These notes are posted on my site for the following reasons:

- for students to copy in their own hand-writing
  - in order to complete their class notes
  - if student did not have enough time in class
  - if student was away and missed this section
- for assistants and tutors to follow progress of the concepts taught

Photocopied/printed notes can not be used during the Unit Notebook Check in class.

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9.2 Calculating Acceleration

- **The acceleration of an object is dependent upon the change in velocity and the time required to change the velocity.**
- **When stopping a moving object, the relationship between time and acceleration is:**
  - **Increasing the stopping time decreases the acceleration**
  - **Decreasing the stopping time increases the acceleration**

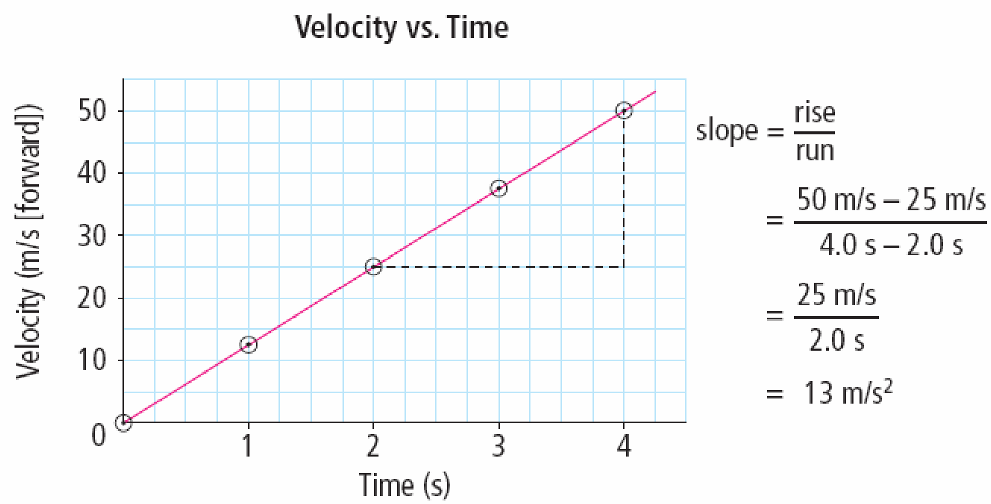
Airbags cause the person to slow down in a longer period of time compared to hitting a solid object, such as the dashboard. This increased time results in a smaller deceleration.

See page 56

Velocity-Time Graphs

- **The motion of an object with uniform motion is best represented by a position-time graph.**
- **The motion of an object with a changing velocity is best represented by a velocity-time graph.**
- **The slope of a velocity-time graph is average acceleration.**
- **Acceleration is measured in m/s^2.**

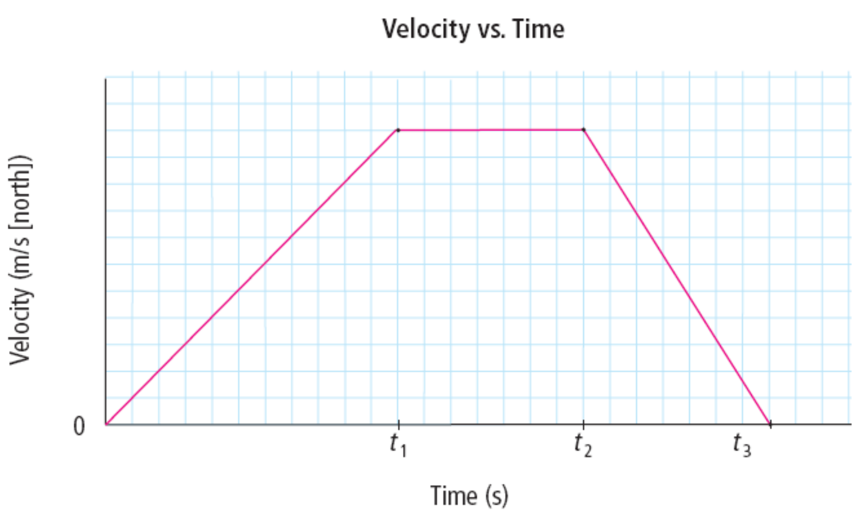
The slope of a velocity-time graph is the average acceleration of the object.



See pages 57 - 58

Determining Motion from a Velocity-Time Graph

- **A velocity-time graph can be analyzed to describe the motion of an object.**
  - **Positive slope (positive acceleration) – object's velocity is increasing in the positive direction.**
  - **Zero slope (zero acceleration) – object's velocity is constant.**
  - **Negative slope (negative acceleration) – object's velocity is decreasing in the positive direction or the object's velocity is increasing in the negative direction.**



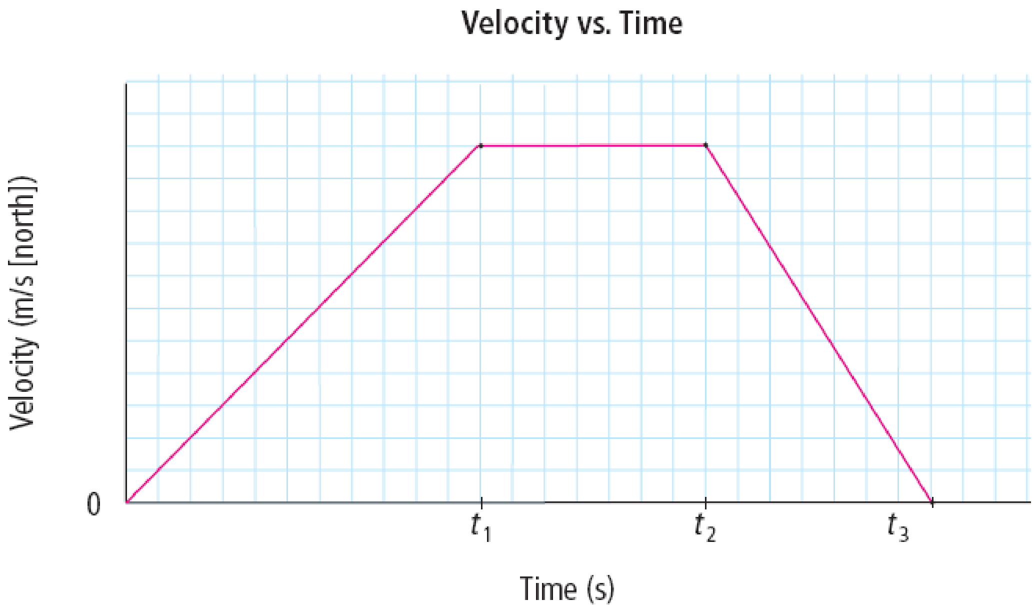
During which time interval was

a) The acceleration zero?
b) The acceleration negative?
c) The acceleration positive?
d) The object increasing it's velocity north?
e) The object decreasing it's velocity north?
f) The object moving at a constant velocity north?

Answers on next slide

See pages 58 - 59

Determining Motion from a Velocity-Time Graph



During which time interval was

a) The acceleration zero? *(t_1 to t_2)*

b) The acceleration negative? *(t_2 to t_3)*

c) The acceleration positive? *(0 to t_1)*

d) The object increasing it's velocity north? *(0 to t_1)*

e) The object decreasing it's velocity north? *(t_2 to t_3)*

f) The object moving at a constant velocity north? *(t_1 to t_2)*

See pages 58 - 59

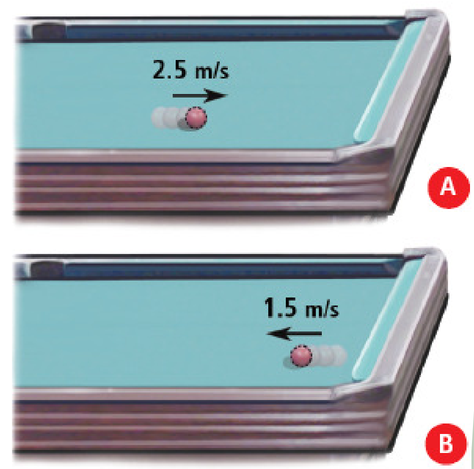
Calculating Acceleration

- The relationship of acceleration, change in velocity, and time interval is given by the equation:

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$$

Example:

- A pool ball traveling at 2.5 m/s, towards the cushion bounces off at 1.5 m/s. If the ball was in contact with the cushion for 0.20 s, what is the ball's acceleration? (Assume towards the cushion is the positive direction.)



$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t} \text{ where } \Delta \vec{v} = \vec{v}_f - \vec{v}_i$$

$$= \frac{-1.5 \text{ m/s} - 2.5 \text{ m/s}}{0.20 \text{ s}}$$

$$= \frac{-4.0 \text{ m/s}}{0.20 \text{ s}}$$

$$= -20 \text{ m/s}^2$$

The acceleration is 20 m/s² away from the cushion.

See pages 60 - 61

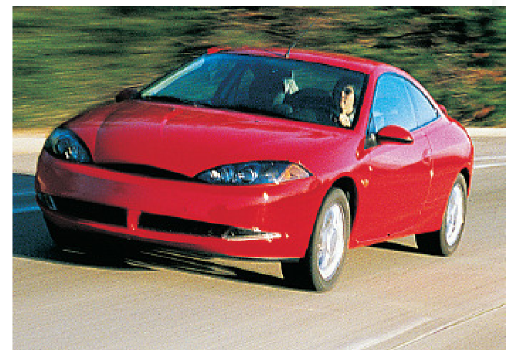
Calculating Acceleration

- The relationship of change in velocity, acceleration, and time interval is given by the equation:

$$\Delta\vec{\mathbf{v}} = (\vec{\mathbf{a}})(\Delta t)$$

Example:

- A car accelerates from rest at 3.0 m/s^2 forward for 5.0 s. What is the velocity of the car at the end of 5.0 s?



$$\begin{aligned} \Delta\vec{\mathbf{v}} &= (\vec{\mathbf{a}})(\Delta t) \\ &= (3.0 m/s^2)(5.0 s) \\ &= 15 m/s \end{aligned}$$

The car's change in velocity is 15 m/s forward, therefore

$$\begin{aligned} \Delta\vec{\mathbf{v}} &= \vec{\mathbf{v}}_{\mathbf{f}} - \vec{\mathbf{v}}_{\mathbf{i}} \\ 15 m/s &= \vec{v}_f - 0 \\ \vec{\mathbf{v}}_{\mathbf{f}} &= 15 m/s \end{aligned}$$

The car's velocity after 5.0 s is 15 m/s forward.

See pages 60 - 61

Calculating Acceleration

- The relationship of time interval, change in velocity, and acceleration is given by the equation:

$$\Delta t = \frac{\Delta \vec{\mathbf{v}}}{\vec{\mathbf{a}}}$$

Example:

- A train is travelling east at 14 m/s. How long would to increase its velocity to 22 m/s east, if it accelerated at 0.50 m/s^2 east? (assign east direction positive (+)).

$$\Delta \vec{\mathbf{v}} = \vec{\mathbf{v}}_{\mathbf{f}} - \vec{\mathbf{v}}_{\mathbf{i}} = (22m/s) - (14\,m/s) = 8.0m/s$$

To find the value of Δt:

$$\Delta t = \frac{\Delta \vec{\mathbf{v}}}{\vec{\mathbf{a}}} = \frac{8.0m/s}{0.50m/s^2} = 16s$$

It would take 16 s for the train to increase it's velocity.

See pages 60 - 61

Calculating Acceleration

Try the following acceleration problems.

Answers on the next slide.

1. A truck starting from rest accelerates uniformly to 18 m/s [W] in 4.5 s. What is the truck's acceleration?

2. A toboggan moving 5.0 m/s forward decelerates backwards at -0.40 m/s^2 for 10 s. What is the toboggan's velocity at the end of the 10 s?

3. How much time does it take a car, travelling south at 12 m/s, to increase its velocity to 26 m/s south if it accelerates at 3.5 m/s^2 south?

See page 61

Calculating Acceleration

Try the following acceleration problems.

1. **A truck starting from rest accelerates uniformly to 18 m/s [W] in 4.5 s. What is the truck's acceleration? (4.0 m/s^2 [W])**

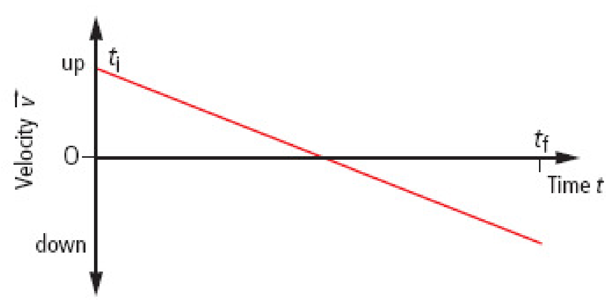
2. **A toboggan moving 5.0 m/s forward decelerates backwards at -0.40 m/s^2 for 10 s. What is the toboggan's velocity at the end of the 10 s? (1.0 m/s forward)**

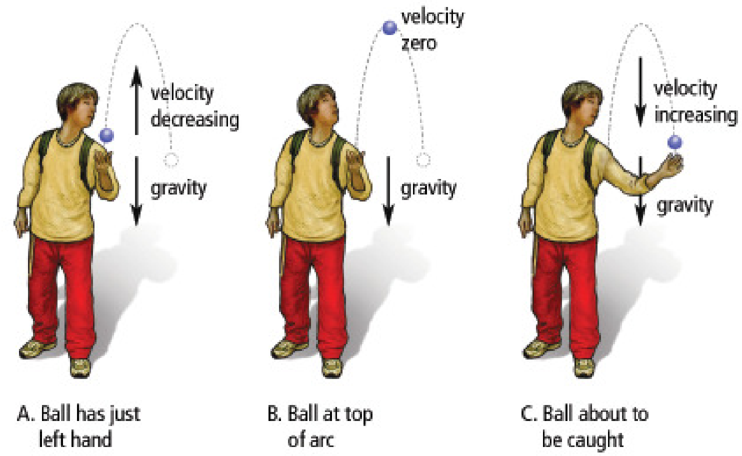
3. **How much time does it take a car, travelling south at 12 m/s, to increase its velocity to 26 m/s south if it accelerates at 3.5 m/s^2 south? (4.0 s)**

See page 61

Gravity and Acceleration

- **Objects, near the surface of the Earth, fall to the Earth due to the force of gravity.**
    - **Gravity is a pulling force that acts between two or more masses.**
- **Air resistance is a friction-like force that opposes the motion of objects that move through the air.**
- **Ignoring air resistance, all objects will accelerate towards the Earth at the same rate.**
    - **The acceleration due to gravity is given as 9.8 m/s^2 downward.**





See pages 62 - 63

Calculating Motion Due to Gravity

- **To analyze situation where objects are accelerating due to gravity, use the equations:**

$$\vec{\mathbf{a}} = \frac{\Delta\vec{\mathbf{v}}}{\Delta t} \qquad \Delta\vec{\mathbf{v}} = (\vec{\mathbf{a}})(\Delta t) \qquad \Delta t = \frac{\Delta\vec{\mathbf{v}}}{\vec{\mathbf{a}}}$$

- **In these equations the acceleration ($\vec{a}$) is 9.8 m/s^2 downward.**
- **Example:**
  - **Suppose a rock falls from the top of a cliff. What is the change in velocity of the rock after it has fallen for 1.5 s? (Assign "down" as negative (-))**

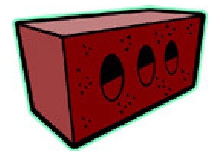
$$\begin{aligned} \Delta\vec{v} &= (\vec{a})(\Delta t) \\ &= (-9.8\ \text{m}/\text{s}^2)(1.5\ \text{s}) \\ &= -15\ \text{m}/\text{s} \end{aligned}$$

Since down is negative (-), the change in the rock's velocity is 15 m/s down.

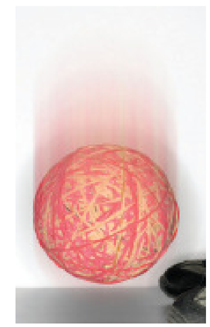
See page 64

Calculating Motion Due to Gravity

Try the following acceleration due to gravity problems. (Answers on the next slide)



1. What is the change in velocity of a brick that falls for 3.5 s?



2. A ball is thrown straight up into the air at 14 m/s. How long does it take for the ball to slow down to an upward velocity of 6.0 m/s?

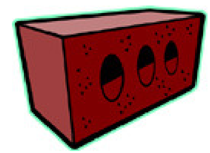
3. A rock is thrown downwards with an initial velocity of 8.0 m/s. What is the velocity of the rock after 1.5 s?

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t} \qquad \Delta \vec{v} = (\vec{a})(\Delta t) \qquad \Delta t = \frac{\Delta \vec{v}}{\vec{a}}$$

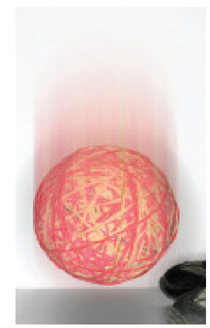
See page 64

Calculating Motion Due to Gravity

Try the following acceleration due to gravity problems.



1. What is the change in velocity of a brick that falls for 3.5 s? (34 m/s downward)



2. A ball is thrown straight up into the air at 14 m/s. How long does it take for the ball to slow down to an upward velocity of 6.0 m/s? (0.82 s)

3. A rock is thrown downwards with an initial velocity of 8.0 m/s. What is the velocity of the rock after 1.5 s? (23 m/s downward)

[Take the Section 9.2 Quiz]

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