Chapter 2: Kinematics

Section 1

To simplify the concept of motion, we will first consider motion that takes place in one direction.

To measure motion, you must choose a frame of reference.

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

Displacement(**Δx**) **-** the change in position of an object

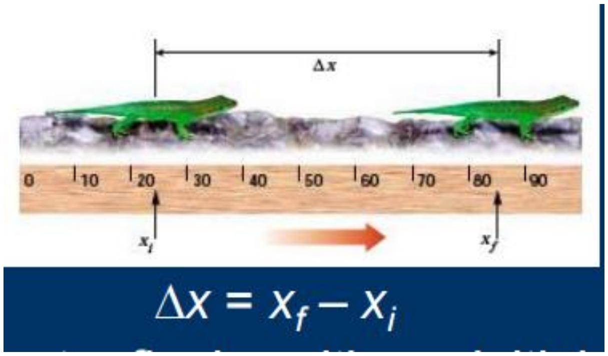
$\Delta x = x_f - x_i$

Displacement = change in position = final position – initial position

The SI unit for displacement is the meter, **m**

Displacement is not always equal to the distance traveled

Displacement can be *positive or negative*, this depends on your frame of reference



EX: A lizard is walking on a meter stick from the 22 cm mark to the 83cm mark.

A) What was the distance traveled by the lizard?

B) What is the lizard's displacement?

C) It then turns backwards and walks to the 25cm mark. What is the total distance its traveled?

D) What is the lizard's total displacement now?

Average Velocity is the total displacement divided by the time interval during which the displacement occurred.

AVERAGE VELOCITY

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

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

In SI, the unit of velocity is meters per second, abbreviated as **m/s**.

Velocity describes motion with both a direction and a numerical value (a magnitude).

Speed, on the other hand, has no direction, only magnitude.

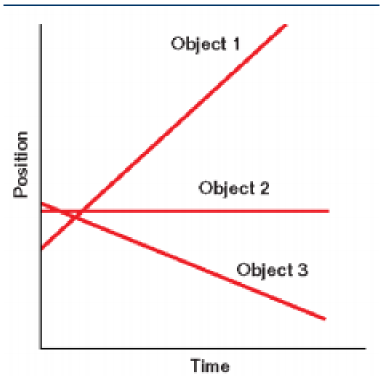
EX: If the motion of the lizard (from the previous problem) took place within 3 seconds, what was the lizard's average velocity?

Practice Problems: Practice A page 44 (2km E; 3.1km; 680m N;3.00h; 0.43h; 77km/h S)

Average speed is equal to the total distance traveled divided by the time interval.

EX: What was the lizard's average speed (from the previous problem)?

Interpreting Velocity Graphically



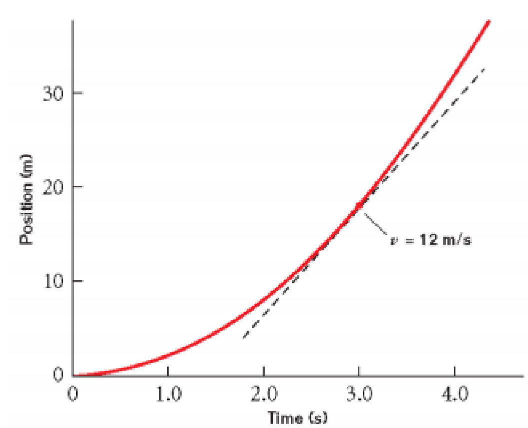
Object 1: positive slope = positive velocity

Object 2: zero slope= zero velocity

Object 3: negative slope = negative velocity

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.

The instantaneous velocity is the velocity of an object at some instant or at a specific point in the object's path.



Section 2:

Acceleration is the rate at which velocity changes over time.

AVERAGE ACCELERATION

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

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

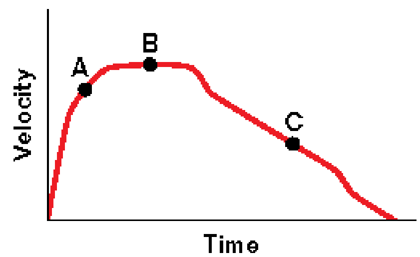
An object accelerates if its speed, direction, or both change.

Acceleration has direction and magnitude.

Consider a train moving to the right, so that the displacement and the velocity are positive.

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

When the velocity in the positive direction is increasing, the acceleration is positive, as at A.



When the velocity is constant, there is no acceleration, as at B.

When the velocity in the positive direction is decreasing, the acceleration is negative, as at C.

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

EX: If a bus slowdown from 25km/h to a complete stop in 10s, what was the average acceleration of the bus?

Practice Problems: Practice B page 49 (2.2s; 2.0s; 5.4s; -3.5×10^{-3}m/s^2; 1.4m/s; 3.1m/s)

Equations for Constantly Accelerated Straight-Line Motion (Kinematics Equations)

Form to use when accelerating object has an initial velocity	Form to use when accelerating object starts from rest
$\Delta x = \frac{1}{2}(v_i + v_f)\Delta t$	$\Delta x = \frac{1}{2}v_f\Delta t$
$v_f = v_i + a\Delta t$	$v_f = a\Delta t$
$\Delta x = v_i\Delta t + \frac{1}{2}a(\Delta t)^2$	$\Delta x = \frac{1}{2}a(\Delta t)^2$
$v_f^2 = v_i^2 + 2a\Delta x$	$v_f^2 = 2a\Delta x$

EX: 1. A car accelerates from the lights, 0 to 60 km/h in 4.0 seconds.

a) Find the distance covered in that time. (34m)
b) What was the total distance traveled?

2. The brakes & tires of a car can provide a maximum deceleration of around 6 m/s^2. If a car is traveling at 100 km/h,

a) What is the minimum distance in which it could stop? (65m)
b) How long will take it to stop?

Practice Problems: Practice C page 53 (21m; 18.8m; 9.1s; 24m/s); Practice D page 55 (9.8m/s;, 29m; 19.3m/s, 59.0m; -7.5m/s, 19m; 2.5s; 32m) and E page 58 (2.51m/s; 21m/s, 16m/s, 13m/s,; 16m/s, 7.0s; 7.4m; 2.4m/s^2; 88m)

Section 3:

Free fall is the motion of a body when only the force due to gravity is acting on the body.

The acceleration on an object in free fall is called the acceleration due to gravity, or free-fall acceleration.

Free-fall acceleration is denoted with the symbols a_g (generally) or g (on Earth's surface).

Free-fall acceleration is the same for all objects, regardless of mass.

This book will use the value g = 9.81 m/s^2 .

Free-fall acceleration on Earth's surface is –9.81 m/s^2 at all points in the object's motion.

Consider a ball thrown up into the air.

– Moving upward: velocity is decreasing, acceleration is – 9.81 m/s^2

– Top of path: velocity is zero, acceleration is –9.81 m/s^2

– Moving downward: velocity is increasing, acceleration is – 9.81 m/s^2

EX: During a tornado in 2008 the Peachtree Plaza Westin Hotel in downtown Atlanta suffered damage. Suppose a piece of glass dropped from the top of the hotel falling 215 meters.

a) Ignoring air resistance, how long would it take the piece of glass to hit the ground?
b) Ignoring air resistance, what will the velocity of the piece of glass be when it strikes the ground?

Practice Problems: Practice F page 64 (-42m/s, 11s; 22.1m/s, 2.25s; 8.0m/s, 1.63s; 1.8m)