Describing Motion: Kinematics in One Dimension

AP Physics

Chapter 2

Describing Motion: Kinematics in One Dimension

AP Physics

Section 2-1 Reference Frames and Displacement

IA1a -

Students should understand the general relationships among position, velocity, and acceleration for the motion of a particle along a straight line

Describing Motion: Kinematics in One Dimension

understand the general relationships among position, velocity, and acceleration

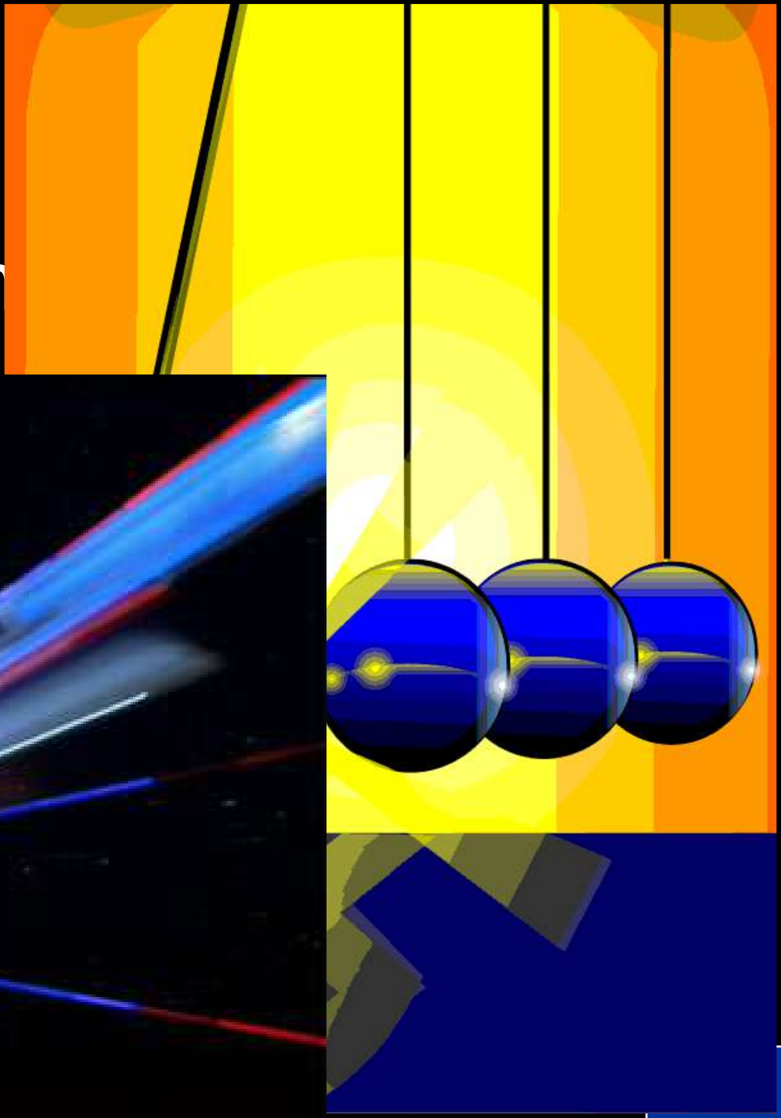
Mechanics – study of

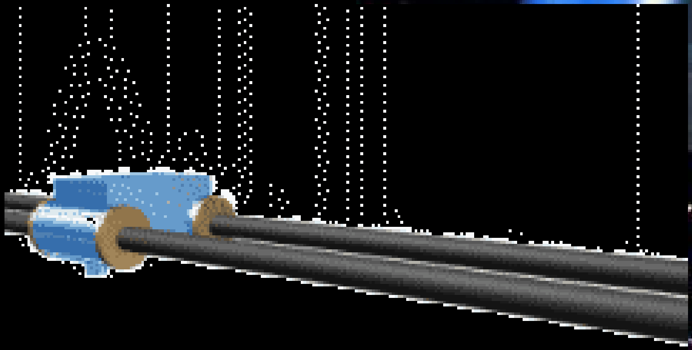
motion, force, energy

Kinematics – how objects n

Dynamics

Translatic





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understand the general relationships among position, velocity, and acceleration

Reference Frames (Frames of Reference)

- Are we moving?
- Compa
- Usually
- Unless
- All othe e of referenc
- Typicall d x and y axis (only

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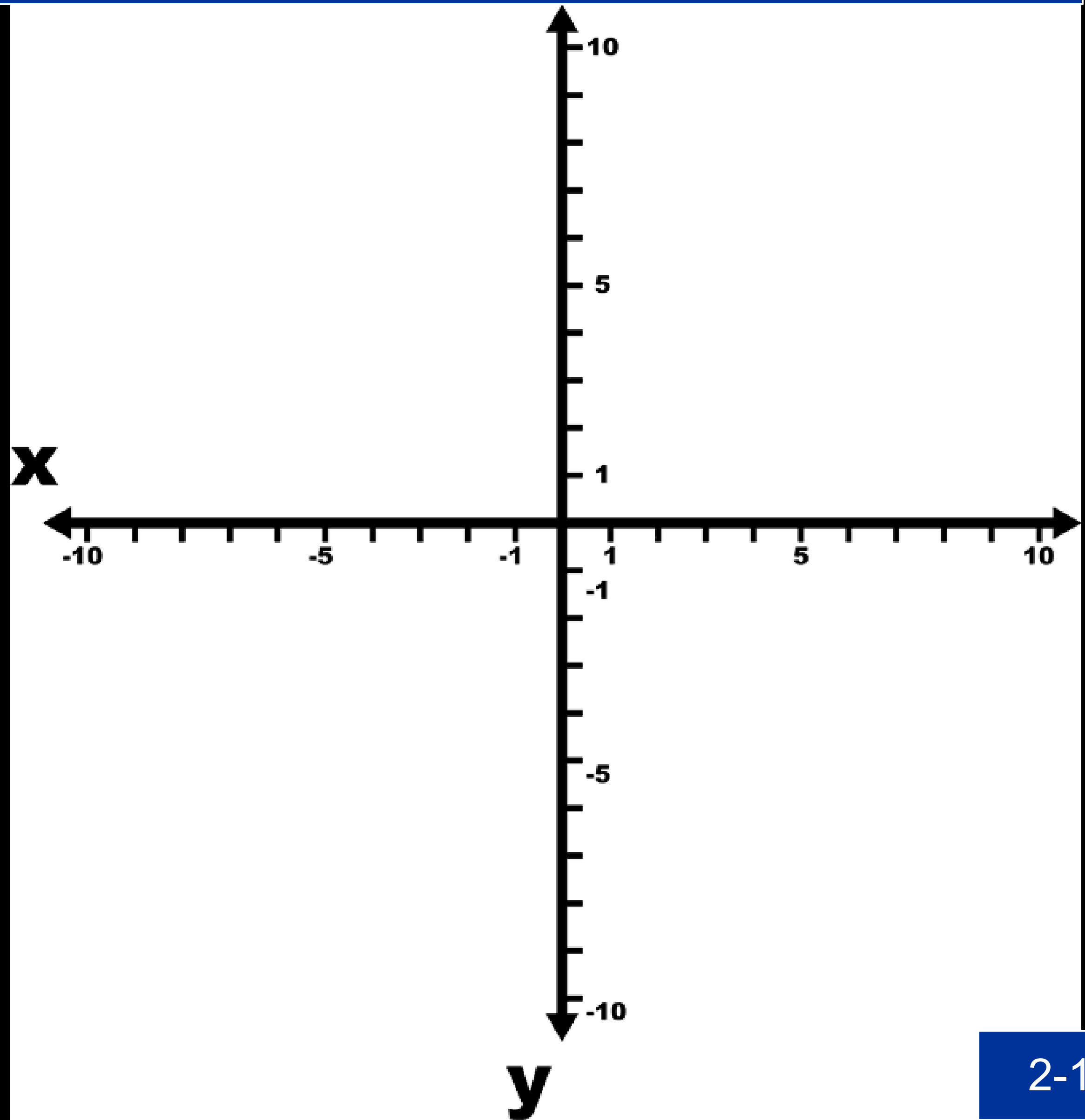
understand the general relationships among position, velocity, and acceleration

Positive – up and right

Negative – down and left



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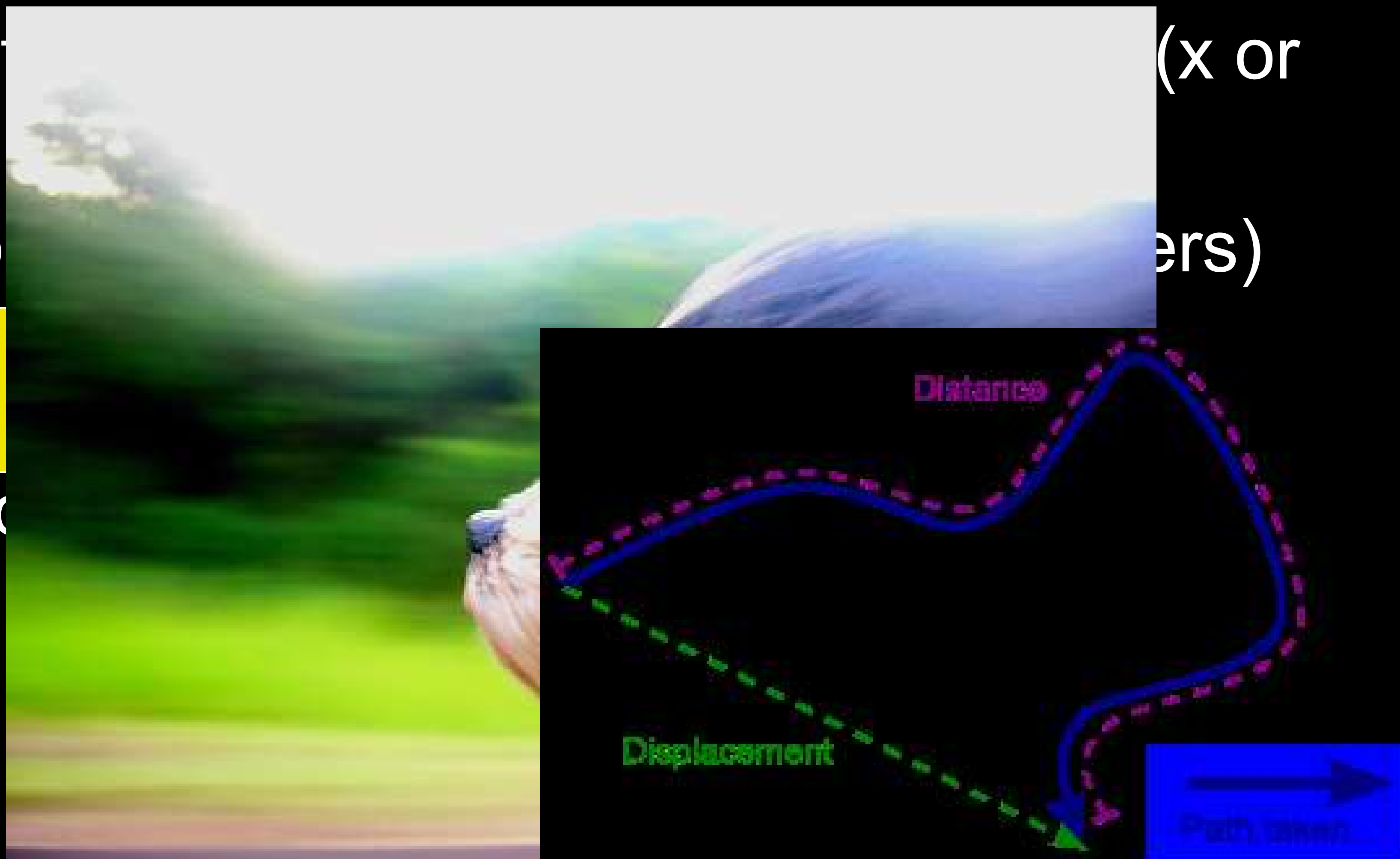
understand the general relationships among position, velocity, and acceleration

Defining Motion

Posi (x or y)

Disp ers)

Not c



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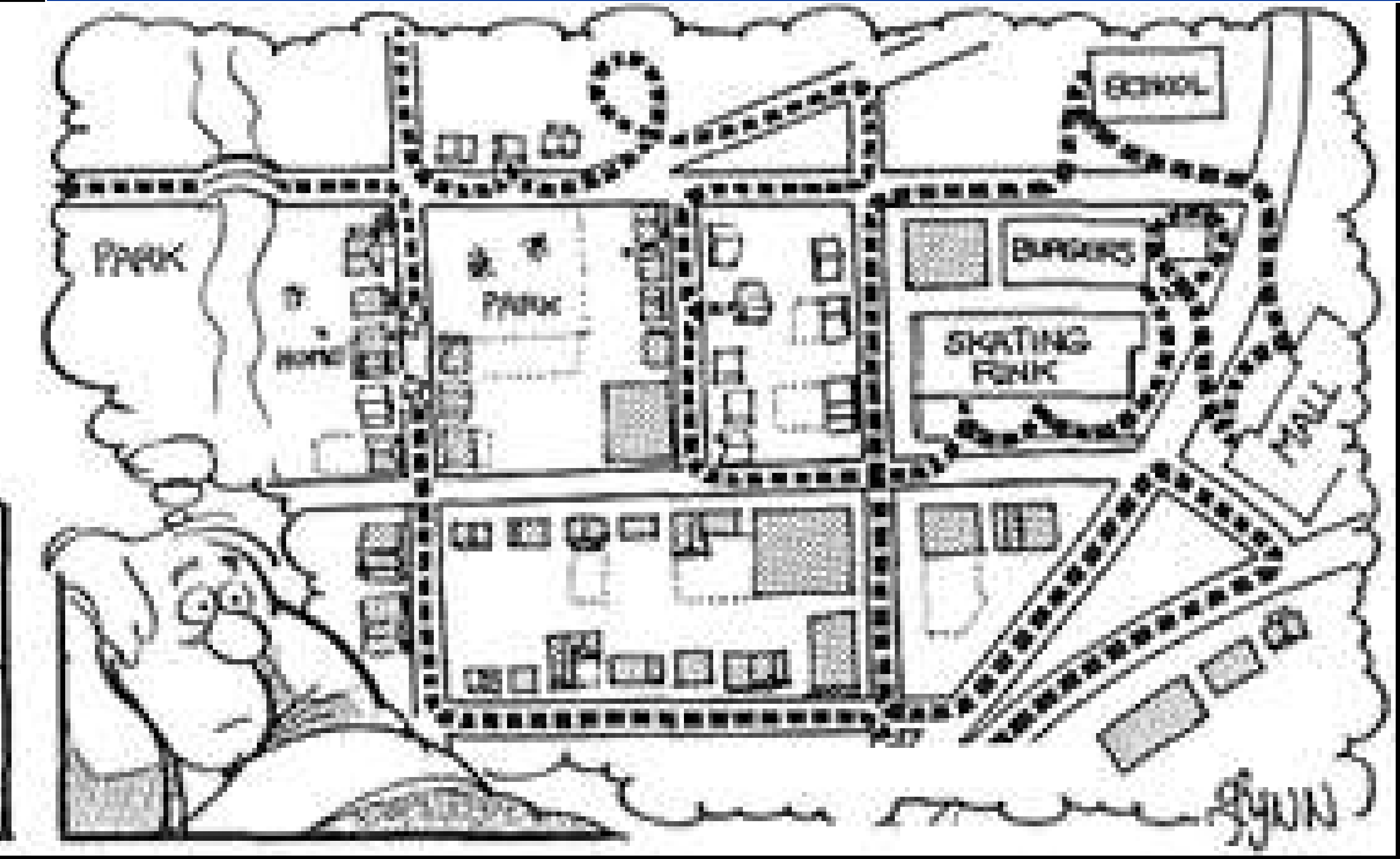

Distance vs. Displacement

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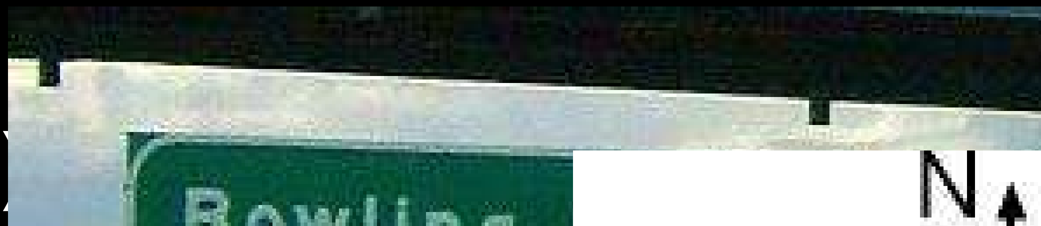
understand the general relationships among position, velocity, and acceleration

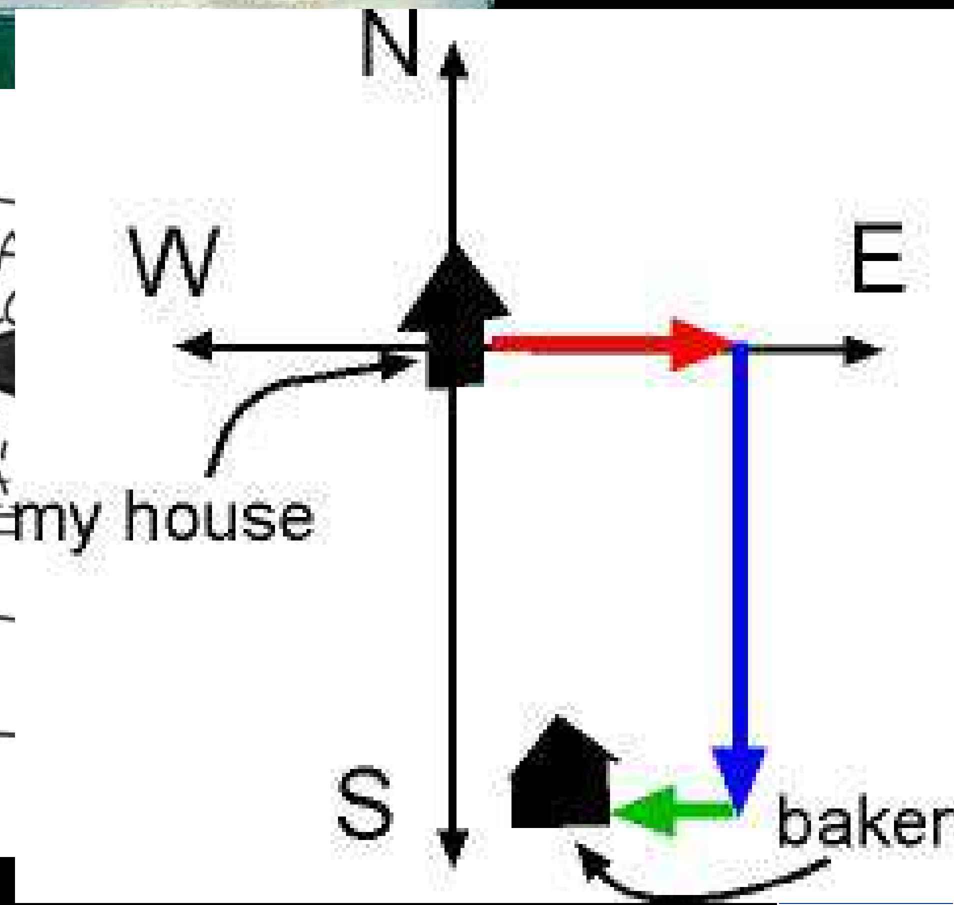
Distance – scalar (magnitude)

Displace nd direction)

Must give

East/Wes





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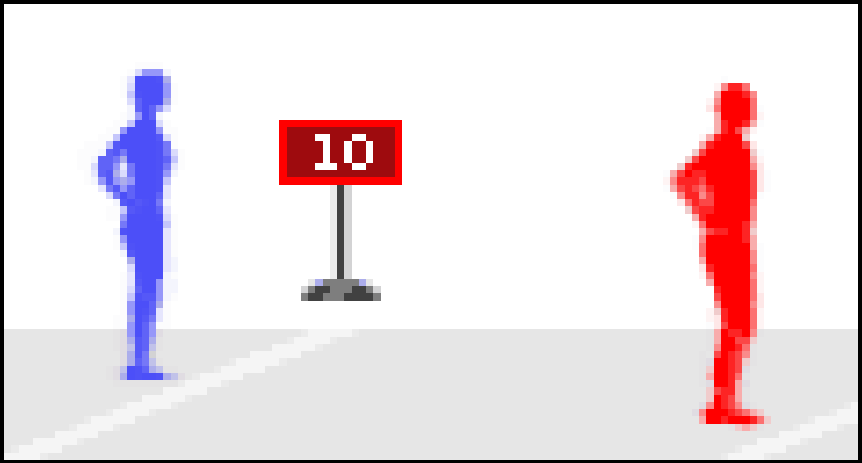
Section 2-2 Average Velocity

Distance Time Graph Gizmo



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Average Speed – distance per unit time (scalar)

Average Velocity – displacement per unit time (vector)(meters/second)

$$\bar{v} = \frac{\Delta x}{\Delta t}$$

Δx = displacement

Δt = change in time

Distance Time Velocity Graph Gizmo

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Section 2-3 Instantaneous Velocity

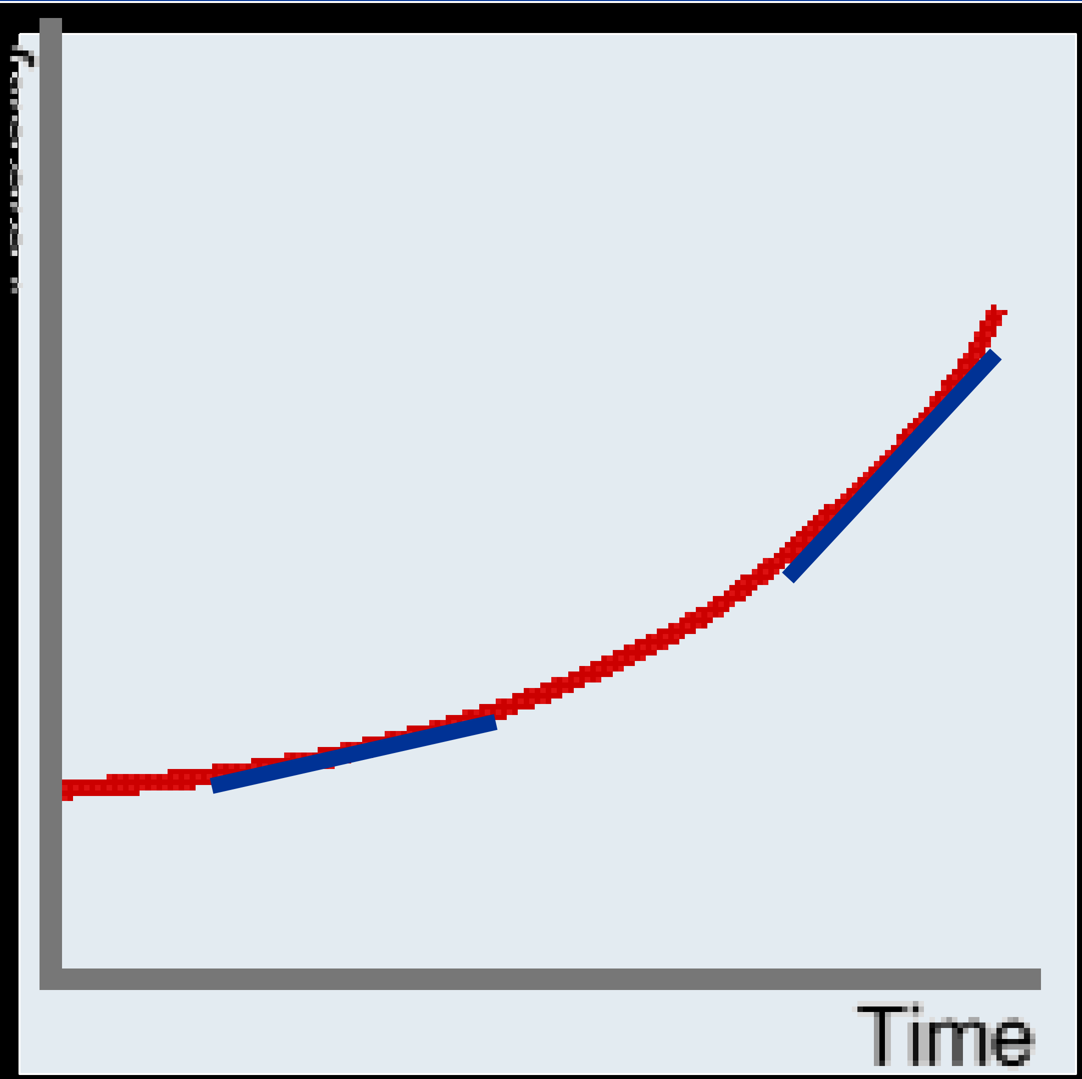
Instantaneous Velocity – the average velocity during an infinitesimally short time interval

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$$

We will only calculate situations with constant velocity or constant acceleration

Calculus is required if acceleration is not constant

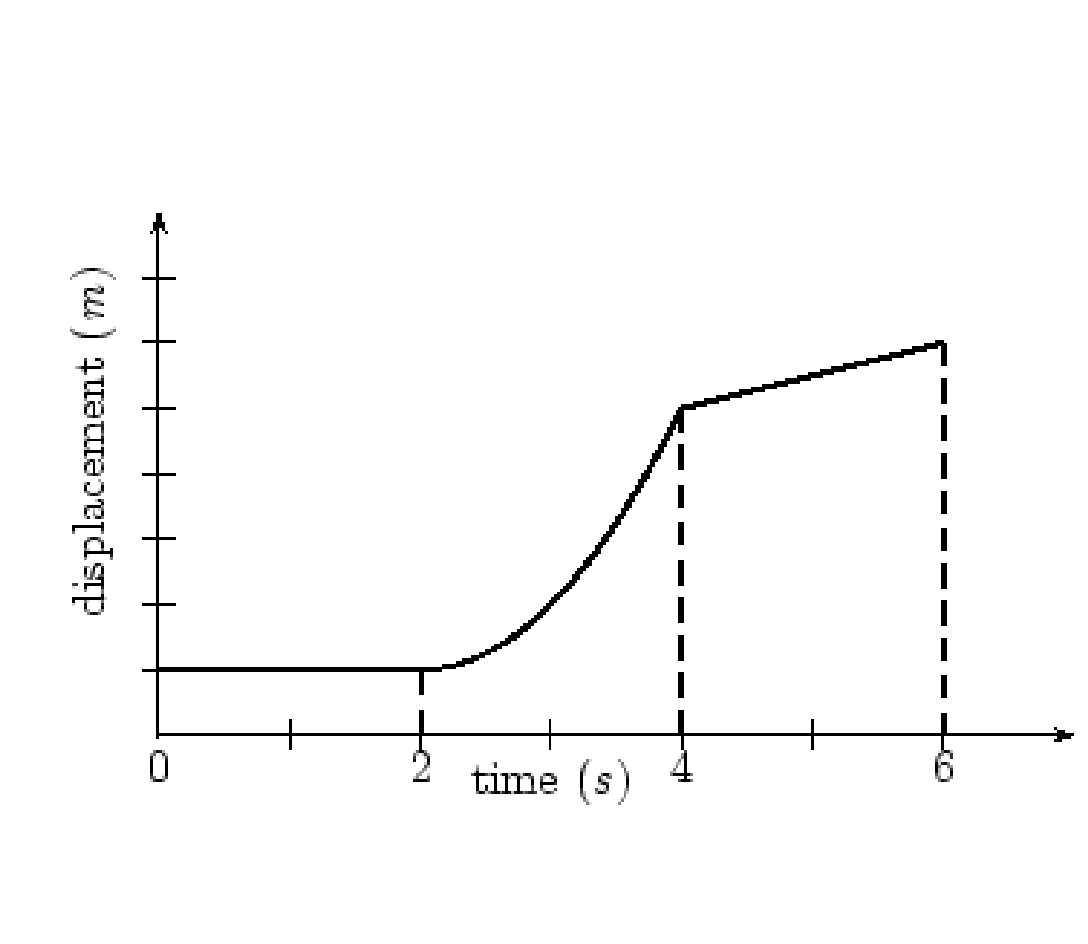
Slope of any displacement time graph is the instantaneous velocity



S-2

Using the graph calculate the average velocity between $t_0=2$ and $t=5$

APP-Matt-09



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Average Acceleration – change in velocity per unit time (vector) (meters/second^2)

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v - v_0}{t - t_0}$$

v is final velocity

v_0 is initial velocity (or at time 0)

Sign of a indicates direction of vector

Deceleration is just negative acceleration

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Section 2-4 Acceleration

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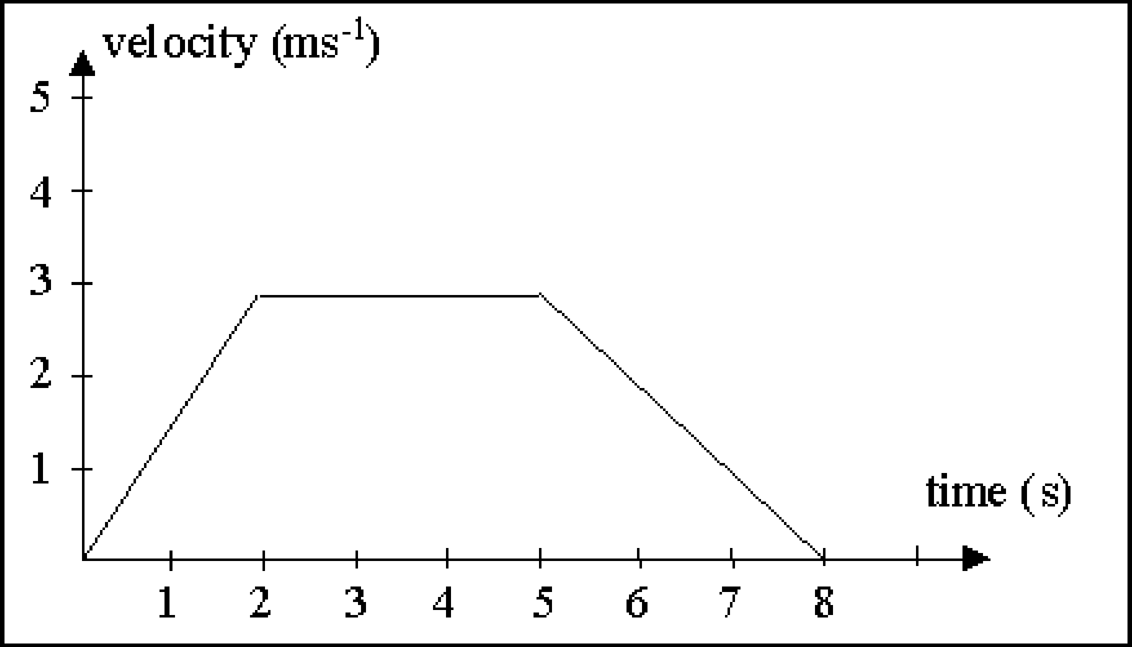
understand the general relationships among position, velocity, and acceleration

Acceleration is the slope of the velocity time graph



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understand the special case of motion with constant acceleration

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Section 2-5 Motion at Constant Acceleration

IA1b -

Students should understand the special case of motion with constant acceleration.

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We are limited to calculations when acceleration is a constant

We will usition of displacem ration to derive 4 K

Memori se them a lot

The Kinematic Equations

$$d = v_i * t + \frac{1}{2} * a * t^2 \qquad v_f^2 = v_i^2 + 2 * a * d$$

$$v_f = v_i + a * t \qquad d = \frac{v_i + v_f}{2} * t$$

Assume

$t_0 = 0$, it drops out of equations

We rework the definition of acceleration to get our first working equation

$$a = \frac{v - v_0}{t - t_0}$$

$$a = \frac{v - v_0}{t}$$

$$v = v_0 + at$$

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For the second equation we first rework the definition of average velocity to solve for displacement

$$\bar{v} = \frac{x - x_0}{t}$$

$$x = x_0 + \bar{v}t$$

We define average velocity as the average of the initial and final velocity (only possible with constant acceleration)

$$\bar{v} = \frac{v + v_0}{2}$$

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Now we combine the last three equations

$$x = x_0 + \bar{v}t$$

$$x = x_0 + \left(\frac{v_0 + v}{2}\right)t$$

$$x = x_0 + \left(\frac{v_0 + v_0 + at}{2}\right)t$$

$$x = x_0 + v_0 t + \tfrac{1}{2}at^2$$

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For the third equation we start by using a version of the definition of velocity

$$x = x_0 + \bar{v}t$$

Combine with our average velocity definition

$$x = x_0 + \bar{v}t$$

$$x = x_0 + \left(\frac{v_0 + v}{2}\right)t$$

Solve the definition of acceleration for time

$$a = \frac{v - v_0}{t}$$

$$t = \frac{v - v_0}{a}$$

Combine and you get

$$x = x_0 + \left(\frac{v_0 + v}{2}\right)t$$

$$x = x_0 + \left(\frac{v_0 + v}{2}\right)\left(\frac{v - v_0}{a}\right)$$

$$x = x_0 + \frac{v^2 - v_0^2}{2a}$$

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Finally, solve for final velocity

$$x = x_0 + \frac{v^2 - v_0^2}{2a}$$

$$v^2 = v_0^2 + 2a\Delta x$$

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The 4th equation is not found in your book, but is in most others

$$x = x_0 + \bar{v}t$$

$$x = x_0 + \left(\frac{v + v_0}{2}\right)t$$

$$x = x_0 + \frac{1}{2}(v + v_0)t$$

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Section 2-6 Solving Problems

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understand the special case of motion with constant acceleration

1. Determine what the object is you are solving for.
2. Draw a diagram. Determine the positive and negative direction for motion.
3. Write down any known quantities.
4. Think about "The Physics" of the problem.
5. Determine what equation, or combination of equations will work under these Physics conditions.

6. Make your calculations.
7. See if your answer is reasonable.
8. Determine what units belong with the number, and what the direction should be if it is a vector.

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understand the special case of motion with constant acceleration

A car slows down uniformly from a speed of 21.0 m/s to rest in 6.00s. How far did it travel in this time?

1. Objec
2. Diagr

Describing Motion: Kinematics in One Dimension
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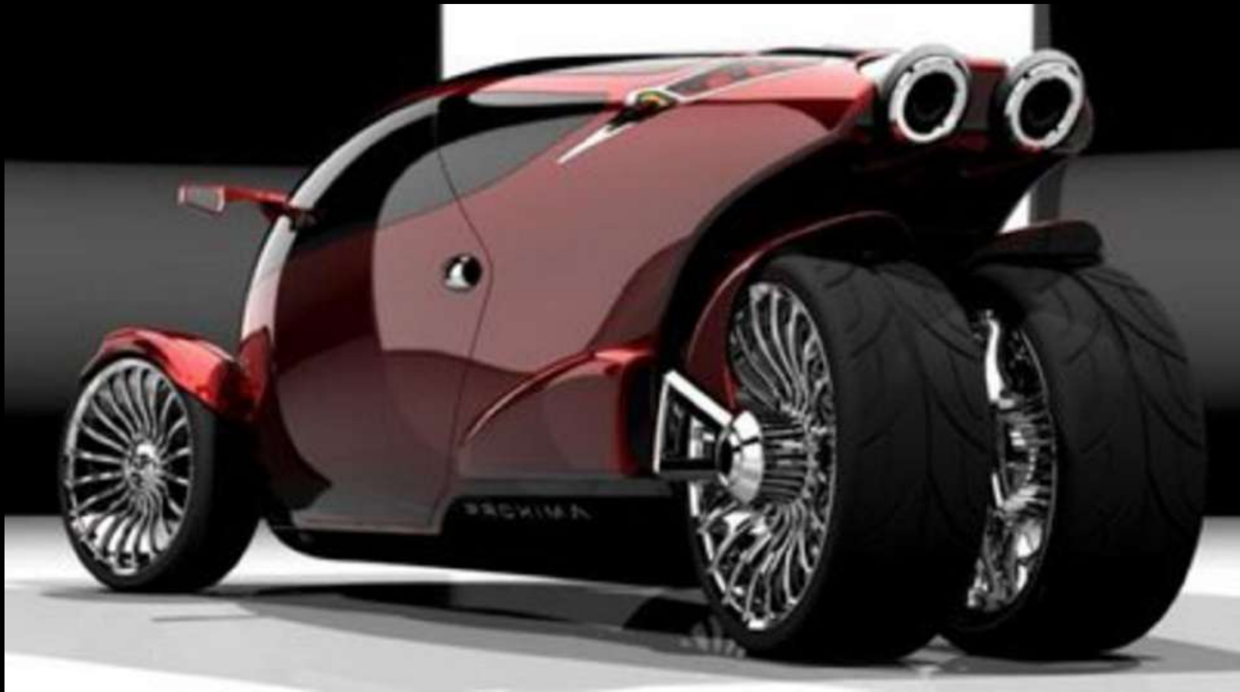
A car slows down uniformly from a speed of 21.0 m/s to rest in 6.00s. How far did it travel in this time?

1. Object – car
2. Diagram
3. Know

   v_0=21.0m/s

   v=0m/s

   t=6.00s



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understand the special case of motion with constant acceleration

A car slows down uniformly from a speed of 21.0 m/s to rest in 6.00s. How far did it travel in this time?

5. Physics – car is going through negative acceleration in 1D, acceleration is constant
6. Equation – needs v_0, v, t, x (define x_0=0)

   So

$$x = x_0 + \frac{1}{2}(v + v_0)t$$

Describing Motion: Kinematics in One Dimension

understand the special case of motion with constant acceleration

A car slows down uniformly from a speed of 21.0 m/s to rest in 6.00s. How far did it travel in this time?

5. Physics – car is going through negative acceleration in 1D, acceleration is constant
6. Equation – needs v_0, v, t, x (define x_0=0)

Solve

$$x = \tfrac{1}{2}(0 + 21m/s)(6s) = 63m$$

A car is behind a truck going 25m/s on the highway. The car's driver looks for an opportunity to pass, guessing that his car can accelerate at 1.0m/s^2. He gauges that he has to cover the 20 m length of the truck, plus 10 m clear room at the rear of the truck and 10 m more at the front of it. In the oncoming lane, he sees a car approaching, probably also traveling at 25 m/s. He estimates that the car is about 400 m away. Should he attempt to pass?

1. Object – car
2. Diagram
3. Known quantities

Car relative truck	Car relative to App. Car
v_0=0m/s	25m/s
a=1m/s^2	1m/s^2
x=40m	

4. Physics – The car travels 40m relative to the truck to complete the pass, but it will travel further relative to the approaching car. We must find how far and see if the position of the two cars overlaps

5. Time for car to pass

$$x = x_0 + v_0 t + \tfrac{1}{2} a t^2$$

$$x = \tfrac{1}{2} a t^2$$

$$t = \sqrt{\frac{2x}{a}} = \sqrt{\frac{2(40m)}{1m/s^2}}$$

$$t = 8.94s$$

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5. How far did the car travel?

5. How far did the other car get in that time?

$$t = 8.94s$$

$$x = vt$$

$$x = (25m/s)(8.94)$$

$$x = 223.5m$$

Can you say ‘boom?’

S-3

A lonely rabbit is standing 30 m from a really cute bunny that is hopping away at a constant 10 m/s. If the rabbit starts from rest, and can accelerate at 5 m/s^2,

A. How long will it take to reach the bunny

B. How far will he have traveled

C. How much faster than the bunny will he be running

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Section 2-7 Falling Objects

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understand the special case of motion with constant acceleration

We will ignore air friction

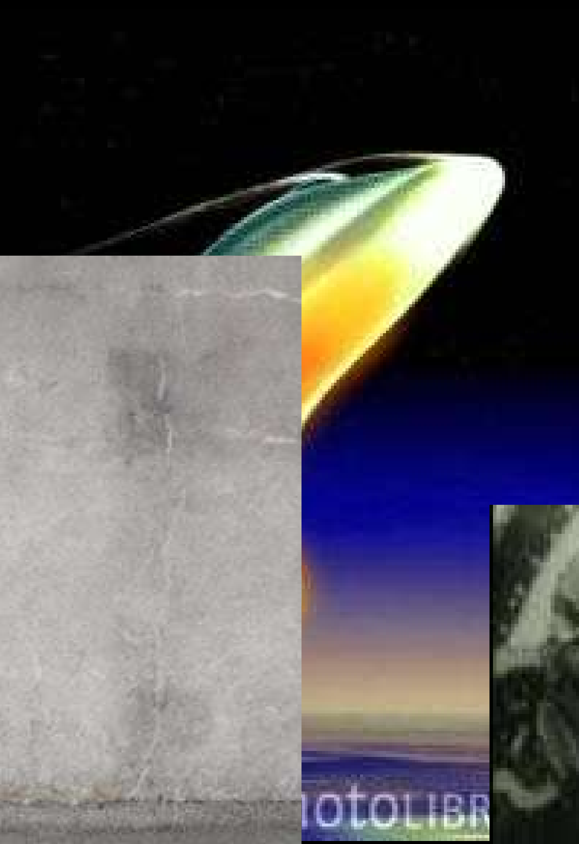
We will learn the why later.

Accelerat … s surface is

9.80 r … .80m/s^2)

S … ue to

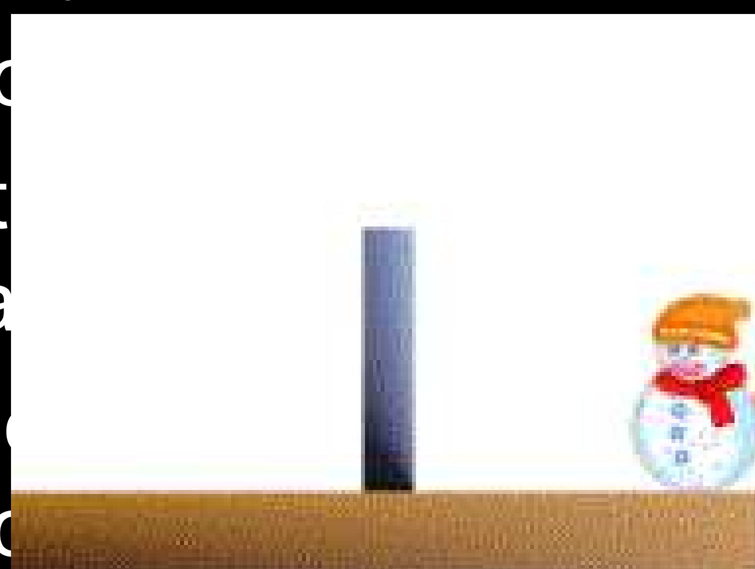
S



Two common misconception

1. Acceleration and velocity are always in the same direction

   a. No, as an object is thrown upward, velocity is +y, acceleration is –y

2. Acceleratihest point.

   a. No, at t e velocity is zero, but a s $-9.80 m/s^2$

   b. The obj , it must have an ac

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Truck and Soccer Ball

Important concepts from video

1. y velocity at the top – 0m/s
2. Displacement at the bottom – 0m
3. Acceleration – always $-9.80 m/s^2$

S-4

A cat is dropped off a cliff that is 145 m tall.

A. What is his acceleration?
B. What is his initial velocity?
C. What is his final velocity?
D. How long is he in the air?
E. Did he land on his feet?

Practice

S-5

A really large mouse sees a cat 100 m away. If he starts from rest and takes 28 s to catch the cat, what is his acceleration? Assume that the cat is moving away at a constant 20 m/s.

S-6

Evil Ralphie is throwing sheep off a cliff. Bad Ralphie! He throws the first sheep upward at 22 m/s. He then waits 6 seconds and throws a second sheep downward. The cliff is 180 m tall and both sheep land (gently and on their feet) at the same time.

What was the initial velocity of the second sheep?