

February 22<sup>nd</sup>, 2010 (Week 3 of 16)

- ✓ Pop Quiz – Chapter 1
  - Closed book
  - Closed notes
  - Closed neighbor
  - When you are done, please place it on my desk.
- ✓ Finish Lecture Chapter 1 (Problems)
- ✓ Lecture Chapter 2
  - I am hoping to begin around 7:15?
  - Hot Dog Lady is open for food

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## Motion

- Motion is everywhere – walking, driving, flying, etc.
- This chapter focuses on definition/discussion of: speed, velocity, and acceleration.
- There are two basic kinds of motion:
  - Straight line (*The one we will be working on*)
  - Circular (*The one we will be skipping*)

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## Defining Motion

- Position – the location of an object
  - A reference point must be given in order to define the position of an object
- Motion – an object is undergoing a continuous change in position
- Description of Motion – the time rate of change of position
  - A combination of length and time describes motion

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## Speed and Velocity

- In Physical Science 'speed' and 'velocity' have different (distinct) meanings.
- Speed is a scalar quantity, with only magnitude
  - A car going 80 km/h
- Velocity is a vector, and has both magnitude & direction
  - A car going 80 km/h north


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## Vectors


- Vector quantities may be represented by arrows. The length of the arrow is proportional to magnitude.




40 km/h



80 km/h



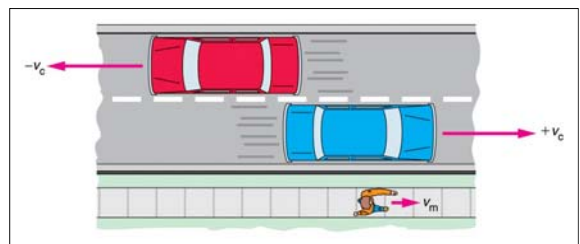
-40 km/h



-80 km/h

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## Vectors



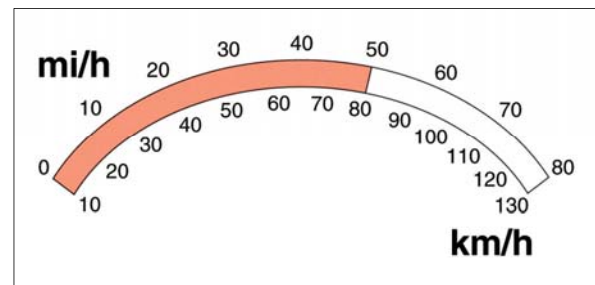
Note that vectors may be both positive and negative.

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## Speed

- Average Speed =  $\frac{\text{distance traveled}}{\text{time to travel distance}}$
- $\bar{v} = d/t$  or  $v = \Delta d/\Delta t$ 
  - (where  $\Delta$  means 'change in')
  - Over the entire time interval, speed is an average
- Distance – the actual path length traveled
- Instantaneous Speed – the speed of an object at an instant of time ( $\Delta t$  is very small)
  - Glance at a speedometer

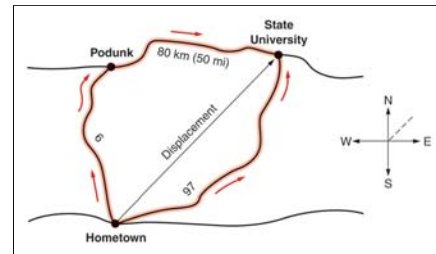
## Instantaneous speed



## Velocity

- Velocity is similar to speed except a direction is involved.
- Average velocity =  $\frac{\text{displacement}}{\text{total travel time}}$
- Displacement – straight line distance between the initial and final position w/ direction toward the final position
- Instantaneous velocity – similar to instantaneous speed except it has direction

## Displacement and Distance



Displacement is a vector quantity between two points.  
Distance is the actual path traveled.

## Acceleration

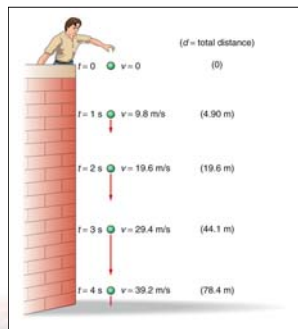
- Changes in velocity occur in three ways:
  - Increase in magnitude (speed up)
  - Decrease in magnitude (slow down)
  - Change direction of velocity vector (turn)
- When any of these changes occur, the object is accelerating.
- Faster the change  $\rightarrow$  Greater the acceleration
- Acceleration – the time rate of change of velocity

## Acceleration

- A measure of the *change* in velocity during a given time period
- Avg. acceleration =  $\frac{\text{change in velocity}}{\text{time for change to occur}}$
- $\bar{a} = \frac{\Delta v}{t} = \frac{v_f - v_o}{t}$  ( $v_f = \text{final}$  &  $v_o = \text{original}$ )
- Units of acceleration = (m/s)/s = m/s<sup>2</sup>
- In this course we will limit ourselves to situations with *constant acceleration*.

## Constant Acceleration of 9.8 m/s<sup>2</sup>

- As the velocity increases, the distance traveled by the falling object increases each second.



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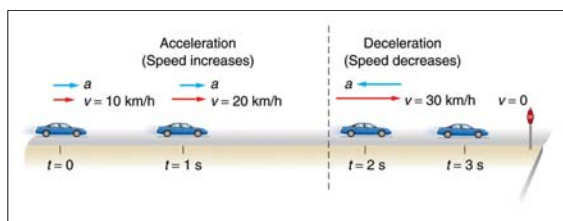
## Using the equation for acceleration

- Remember that  $a = \frac{v_f - v_o}{t}$
- Rearrange this equation:
- $at = v_f - v_o$
- $v_f = v_o + at$  (solved for final velocity)
- This equation is very useful in computing final velocity.

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## Acceleration is a vector quantity, since velocity is a vector quantity



Acceleration (+)

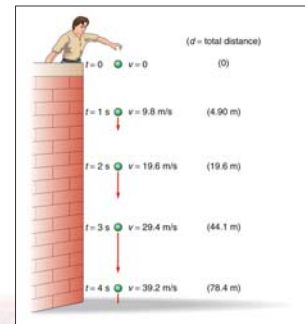
Deceleration (-)

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## Constant Acceleration = Gravity = 9.8 m/s<sup>2</sup>

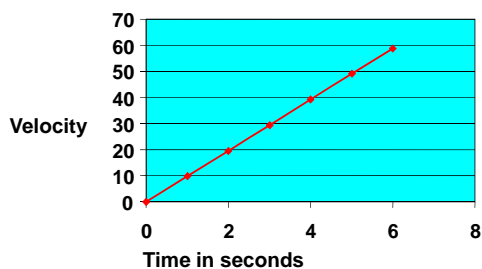
- Special case associated with falling objects
- Vector towards the center of the earth
- Denoted by "g"
- $g = 9.80 \text{ m/s}^2$



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## Graph – Acceleration due to Gravity

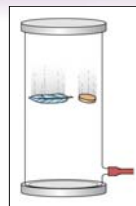


The increase in velocity is linear.

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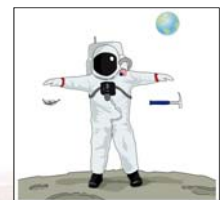
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## Frictional Effects



- If frictional effects (air resistance) are neglected, every freely falling object on earth accelerates at the same rate, regardless of mass. Galileo is credited with this idea/experiment.

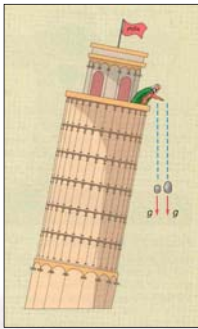
- Astronaut David Scott demonstrated the principle on the moon, simultaneously dropping a feather and a hammer. Each fell at the same acceleration, due to no atmosphere & no air resistance.



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**Figure 2**



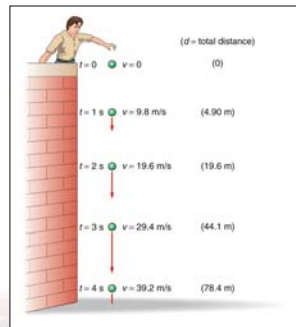
- Galileo is also credited with using the Leaning Tower of Pisa as an experiment site.

**What about the distance a dropped object will travel?**

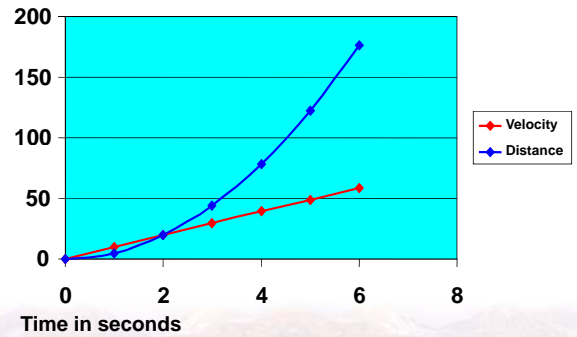
- $d = \frac{1}{2} g t^2$
- This equation will compute the distance ( $d$ ) an object drops due to gravity (neglecting air resistance) in a given time ( $t$ ).

**Constant Acceleration = Gravity  $9.8 \text{ m/s}^2$**

- Distance is proportional to  $t^2$ 
  - Remember that ( $d = \frac{1}{2} g t^2$ )
- Velocity is proportional to  $t$ 
  - Remember that ( $v_f = at$ )

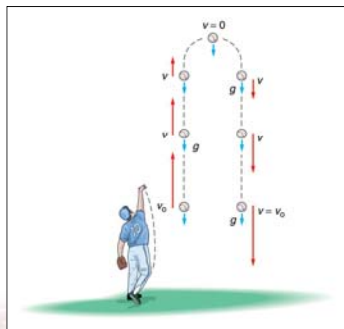


**v proportional to time (t)  
d proportional to time squared ( $t^2$ )**



**Up and Down – Gravity slows the ball, then speeds it up**

- Acceleration due to gravity occurs in BOTH directions.
  - Going up (-)
  - Coming down (+)
- The ball returns to its starting point with the same speed it had initially.  $v_o = v_f$

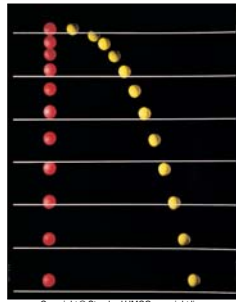


**Projectile Motion**

- An object thrown horizontally combines both straight-line and vertical motion each of which act independently.
- Neglecting air resistance, a horizontally projected object travels in a horizontal direction with a constant velocity while falling vertically due to gravity.

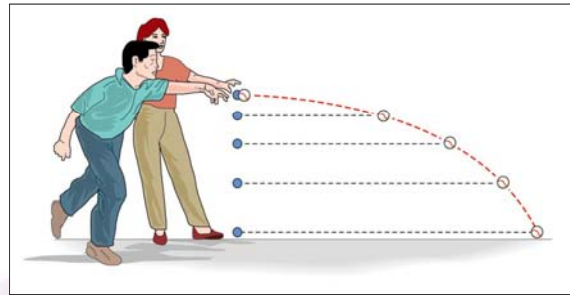
Figure 2.14(b)

- An object thrown horizontally will fall at the same rate as an object that is dropped.

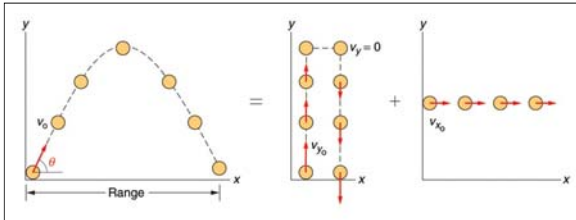


Multiflash photograph of two balls

The velocity in the horizontal direction does not affect the velocity and acceleration in the vertical direction.

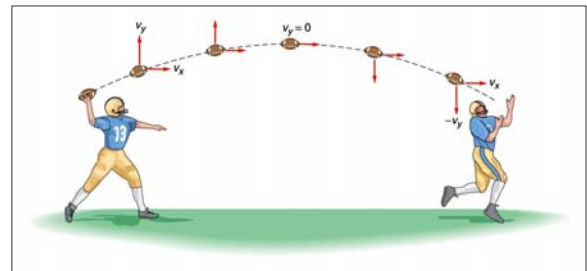


Projected at an angle (not horizontal)

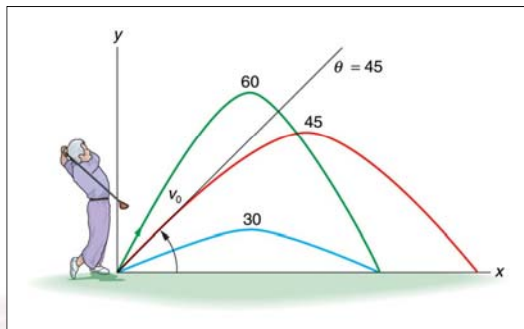


Combined Horz/Vert. Components = Vertical Component + Horizontal Component

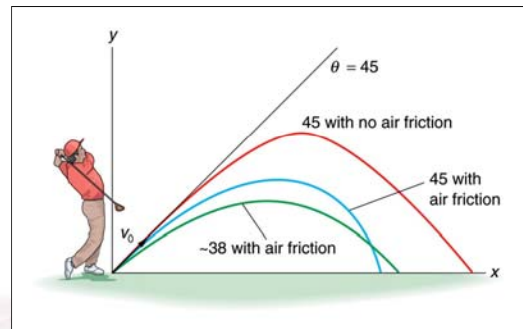
In throwing a football the horizontal velocity remains constant but the vertical velocity changes like that of an object thrown upward.



If air resistance is neglected, projectiles have symmetric paths and the maximum range is attained at 45°.



Under real-world conditions, air resistance causes the paths to be non-symmetric. Air resistance reduces the horizontal velocity.



## Projectiles - Athletic considerations

- Angle of release
- Spin on the ball
- Size/shape of ball/projectile
- Speed of wind
- Direction of wind
- Weather conditions (humidity, rain, snow, etc)
- Field altitude (how much air is present)
- Initial horizontal velocity (in order to make it out of the park before gravity brings it down, a baseball must leave the bat at a high velocity)

## Important Equations – Chapter 2

- $\bar{v} = d/t$  (average speed)
- $d = \frac{1}{2}at^2$  (distance traveled, starting from rest)
- $d = \frac{1}{2}gt^2$  (distance traveled, dropped object)
- $g = 9.80 \text{ m/s}^2 = 32 \text{ ft/s}^2$  (acceleration, gravity)
- $a = \frac{\Delta v}{t} = \frac{v_f - v_o}{t}$  (constant acceleration)
- $v_f = v_o + at$  (final velocity with constant  $a$ )
- $a_c = v^2/r$  (centripetal acceleration)

## Break Time

Please be back by 8:45 PM



## My Apology...

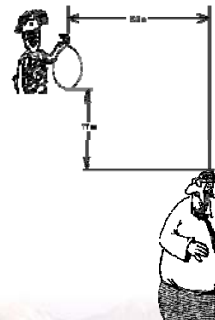
During the semester I will typically pick on students. I hope that you do not take any offense to this. If I am offending you, please let me know. And if I offend you, please forgive me.

## Questions...

7. A student drives the 100 mile trip back to campus after spring break and travels with an average speed of 55 mi/hr for 1 hour and 30 minutes?
  - a. What distance was traveled during this time?
  - b. Traffic gets heavier, and the last part of the trip takes another half-hour. What was the average speed during this leg of the trip?
  - c. Find the average speed for the total trip.
9. An airplane flying directly eastward at a constant rate travels 300 km in 2.0 h.
  - a. What is the average velocity of the plane?
  - b. What is its instantaneous velocity?
11. A sprinter starting from rest on a straight and level track is able to achieve a speed of 12 m/s in a time of 4.0 s. What is the sprinter's average acceleration?
12. A motorboat starting from rest travels in a straight line on a lake.
  - a. If the boat achieves a speed of 12 m/s in 10 s, what is the boat's average acceleration?
  - b. Then, in 5.0 more seconds, the boat's speed is 18 m/s. What is the boat's average acceleration for the total time?

## Questions...

18. A student sees her physical science professor approaching on the sidewalk that runs by her dorm. She gets a water balloon and waits. When the professor is 2.0 s from being directly under her window 11 m above the sidewalk, she drops the balloon. You finish the story.



## End of Day

