the trailer.

16.

17. (a) The total distance is 17 km \((d = 5.0 \, \text{km} + 12 \, \text{km})\).
    (b) Their displacement is 7 km[S].
    (c) To get back to their starting point, the displacement would be 7 km[N].

18. The cyclist travels 25 km[W],
\[
\Delta d = v_i \Delta t,
\]
\[
\begin{align*}
\Delta d &= \frac{25 \, \text{km}}{1 \, \text{hr}} \times \frac{3600 \, \text{s}}{1 \, \text{hr}} \\
\Delta d &= 5.9 \, \text{m/s}[\text{W}](4320 \, \text{s}) \\
\Delta d &= 25,488 \, \text{m}[\text{W}] \\
\Delta d &= 25,488 \, \text{km}[\text{W}]
\end{align*}
\]

19. (a) The displacement of the canoeist is 0.4 km[downstream].
    Let downstream be positive and upstream be negative.
Practice Problems
Student Textbook page 45
All solutions for Practice Problems are in the Solutions Manual.

2.2a Section Review: Answers
Student Textbook page 46
1. (a) Four scalar quantities are time, mass, speed, and distance. Five vector quantities are position, displacement, velocity, acceleration, and force.
   (b) "Time" refers to time interval. "Time interval" means the period of time between two instants and is given by \( \Delta t = t_2 - t_1 \).
   (c) Position, displacement, and distance are all measures of length and have a magnitude. Position and displacement have a direction, whereas distance does not have a direction.
   (d) Speed is how measure the speed at which an object is travelling. Speed is a scalar quantity, and velocity is a vector quantity. Velocity has magnitude, unit, and direction, whereas speed has magnitude and unit only.
3. (a) Missed 365 1/4 days, Earth returns to its initial position in its orbit around the Sun, and thus its displacement is zero.
   (b) For example, "The displacement of my house to the school is \( \Delta d = 1.4 \) km [567° W]."
   (c) Refer to the scale drawings below.

- **Scale 1 cm = 2 km**
  - \( \Delta d = 9 \) km [146° W]

- **Scale 1 cm = 100 m**
  - \( \Delta x = 1.23 \) m [346° W]

- **Scale 1 cm = 1 m/s**
  - \( v = 0.3 \) m/s [346° W]

- **Scale 3 cm = 1 m/s**
  - \( v = 1.07 \) m/s [346° W]

2.3 Constant, Average, and Instantaneous Velocity
Student Textbook pages 47-50
In uniform motion, the velocity is constant. In non-uniform motion, the velocity changes. The average velocity is the velocity between two points on a position-time graph and may be unreasonable if the direction changes between the two points. The instantaneous velocity is actually an average velocity between two points where the time interval is so small that it approaches zero.

**Constant Velocity**
Student Textbook pages 47-49

**Physics Background**
The only way to be certain that an object has constant velocity is to have continuous data indicating that the same velocity is being maintained during each time interval.

**Teaching Strategy**
Brainstorm situations in which students believe velocity is constant. Discuss the reasons why it might or might not be constant.

**Quick Lab**
Maintaining a Constant Pace
Student Textbook page 59
Approximate Time Required: 30 min

**Teaching Tip**
Have students practice pulling the tape at a constant speed before the actual slalom run.

Answers to Analyze and Conclude Questions
1. Answers will vary.
2. Answers will vary.

Answers to Apply and Extend Questions
2. (a) No, there is not enough data. The student may have stopped, slowed down, or speeded up during the trip.
   (b) You have data for several instants in time, but no data for displacements.
   Therefore, you cannot determine whether the dog's velocity was constant.
   (c) Without continuous data, you cannot be certain that the swimmer's velocity is constant.
UNIT II Chapter 2 MECHANICAL MOTION

Assessment and Evaluation

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<th>Feature</th>
<th>Current Expectation</th>
<th>Assessment/Target/Interval</th>
<th>Achievement/Digit/Qualifiers</th>
<th>Learning Skills</th>
</tr>
</thead>
<tbody>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
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<td>(20)</td>
<td>-</td>
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<td>- (Q3)</td>
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<td>- (Q4)</td>
<td>(20)</td>
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<td>- (Q5)</td>
<td>(20)</td>
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<tr>
<td>- (Q6)</td>
<td>(20)</td>
<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>- (Q7)</td>
<td>(20)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Practice Problems

Student Textbook pages 77-78
All solutions for Practice Problems are in the Solution Manual.

2.3 Section Review Answers

Student Textbook page 66

1. an a Diving downtown in rush hour will involve changes in direction and frequent changes in speed, so it is non-uniform motion.
   an b Whenever an object moves in steps, its velocity changes, making the motion non-uniform.
   an c The pendulum changes direction and speed as it swings in its cycle, therefore, it experiences non-uniform motion.
   an d A ball rolling down a ramp experiences an increase in velocity and, thus, non-uniform motion.
   an e The merry-go-round motion implies change in direction and, thus, non-uniform motion.
motion and attitude. How is the property of a body known?

- Distance from the center of mass
- Angular momentum
- Angular velocity
- Torque
- Angular acceleration

**Learning Objectives**

- Understand the relationship between angular motion and linear motion.
- Learn how to calculate the properties of a rotating body.
- Explore the conservation of angular momentum.

The properties of a rotating body are determined by its moment of inertia and angular velocity.

**Physical Background**

- **Moment of Inertia:** The moment of inertia is a measure of an object's resistance to rotation.
- **Angular Velocity:** The angular velocity is the rate at which an object rotates.
- **Torque:** The torque is the rotational equivalent of force.

**Direction of Acceleration Vectors**

- The direction of acceleration vectors at a point on a rotating object is given by the direction of the net torque divided by the moment of inertia.

**Problem**

- Given a rotating object with a moment of inertia of 1 kg m² and a net torque of 5 N m, calculate the angular acceleration.

**Solution**

- \[ \alpha = \frac{T}{I} \]
- \[ \alpha = \frac{5 \text{ N m}}{1 \text{ kg m}^2} = 5 \text{ rad/s}^2 \]

**Diagram**

- A diagram showing the relationship between the moment of inertia, angular velocity, and torque is included.

**Graph**

- A graph illustrating the conservation of angular momentum is included.

- The relationship between the moment of inertia, angular velocity, and torque is shown.
9. Air friction would produce a decrease in the value of $a$, causing objects to fall at a slower rate.
10. The precision and accuracy of the measuring instruments could introduce errors.
11. Students might not have been accurate or careful enough while remeasuring the distance between dots, making the velocity and then the acceleration determination inaccurate. Make sure the timer frequency is adjusted properly and use new carbon discs. Make sure the recording tape falls freely through the timer.
12. The shape of the object may affect its free-fall properties. Objects that are not streamlined and have flat shapes might be slowed down by drag forces.

Answer to Apply and Extend Question
13. You could use the same equipment as in the above investigation to test objects of the same mass but with different slopes. Oval streamlined shapes would be the most aerodynamic, due to a low drag coefficient.

Assessment and Evaluation

<table>
<thead>
<tr>
<th>Assessment - Tool/Outcomes</th>
<th>Assessment - Checklist &amp; Rubric</th>
<th>Anticipated - Class Categories</th>
<th>Learning Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understanding Basic Concepts</td>
<td>- Assessment Checklist &amp; Laboratory Rubric</td>
<td>- Knowledge and Understanding</td>
<td>- Testwork</td>
</tr>
<tr>
<td>- FM &amp; LSE analysis and interpretation of the gravitational force acting on an object mass, and at a distance using the surface of Earth</td>
<td>- Understanding</td>
<td>- Organization</td>
<td>- Initiative</td>
</tr>
<tr>
<td>Developing Skills of Inquiry and Communication</td>
<td>- Individual/Group Experiment to identify specific variables that affect motion</td>
<td>- Inquiry</td>
<td>- Inquiry</td>
</tr>
<tr>
<td>- FM &amp; LSE</td>
<td>- Using Math in Science</td>
<td>- Communication</td>
<td>- Inquiry</td>
</tr>
<tr>
<td>- FM &amp; LSE</td>
<td>- Rubric for Investigations 2-3</td>
<td>- Writing Connections</td>
<td>- Writing</td>
</tr>
<tr>
<td>- FM &amp; LSE</td>
<td>- &quot;Assessment and Evaluation&quot; in the front matter of Teacher's Resource</td>
<td>- Writing Connections</td>
<td>- Writing</td>
</tr>
</tbody>
</table>

2.4 Section Review Answers

Student Textbook page 70
1. (a) Bob and Al are walking together during the following time periods: 17.5 s to 27 s, 35 s to 48 s, 54 s to 69 s, 72 s to 81 s.
   (b) Al and Bob are 12.5 s, 22.5 s, 50 s, and 62.5 s.
   (c) Al and Bob are 12.5 s, 22.5 s, 32.5 s, and 42.5 s.
   (d) Bob is increasing in speed in a certain direction.
   (e) The velocity is zero when the ball is at the top of its path. There is no point on the following graph where the acceleration is zero.

2. (a) A constant acceleration means that the velocity of an object changes uniformly for equal time intervals. A non-uniform acceleration implies the velocity of an object is changing by a different amount (discontinuously) for equal time intervals.
   (b) Average acceleration for an interval of time is equal to the slope of the line joining the two points on a velocity-time graph. Instantaneous acceleration is the value approached by the average acceleration as the time interval approaches zero. The average acceleration is equal to the instantaneous acceleration if the velocity-time graph is a straight line.
   (c) A tangent line is drawn to find the instantaneous acceleration at a specific point of time on a velocity-time graph. To calculate the acceleration, you must find the slope of the tangent. The time interval is the run between any two points selected on the tangent line.
   (d) "Negative acceleration" means that the acceleration vector points in the negative direction, according to the chosen frame of reference. "Deceleration" is a non-technical term that means "slowing down."
   (e) m/s² are units for velocity, and m/s are units for acceleration. Acceleration is defined as the change in velocity during a time interval. You can express the units as "meters per second, second squared." Thus, a change in velocity (m/s) gives its acceleration (m/s²).

3. (b) The direction of an acceleration vector obtained by subtracting the initial velocity vector from the final velocity vector (F = V - V). Join the vectors tail to tail and the resultant is a vector joining the head of the "m" vector to the head of the "F" vector.
   (c) Both are increasing in speed, moving in a certain direction.

7. (a) The top left-hand graph in the textbook represents constant positive acceleration. The top right-hand graph represents constant negative acceleration and, thus, no acceleration. The bottom left-hand graph represents constant velocity, and thus, no acceleration. The bottom right-hand graph represents increasing negative acceleration (non-uniform acceleration).


### Chapter 2 Review Answers

**Knowledge and Understanding**

1. **Kinematics** is the study of the description of motion without regard to its causes.
2. **Dynamics** is the study of the causes (forces or other agents) of motion.
3. **Mechanics** is the study of motion and includes both kinematics and dynamics.
4. **Velocity** is the rate of change of displacement.
5. **Acceleration** is the rate of change of velocity.
6. The frame of reference is the location or position with which the motion of an object is compared. The selected coordinate system is at rest in the frame of reference.
7. A vector is a quantity that contains a magnitude, unit, and direction, such as position and acceleration.
8. A scalar is a quantity that contains a magnitude and unit only such as speed and distance.

2. Movies, videos, and cartoons are actually still frames in which the positions of objects change a small amount from frame to frame. The frame rate is so low that we do not perceive that the objects are moving.

2. **Average velocity** is equal to the slope of the straight line joining two points on a position-time graph. The instantaneous velocity is the value approached by the average velocity as the time interval approaches zero. It is obtained by finding the slope of the tangent at a moment in time on a position-time graph.

3. **Average acceleration** for an interval of time is equal to the slope of the line joining the two points on a velocity-time graph. Instantaneous acceleration is the value approached by the average acceleration as the time interval approaches zero. It is obtained by finding the slope of the tangent at a moment in time on a velocity-time graph.

4. **Application of a changing force on an object could produce a non-uniform acceleration.** A constant force such as gravity would cause a uniform acceleration.

5. The area under a force-time graph is equal to the impulse of the force. The area under a force-time graph is equal to the impulse of the force. The area under a force-time graph is equal to the impulse of the force. The area under a force-time graph is equal to the impulse of the force.

6. When an object is accelerating, its velocity is changing every second. For example, if an object is accelerating at 5 m/s², its velocity is changing, increasing by 5 m/s every second.

7. **Application of a centripetal force at a constant speed produces a circular motion.** A centripetal force such as gravity would cause a uniform circular motion.

8. Some applications of centripetal force are a car driving around a curve; the design of runways, where planes speed up or slow down; spacecraft and all vehicles undergoing rapid velocity changes; parachutes and braking systems designed to slow down objects; anti-gravity suits, etc.

9. A negative sign under a velocity-time graph means the object is moving in the negative direction. For example, if east is defined as the positive direction, the object would be moving west.
Problems For Understanding

11. How can this be achieved with your

12. What is the impact of this action?

Thinking Connections

13. I can see a clear pattern here, can you explain it?

Communication

14. The diagram illustrates the interaction of the components shown.

Integrity

15. It is important to understand the underlying principles.