Chapter 11

Motion

Section 11.1

Describing Motion

Motion

- Are distance and time important in describing running events at the track-and-field meets in the Olympics?
- Distance and time are important. In order to win a race, you must cover the distance in the shortest amount of time.

Motion and Position

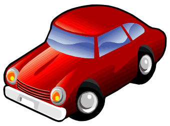
- You don't always need to see something move to know that motion has taken place.
- A reference point is needed to determine the position of an object.
- Motion occurs when an object changes its position relative to a reference point.
- The motion of an object depends on the reference point that is chosen.

Relative Motion

- Look at the stapler sitting my the desk in the front of the room.
- It IS moving!**,** How is this possible?
- You are not moving relative to your desk or your school building, but you are moving relative to the other planets in the solar system and the Sun.

Relative Motion

- Examples
  - Car passing you standing by a tree
  - Car passing you driving in a car in the same direction
  - Car passing you driving in a car in the opposite direction



Distance

- An important part of describing the motion of an object is to describe how far it has moved, which is **distance.**
- Distance is the total amount covered
- The SI unit of length or distance is the meter (m). Longer distances are measured in kilometers (km).

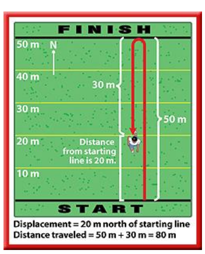
Distance

- Shorter distances are measured in centimeters (cm).

SI Metric/English, English/Metric Conversions		
When you want to convert:	To:	Multiply By:
inches	centimeters	2.54
centimeters	inches	0.39
yards	meters	0.91
meters	yards	1.09
miles	kilometers	1.61
kilometers	miles	0.62

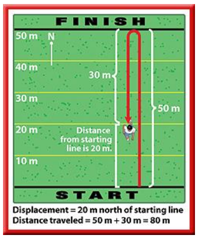
Distance

- Suppose a runner jogs to the 50-m mark and then turns around and runs back to the 20-m mark.
- The runner travels 50 m in the original direction (north) plus 30 m in the opposite direction (south), so the total <u>distance</u> she ran is 80 m.



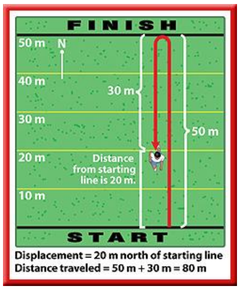
Displacement

- Sometimes you may want to know not only your distance but also your direction from a reference point, such as from the starting point.
- **Displacement** is the distance and direction of an object's change in position from the starting point.



Displacement

- The length of the runner's displacement and the distance traveled would be the same if the runner's motion was in a single direction.
- The runners displacement is 20 m north



Displacement

- Example
- Student walking
  - Count the amount of steps it takes to walk out the back door, in the front door, and back to your desk.

Speed

- You could describe movement by the distance traveled or by the displacement from the starting point.
- You also might want to describe how fast it is moving.
- Speed is the distance an object travels per unit of time.

Velocity

- Speed describes only how fast something is moving.
- To determine direction you need to know the velocity.
- **Velocity** includes the speed of an object and the direction of its motion.

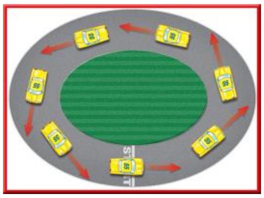
Velocity

- Velocity is relative to a reference point
  - (+) is up, right, north, east
  - (-) is down, left, south, west
- Relative velocity is the combo of velocities
  - You are walking backwards at 2 m/s on a bus going forward at 9 m/s. What is your relative velocity?
  - Another example…

Velocity

- Because velocity depends on direction as well as speed, the velocity of an object can change even if the speed of the object remains constant.

The speed of this car might be constant, but its velocity is not constant because the direction of motion is always changing.



Calculating Speed

- Any change over time is called a rate.
- If you think of distance as the change in position, then speed is the rate at which distance is traveled or the rate of change in position.

$$\text{speed}\left(\frac{\text{m}}{\text{s}}\right) = \frac{distance\ (m)}{time\ (s)}$$

$$v = \frac{m}{s}$$

Calculating Speed

- The SI unit for distance is the meter and the SI unit of time is the second (s), so in SI, units of speed are measured in meters per second (m/s).

Examples of Units of Speed

Unit of Speed	Examples of Uses	Approximate Speed
km/s	rocket escaping Earth's atmosphere	11.2 km/s
km/h	car traveling at highway speed	100 km/h
cm/yr	geological plate movements	2cm/yr–17 cm/yr

You walk North 80 m, then South 30 m, then North 50 m, and finally 60 m South. What is your distance?

- Numeric

The SI unit for speed is___

A. Meters per second
B. Miles per hour
C. Kilometers per hour
D. Meters per hour
E. Kilometers per second
F. Miles per second
G. None of the above

You walk North 80 m, then South 30 m, then North 50 m, and finally 60 m South. What is your displacement?

- Numeric

You drive 40 km in 20 minutes. What is your speed in km/min?

- Numeric

Average Speed

- Average speed describes speed of motion when speed is changing.
- Average speed is the <u>total</u> distance traveled divided by the <u>total</u> time of travel.
- If the total distance traveled was 5 km and the total time was 1/4 h, or 0.25 h. The average speed was:

Instantaneous Speed

- A speedometer shows how fast a car is going at one point in time or at one instant.
- The speed shown on a speedometer is the instantaneous speed. **Instantaneous speed** is the speed <u>at a given point</u> in time.

Instantaneous Speed

- When something is speeding up or slowing down, its instantaneous speed is changing.
- If an object is moving with constant speed, the instantaneous speed doesn't change.

Practice

- Examples on board

1. You run 3 km North in 28 minutes, what is your average velocity (m/s)?
2. You run for 3 minutes with an average speed of 1.8 m/s, how far did you run?
3. How log will it take you to run 1.2 km if you are running with a speed of 2.6 m/s?

You do 1-3 on page 369

Graphing Motion

- The motion of an object over a period of time can be shown on a distance-time graph.
- Time is plotted along the horizontal axis of the graph and the distance traveled is plotted along the vertical axis of the graph.

Graphing Motion

- When graphing motion, your distance goes on the Y axis and your time goes on the X axis
- The slope of a distance-time graph equals the average speed
- Slope equals….

Graph the following data

Distance (m)	Time (s)
0	0
1	30
2	60
4	90
6	120
7	150
8	180
5	210
2	240
0	270

Questions

- Do you ever change speed?
  – Explain
- What is your average speed from
  – 0 – 60 s
  – 0 – 90 s
  – 180 – 240 s
- Answer 1-2 on page 370

You drive 8 km north in 2 hours. What is your velocity?

A. 8 km/h
B. 16 km/h
C. 4 km/h
D. 10 km/h
E. None of the above

A horizontal line on a distance-time graphs means…

A. The object is moving with a constant speed
B. The object is not moving
C. The object is speeding up
D. The object is slowing down
E. None of the above

A speedometer show you…

A. Velocity
B. Average speed
C. Instantaneous speed
D. More than one of the above
E. None of the above

You walk North 80 m, then South 30 m, then North 50 m, and finally 60 m South. What is your displacement?

- Numeric

Homework

- 11.1 CR
- 11.1 Worksheet
- MS - Velocity
- Graph

Section 2.2

Acceleration

Acceleration, Speed, and Velocity

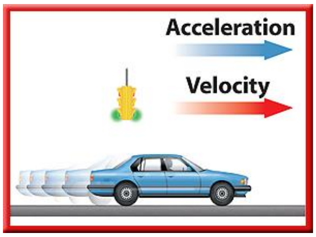
- **Acceleration** is the rate of change of velocity. When the velocity of an object changes, the object is accelerating.
- A change in velocity can be either a change in how fast something is moving, or a change in the direction it is moving.
- Acceleration occurs when an object changes its **speed**, it's **direction**, or **both**.

Speeding Up and Slowing Down

- When you think of acceleration, you probably think of something speeding up. However, an object that is slowing down also is accelerating.
- Acceleration also has direction, just as velocity does.

Speeding Up and Slowing Down

- If the acceleration is in the same direction as the velocity, the speed increases and the acceleration is positive.



Speeding Up and Slowing Down

- If the speed decreases, the acceleration is in the opposite direction from the velocity, and the acceleration is negative.

Changing Direction

- A change in velocity can be either a change in how fast something is moving or a change in the direction of movement.
- Any time a moving object changes direction, its velocity changes and it is accelerating.

Changing Direction

- The speed of the horses in this carousel is constant, but the horses are accelerating because their direction is changing constantly.

Changing Direction

- When something moves in a constant speed in a circle, it has centripetal acceleration.

Calculating Acceleration

- To calculate the acceleration of an object, the change in velocity is divided by the length of time interval over which the change occurred.
- To calculate the change in velocity, subtract the initial velocity—the velocity at the beginning of the time interval—from the final velocity—the velocity at the end of the time interval.

Calculating Acceleration

- Using this expression for the change in velocity, the acceleration can be calculated from the following equation:

$$acceleration = \frac{final\ velocity\ - initial\ velocity}{time}$$

$$a = \frac{v_f\ - v_1}{t}$$

Calculating Acceleration

- If the direction of motion doesn't change and the object moves in a straight line, the change in velocity is the same as the change in speed.
- The change in velocity then is the final speed minus the initial speed.

Calculating Negative Acceleration

- A skateboarder slows from 3 m/s to a stop in 2 seconds

$$a = \frac{(v_f - v_i)}{t} = \frac{(0\ m/s - 3 m/s)}{2\ s} = -1.5\ \text{m}/s^2$$

Calculating Negative Acceleration

- The stop light turns green and a car accelerates to 3 m/s in 2 seconds

$$a = \frac{(v_f - v_i)}{t} = \frac{(3\ m/s - 0 m/s)}{2\ s} = 1.5\ \text{m}/s^2$$

Practice

- Page 375
  - 1 (in class)
  - 2-3, 5 (On your own)

Graphing Accelerated Motion

- Read “Graphing Accelerated Motion” on page 376-377
- Get into groups of 2-3 and discuss
- Complete the practice problems (1-2)

A car accelerates from 10 km/h to 40 km/h in 900 s. What is the cars acceleration?

When a car turns a corner, it MUST be accelerating.

A. True
B. False

A car has an acceleration of 4 km/h. If the cars accelerates from 50 km/h, what is the cars final speed after 10 minutes? (In km/h)

Homework

- Work on in class tomorrow
  - Math Skills
  - CR
  - EOSQ (1-4)
  - 11.2 wkst
  - Acceleration Wkst

Section 11.3

Motion and Forces

What is a Force?

- A **force** is a push or pull.
- Sometimes it is obvious that a force has been applied.
- But other forces aren't as noticeable.

4 Fundamental Forces

1. Force of gravity
2. Electromagnetic
3. Strong Nuclear
4. Weak Nuclear

Forces

- There are 2 types of forces we will be focusing on, Contact and Field Forces
- Contact Forces require contact
  - Push, pull, friction, etc.
- Field forces do not require contact
  - Gravity, magnetism
- Both of the forces can cause something to accelerate

What Forces are present?

Contact, field, both, or none

1. Pushing a sled across a flat spot of ground
2. Picking up a box of salamanders
3. A stapler sitting on a desk

What is a Force?

- A force can cause the motion of an object to change.
- If you have played billiards, you know that you can force a ball at rest to roll into a pocket by striking it with another ball.
- The force of the moving ball causes the ball at rest to move in the direction of the force.

Balanced Forces

- Force does not always change velocity.
- When two or more forces act on an object at the same time, the forces combine to form the net force.

Net Force

- When you are finding net force you ADD the forces together if they are in the SAME direction.
- When you are finding net force you SUBTRACT the forces together if they are in OPPOSITE directions.
- You MUST put a direction on the net force
  - To the left, north, up…

Balanced Forces

- The net force on the box is zero because the two forces cancel each other.
- Forces on an object that are equal in size and opposite in direction are called **balanced forces**.

Unbalanced Forces

- When two students are pushing with unequal forces in opposite directions, a net force occurs in the direction of the larger force.

Unbalanced Forces

- The net force that moves the box will be the difference between the two forces because they are in opposite directions.
- They are considered to be unbalanced forces.

Unbalanced Forces

- The students are pushing on the box in the same direction.
- These forces are combined, or added together, because they are exerted on the box in the same direction.
- The net force that acts on this box is found by adding the two forces together.

Force of Friction

- What force opposes motion?
- Friction ALWAYS opposes motion
- **Friction** is a force that opposes motion between 2 surfaces that are in contact

Friction

- **Static Friction**: the friction between objects that are NOT moving
  - It resists the initiation of movement
- **Kinetic Friction**: the force that opposes the movement between 2 surfaces that are in contact
  - It tries to "slow down" the movement

Kinetic Friction

- There are 2 types of kinetic friction

1. *Sliding friction*: when an object slides over a surface
2. *Rolling friction*: when an object roll over a surface

Friction and Motion

- Lower friction
  - Lubricants: cooking oil, wax, grease
- Increase friction
  - Sand on roads

When 2 people push on a box with the same amount of force, the net force is always zero.

A. True
B. False

What is the net force if you push E with 50 N and I push with 75 N W?

- Numeric

Assignment

- EOSQ (2-3)
- 11.3 CR