Motion in One Dimension

Chapter 2: read pgs 39-62

Key terms

- Frame of Reference
- Displacement vs. Distance
- Velocity
- Acceleration
  - Motion with Constant Acceleration
- Free-fall

Frame of Reference

- Choosing a simple frame of reference Allows us to simplify problems.
  - Look at the truck on the table and draw a diagram showing it's motion if we want to measure the total distance traveled.

- ANY frame of reference can be used to solve problems as long as it is used consistently.
- This concept will be valuable later in the course.

Displacement

Displacement is
the total change of position
of an object,
not
the total distance traveled

WHAT IS HOMER'S NET (TOTAL) DISPLACEMENT?

19.5 km

1 km

5 km

ZERO !!!!!

10 km

!!

Displacement

- When things start moving, the *length of a straight line drawn from the object's initial position to it's final position* is it's displacement
- In one dimension…

$$\Delta x = x_f - x_i$$

Change in position along x-axis = (final position on x-axis) – (initial position on x-axis)

*Read the **TIP** at the bottom of p 41!*

Motion in One Dimension

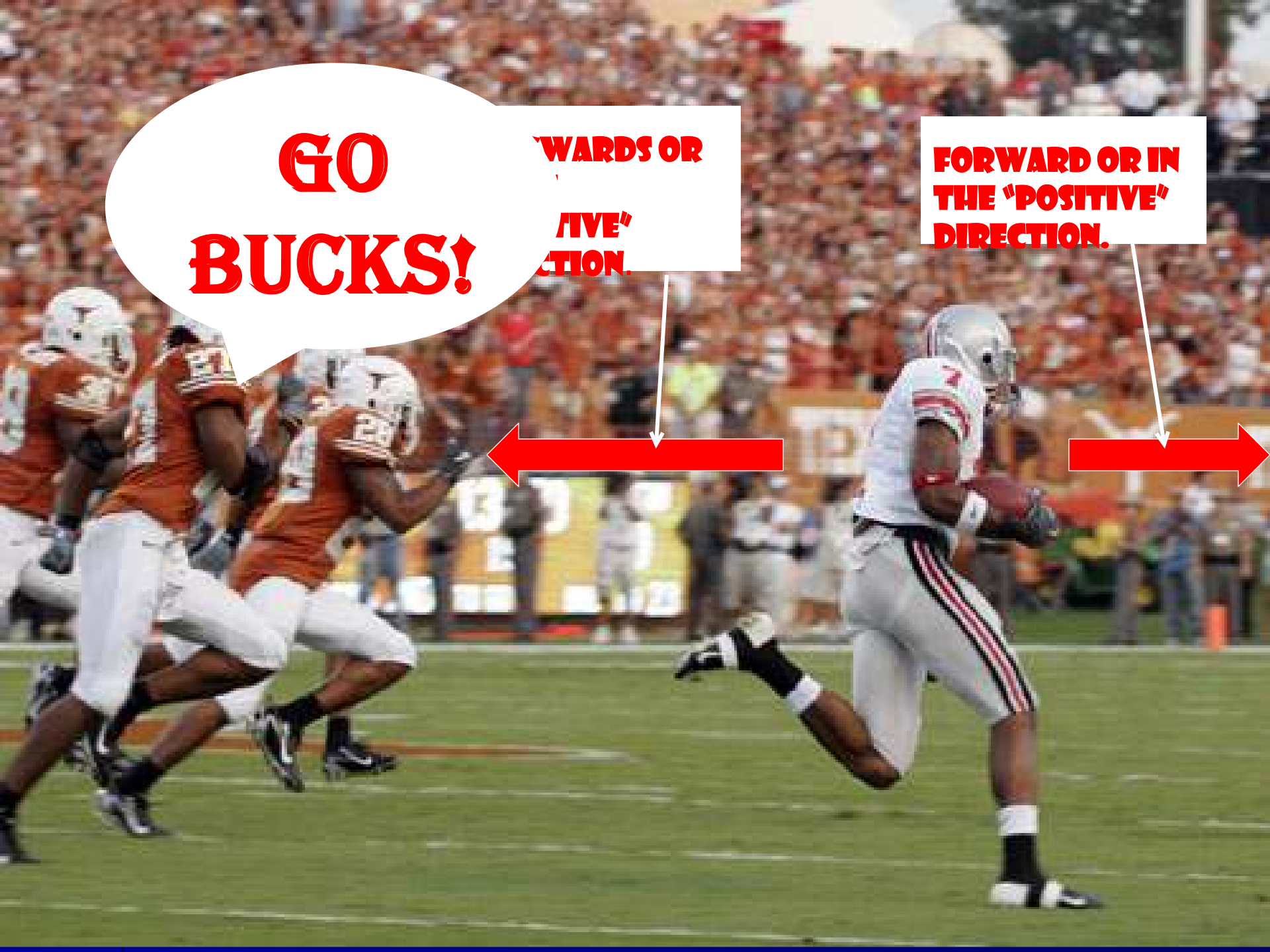
- Same concepts apply to any axis!
  - Space shuttles instead of trains

$$\Delta y = y_f - y_i$$

Change in position along y-axis = (final position on y-axis) – (initial position on y-axis)

One-Dimensional Motion

- The simplest kind of motion
- Things can move forward and backward, or “up” or “down.”
  - This will depend on your frame of reference.

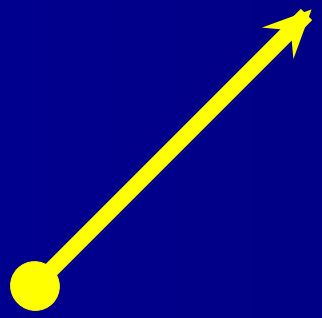

GO BUCKS!
WARDS OR
TIVE"
CTION.
FORWARD OR IN THE "POSITIVE" DIRECTION.

Remember…

- Displacement is not always equal to the distance traveled!
- Displacement can be positive or negative!

***POSITIVE* AND *NEGATIVE* QUANTITIES**

Tell you the *DIRECTION of Motion* !



ONE OF THE MOST USEFUL TOOLS OF THE PHYSICS STUDENT....


Our first model
THE FLASH

The Flash

In order to use superheroes as physics models we will need to make several "miracle exceptions"

If we assume their "miracle exceptions" to the laws of physics we can see if their powers are actually realistic.


BRAND NEW NEVER BEFORE

Speed and Velocity

- We have three important questions to answer….
  - What do these words mean?
  - Are they the same thing?
  - What time is this class over?

SPEED

Speed = distance/time (d/t)

- SI unit for speed is ***meters*** per ***second*** (m/s)
- If speed is constant we can predict the amount of distance an object will travel in a set amount of time.

VELOCITY

velocity = distance/time (d/t)

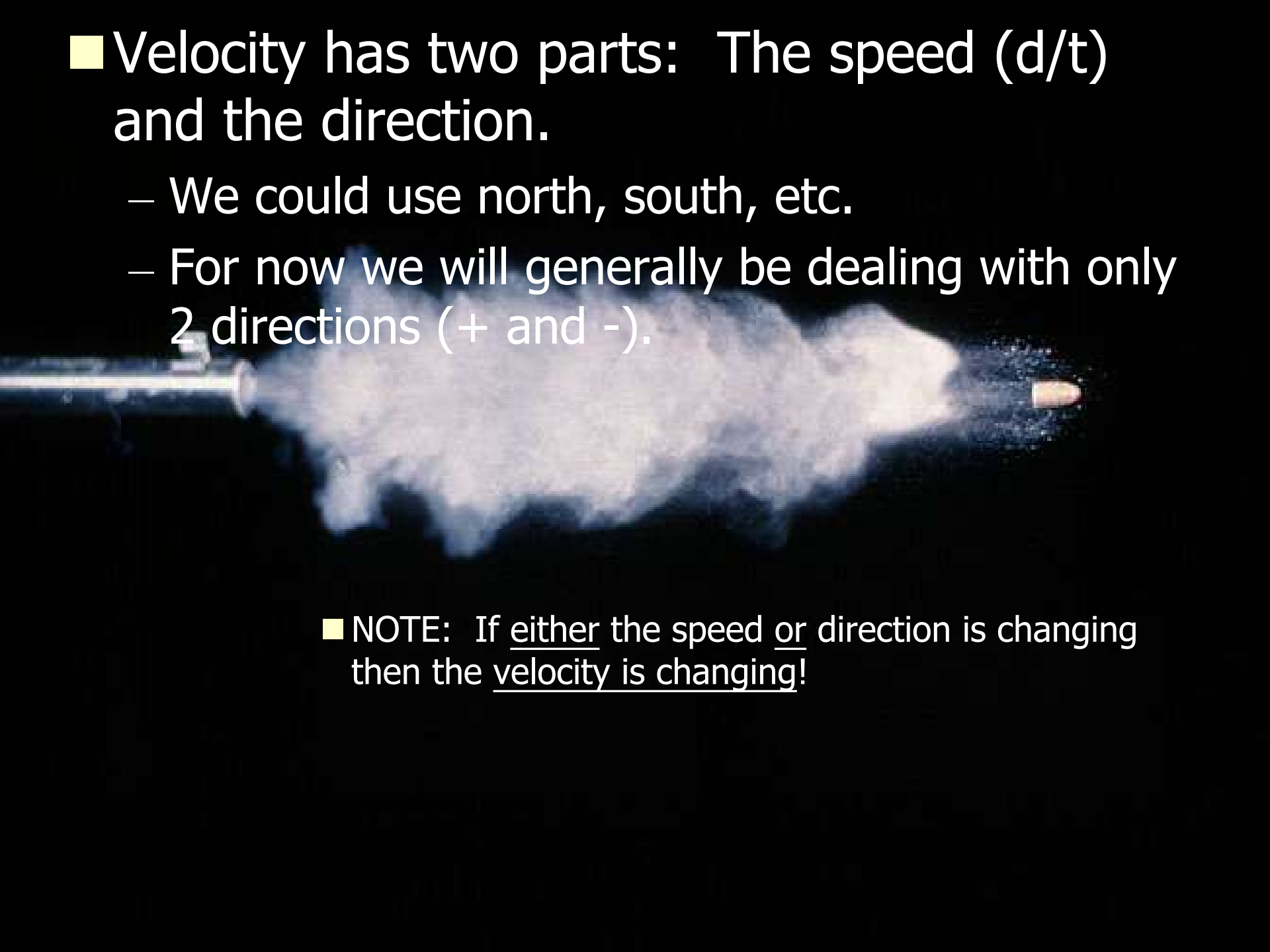
- SI unit for velocity is ***meters*** per ***second*** (m/s)
- If velocity is constant we can predict the amount of distance an object will travel in a set amount of time.
- ***Velocity also has a specific direction assigned to it.***

Velocity

Velocity and speed are like 2 very athletic brothers.

- The older brother (speed) can run as fast as he wants but has no "direction" in his life. He will live with his parents when he's 40.
- The younger brother (velocity) is just as fast but he knows where he's going (he has a direction). He will finally help the Astros win the series and make millions $$$$UU

- Velocity has two parts: The speed (d/t) and the direction.
  - We could use north, south, etc.
  - For now we will generally be dealing with only 2 directions (+ and -).



- NOTE: If either the speed or direction is changing then the velocity is changing!

-5 m/s

and
cept
That

G!!!!!

5 m/s

You see my speed is the same in both directions but my true movement isn't! That is what velocity does! It just describes speed more accurately. This will be very important when you all grow up to become super villains. You can't dominate the world without a good understanding of these basic concepts!

Velocity is known
"VECTOR QUANTITY
"VECTOR" for shor

Is my hair considered a vector quantity?

Any value with a direction and a magnitude is considered a vector.

I hate you Michael

Problems

- What is the speed in kilometers per hour of the Flash if he runs 3701 km in 3 hours?
- What is his velocity in meters per second if the Flash runs 149 m away from the shore in 16.8 s?

Practice!

- Page 255 question 1-4.
  - Homework if you don't finish today.

Average Velocity

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

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

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

+'s and –'s are *Directional!*

- Click here for a helpful animation

Left at 5 m/s

Right at 5 m/s

Do Bart and Homer have the Same Velocity in these two pictures?

NO!

Their SPEED is the same but their VELOCITY is different because of the direction!

Practice Time

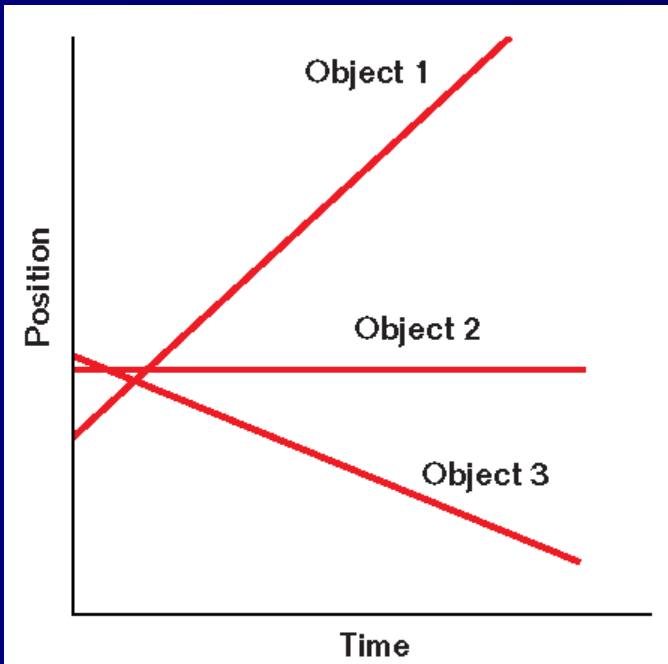
- Practice A 1-5
  - Group problems pg 44 Practice 2A #1-6
  - Conceptual Challenge ph 4g #1 & 2
    - HOMEWORK if you don't finish in class!

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

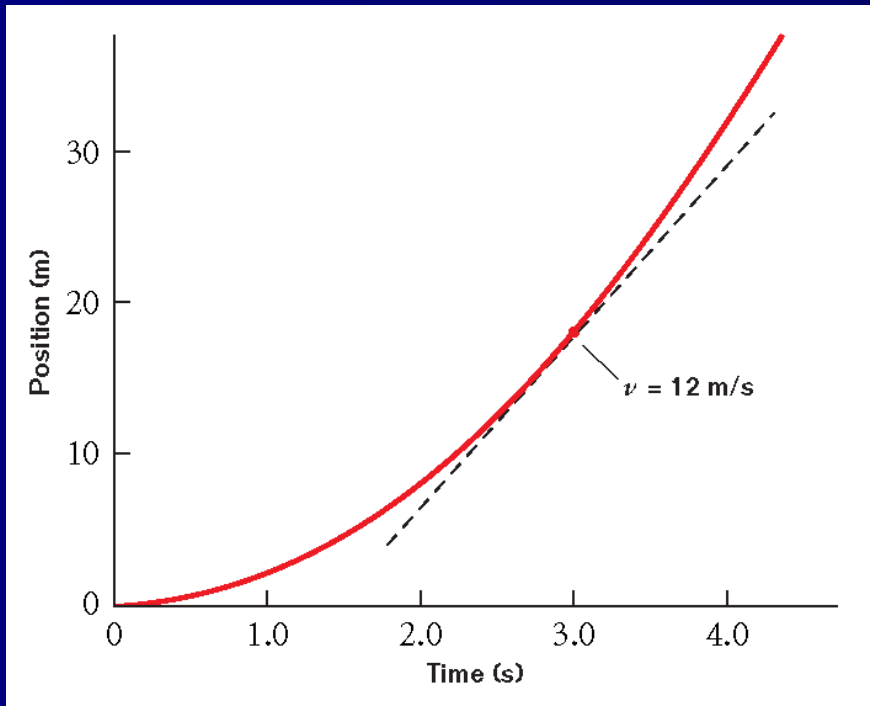


Click on Graph for Flash Animation

Instantaneous Velocity

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.



Instantaneous Velocity

- Movie Clip
  - Can you graph the velocity for this bungee jumper?

Height = 220 m

Time of free fall = 7.5 s

Top speed = 120 kmph

Practice Time

- Section Review p.47
  - #1-6

Equations for Chapter 2

$$\Delta x = x_f - x_i$$

$$v_{avg} = \frac{v_i + v_f}{2}$$

$$\Delta x = v_i \Delta t + \frac{1}{2} a (\Delta t)^2$$

$$v_{avg} = \frac{\Delta x}{\Delta t}$$

$$\Delta x = \frac{1}{2}(v_i + v_f)\Delta t$$

$$a_{avg} = \frac{\Delta v}{\Delta t}$$

$$v_f = v_i + a\Delta t$$

Quick!

- You're in your car, driving at 100 km/h
  - Situation 1: see a red light a quarter-mile away, so you slow down to a stop
  - Situation 2: a deer runs out in front of you, so you slam on your brakes to stop
- In which situation do you feel the most?

Acceleration is EXTREMELY important!!!!

It is a MAJOR factor in the study of motion

$$A = \frac{(v_f - v_i)}{t}$$

Acceleration

- Acceleration = measure of the change of velocity.
  - If an object's velocity changes it is accelerating.
  - This means that if the speed or direction of motion is changing then the object is accelerating.
  - Acceleration can be positive or negative (what we normally call deceleration).

Acceleration is

- "rate of change of velocity with respect to time"
  - How much does your velocity change, and how fast does this happen?

AVERAGE ACCELERATION

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

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

Dimensions of *a*

- Work it out from the formula…

AVERAGE ACCELERATION

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

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

- *a* is measured in m/s^2

Practice Problems

- With an average acceleration of -1.2 m/s^2, how long will it take a cyclist to bring a bicycle with an initial speed of 6.5 m/s to a complete stop?
  - **A: 5.4 s**
- Suppose a treadmill has an average acceleration of 4.7 × 10.3 m/s2.

a. How much does its speed change after 5.0 min?

b. If the treadmill's initial speed is 1.7 m/s, what will its final speed be?

  - **1.4 m/sand3.1 m/s**

Just like Velocity

- Acceleration is a *vecto*
  - Has both a magnitude (
    direction

- Can be positive or ne
  - **JUST DIRECTIONAL**

What other Vector quantity have we talked about?

Graphs can tell us things

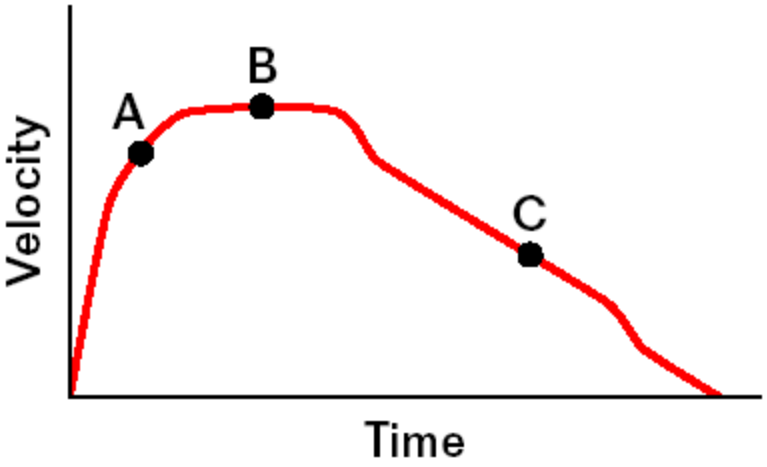


Figure 10

When the velocity in the positive direction is increasing, the acceleration is positive, as at point A. When the velocity is constant, there is no acceleration, as at point B. When the velocity in the positive direction is decreasing, the acceleration is negative, as at point C.

Small Group Questions

- If a baseball has zero velocity at some instant, is the acceleration of the baseball necessarily zero at that instant?
- If a passenger train is traveling on a straight track with a negative velocity and a positive acceleration, is it speeding up or slowing down?
- When you are out for a bike ride, you slow down on your bike as you approach a group of hikers on a trail. Explain how your acceleration can be positive even though your speed is decreasing.

Relating the two…

Table 3 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

Practice

- P.59 #1-6

Review

- Position: where are you at?
- Displacement: change in position
- Velocity: rate of change in position
- Acceleration: rate of change of velocity

Review

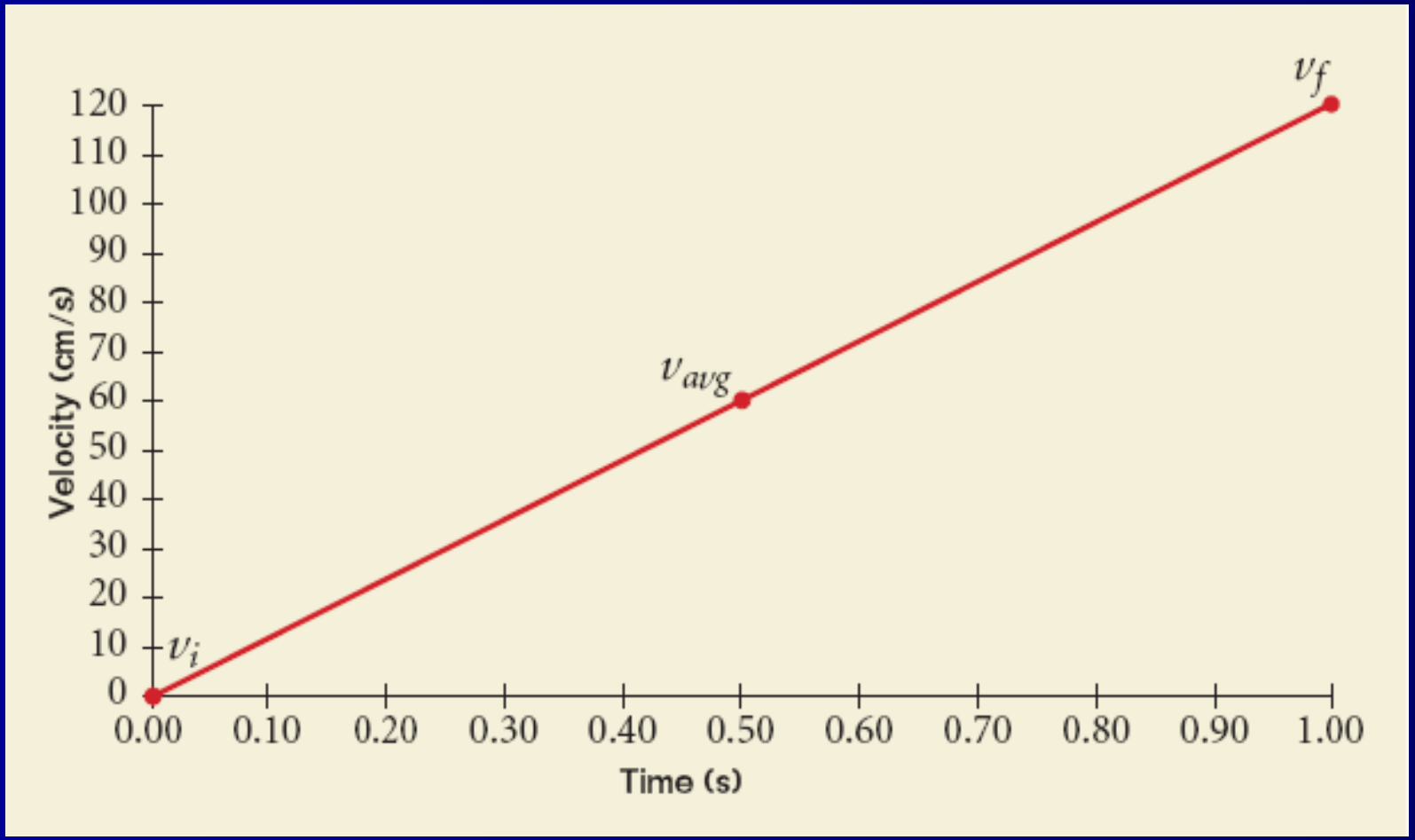
Table 3 Velocity and Acceleration

v_f	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

- Velocity changes at a constant rate
- What does displacement really depend on?
  - Acceleration
  - Initial Velocity
  - Time

Velocity vs. Time



Δx with constant a

$$\Delta x = \frac{1}{2}(v_i + v_f)\Delta t$$

Let's see what we can do with this formula…

p.53 Practice

- #1: 21 m
- #2: 18.8 m
- #3: 9.1 s
- #4: 24 m/s

Our lonely equation

$$\Delta x = \frac{1}{2}(v_i + v_f)\Delta t$$

This is great, but what if we don't know v_f?

Can we still solve for displacement?

v with constant *a*

$$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t}$$

Rearranging the equation tells us that…

$$v_f = v_i + a\Delta t$$

Finding displacement

$$\Delta x = \frac{1}{2}(v_i + v_f)\Delta t$$

Let's substitute our new equation in for v_f...

$$\Delta x = \frac{1}{2}(v_i + v_i + a\Delta t)\Delta t$$

...and simplify the new equation.

$$\Delta x = v_i \Delta t + \frac{1}{2} a(\Delta t)^2$$

p.55 Practice D

1. 9.8 m/s; 29 m or 36 km/h; 0.030 km

2. 19.3 m/s; 59.0 m

3. -7.5 m/s; 19 m

4. 2.5 s; 32 m

One last equation…

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

- See handout:
  - "Final Velocity after any Displacement"
- Equation Sheet Handout
  - This is what you will get for your test next week

p. 58 Practice

- +2.51 m/s
- a. +21 m/s

  b. +16 m/s

  c. +13 m/s
- a. 16 m/s

b. 7.0 s

- 7.4 m/s
- +2.3 m/s^2
- 88 m

Definitions

- Frame of reference: a system for specifying the precise location of objects in space and time

Back