Lecture 3: One D-Kinematics

1. Definitions
    - Kinematics
    - Position
    - Distance
    - Displacement
    - Velocity
    - Acceleration
2. Equations for One-Dimensional Motion with Constant Acceleration

Definitions

- Kinematics

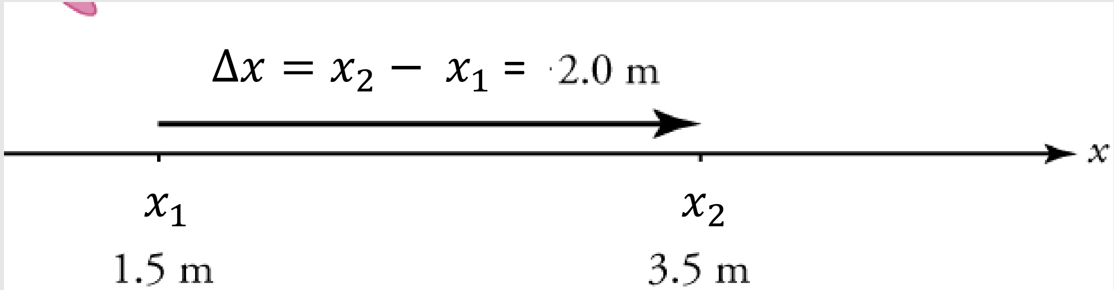
The study motion without thinking about its cause

- Position

The location where something is relative to a coordinate system called a frame of reference

  - Position is relative to a reference frame
  - Most common coordinate system is *x-y* coordinate system

- **Displacement**
  - Change in position relative to a reference frame
  - $\Delta x = x_2 - x_1$
  - Vector (see detail later)
    - Has direction and magnitude
  - Path does not matter
  - Only depends on final and initial position



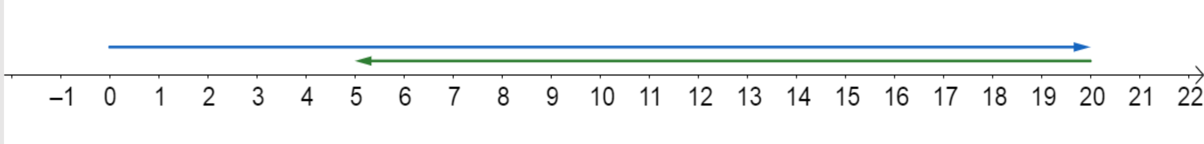
- Distance
  - Total length of the path taken
  - Scalar
    - Only has magnitude

Example: d= 30 m

Example:

- You drive 20 km east, then turn around and drive 15 km west.

What is your displacement?



- $\Delta x = x_2 \quad - \quad x_1$
- $\Delta x = 5\ km - 0\ km$
- $5\ km$
- 5 km **east** of your starting point

- What is your distance traveled?
  - $20\ km + 15\ km$

  d= $35\ km$

Velocity and Graphs

Velocity is the rate of change of position

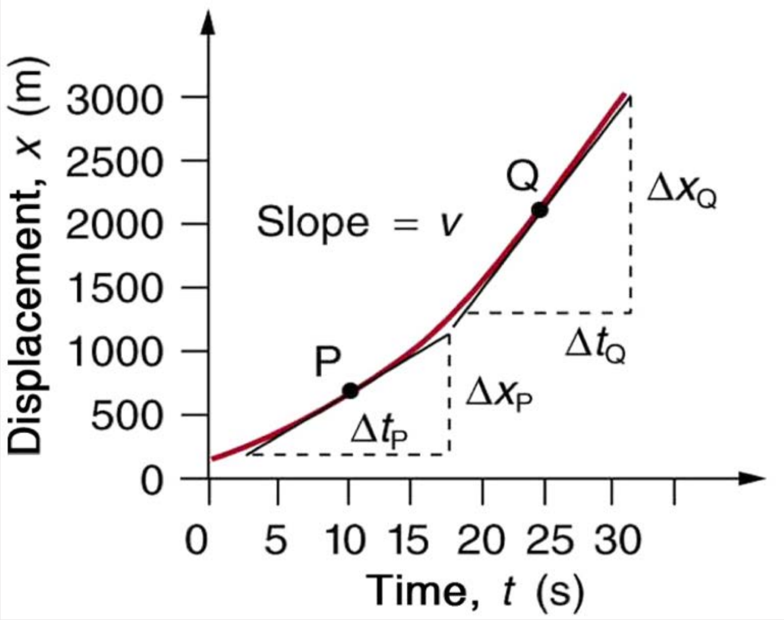
- The slope of a position vs. time graph is the velocity

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$$

If $t_1 = 0$ and $t_2 = t$

$$\boxed{x_2 = \bar{v}t + x_1}$$

- If the graph is not a straight line, then use the slope of a tangent line drawn to that point.



Velocity and Graphs_ continued

- Velocity is a vector (has direction) $v = \frac{displacement}{time}$
- Speed is a scalar (no direction) $v = \frac{distance}{time}$

- Units of both are m/s

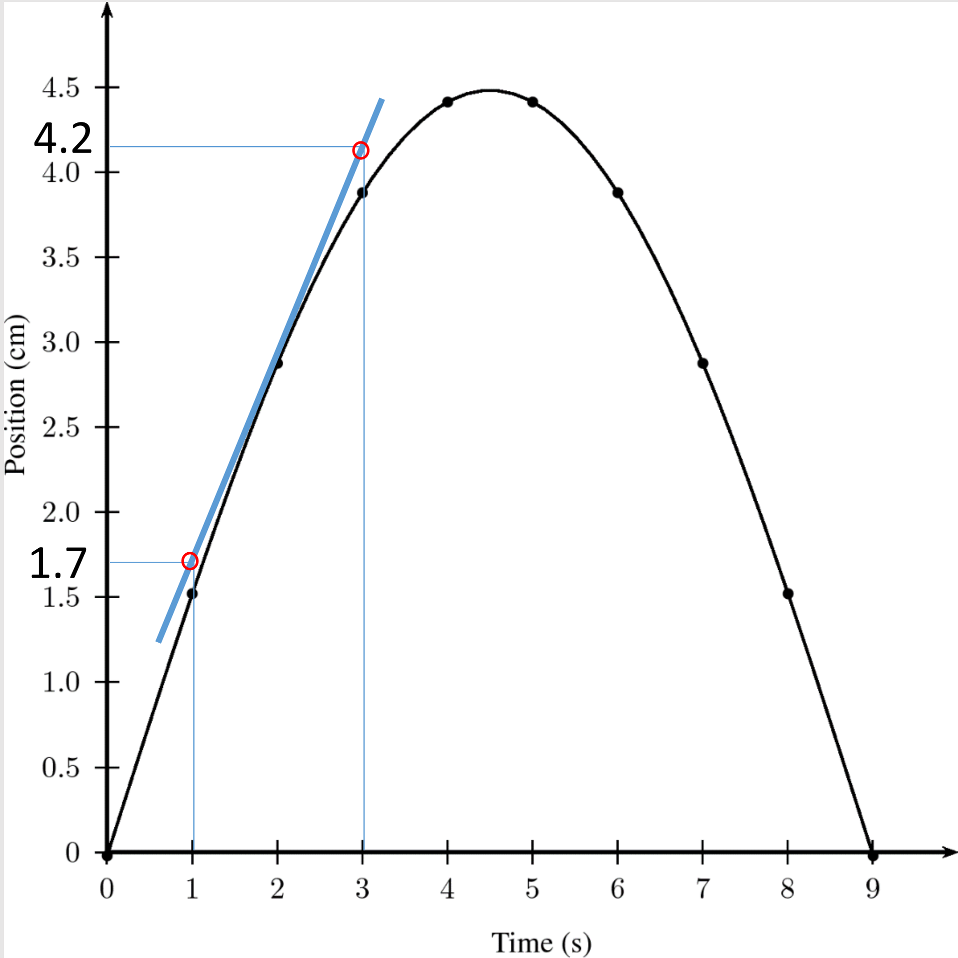
Example 1

The graph shows the height of a ball thrown straight up vs time. Find the velocity of the ball at 2 seconds.

$$v = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1}$$

$$v = \frac{4.2 - 1.7}{3 - 1}$$

$$v = \frac{2.5\ cm}{2\ s} = 1.3\,\frac{cm}{s}$$



Example 2

The spine-tailed swift is the fastest bird in powered flight. On one flight a particular bird flies 306 m east, then turns around and flies 406.5 m back west. This flight takes 15 s.

1. What is the bird's average velocity?
2. What is the average speed?
3. Which of these would we use to say how fast the bird is?

1. average velocity

- $\overline{v} = \frac{\Delta x}{\Delta t} = \frac{306\ m - 406.5\ m}{15\ s} = -6.7\ m/s$
- 6.7 m/s west

2. Average speed

1. $v = \frac{distance}{time}$

$v = \frac{(306 + 406.5)}{15} = 47.5 \frac{m}{s}$

3. Average speed

Acceleration and Graphs

Acceleration is the Rate of change of velocity.

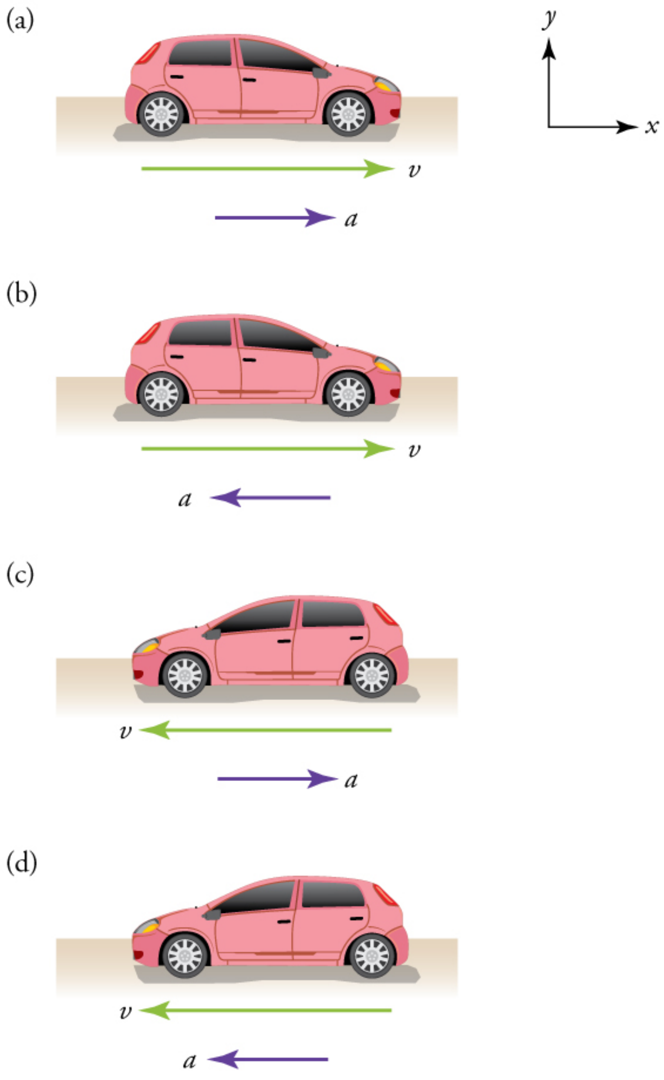
In this course, we will consider **a=constant**

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1}$$

If we assume $t_2 = t \; and \; t_1 = 0$

$$\boxed{v_2 = at + v_1}$$

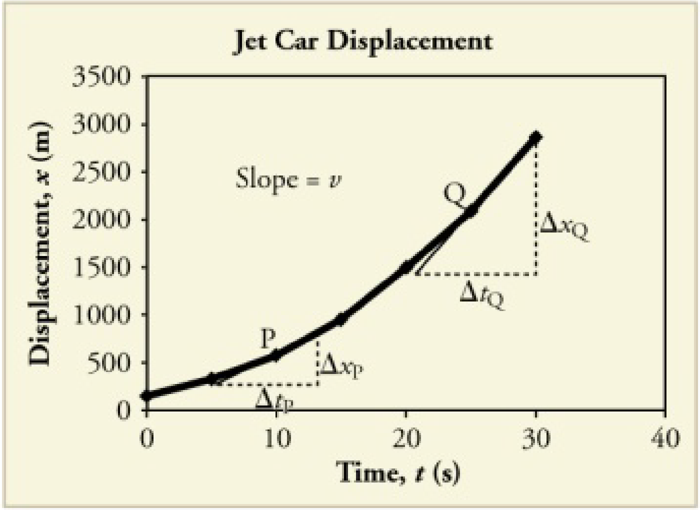
- Vector (see details later)
- Unit: m/s^2
- If the acceleration is in the same direction as motion, then the object is increasing speed (accelerating).
- If the acceleration is opposite direction as motion, then the object is decreasing speed (decelerating).



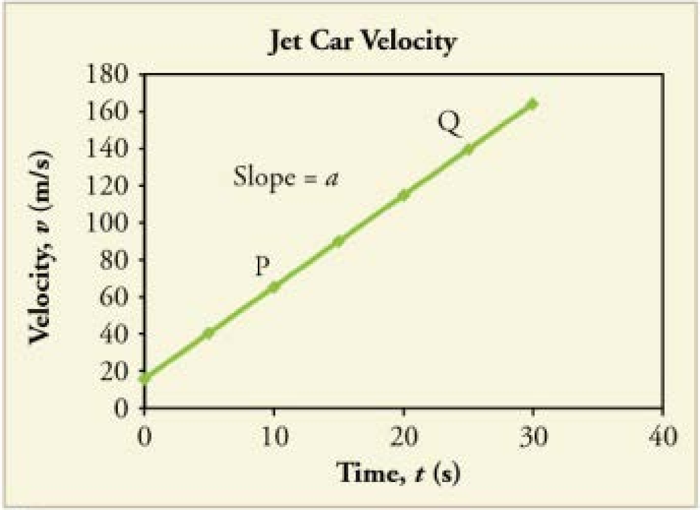
Acceleration and Graphs

- Constant acceleration
  - The graph of position–time is parabolic (see later)

  - The graph of velocity–time is linear
    $v = at + v_0$ is linear



(a)



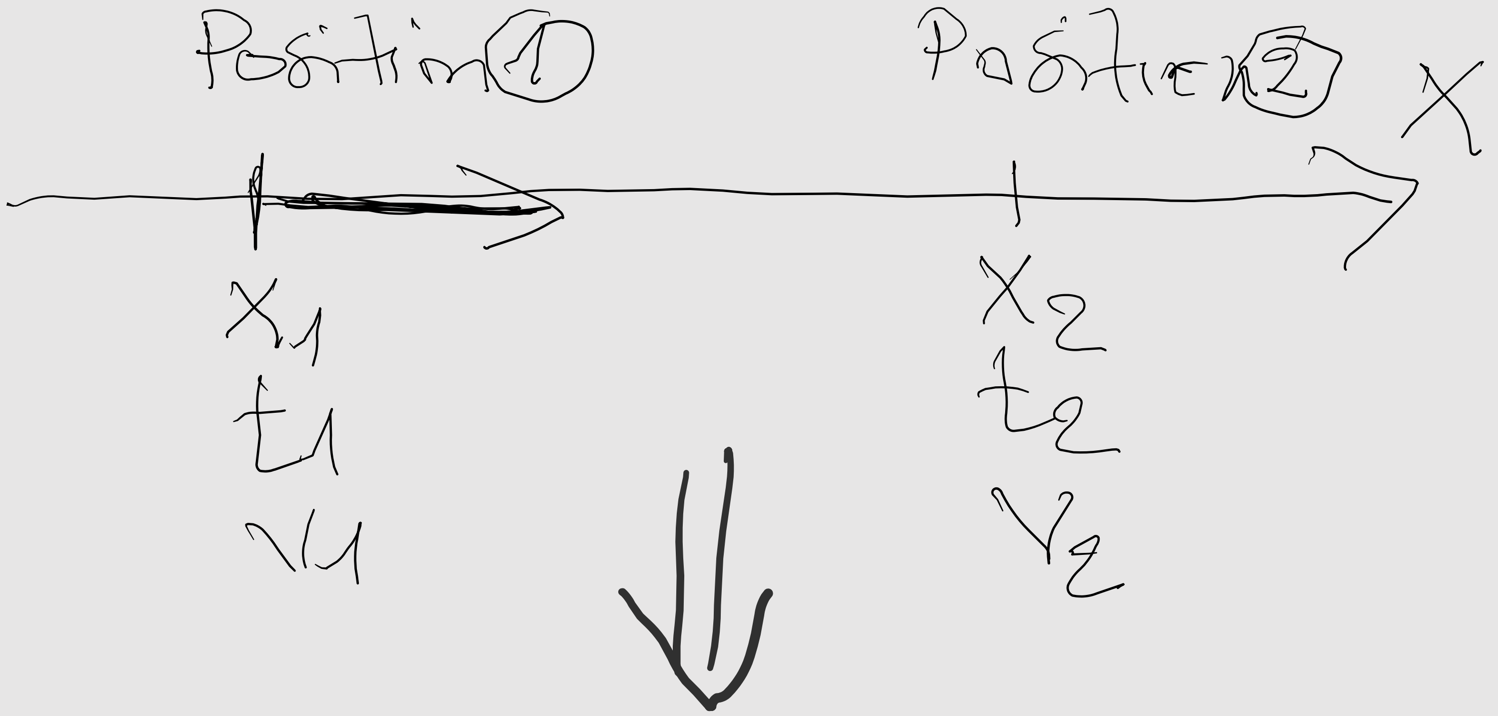
Equations for One-Dimensional Motion with **Constant** Acceleration

We will:

- Calculate the displacement of an object that is not accelerating, given initial position and velocity.
- Calculate the final velocity of an accelerating object, given initial velocity, acceleration, and time.
- Calculate displacement and final position of an accelerating object, given initial position, initial velocity, time, and

acceleration.

after defining all quantities
let have our equations



$$v = \frac{x_2 - x_1}{t_2 - t_1} \Rightarrow x_2 = x_1 + v(t_2 - t_1)$$

$$a = \frac{v_2 - v_1}{t_2 - t_1} \Rightarrow \boxed{v_2 = v_1 + a(t_2 - t_1)} \quad (1)$$

<u>also</u>: $v = \dfrac{v_2 + v_1}{2}$ (by definition)

$$v = \frac{x_2 - x_1}{t_2 - t_1}$$

$$\Rightarrow \frac{v_2 + v_1}{2} = \frac{x_2 - x_1}{t_2 - t_1}$$

solve for x_2

$$⑵\ \boxed{x_2 = x_1 + v_1(t_2 - t_1) + \frac{1}{2}a(t_2 - t_1)^2}$$

<u>NOW</u> we take ① and sub into ②, solve for v_2.

$$\Downarrow$$

$$\boxed{v_2^2 = v_1^2 + 2a(x_2 - x_1)} \quad (3)$$

For any 2 positions P_1 & P_2:

1. $$v_2 = v_1 + a(t_2 - t_1)$$

2. $$x_2 = x_1 + v_1(t_2 - t_1) + \frac{1}{2}a(t_2 - t_1)^2$$

3. $$v_2^2 = v_1^2 + 2a(x_2 - x_1)$$

We can simplify these equations

if:

$t_1 = 0$

$t_2 = t$

$$V_2 = V_1 + at$$

$$X_2 = X_1 + V_1 t + \frac{1}{2} a t^2$$

$$V_2^2 = V_1^2 + 2a(X_2 - X_1)$$

Steps to solve a problem in one-Dimensional Motion with Constant Acceleration

1. Examine the situation to determine which physical principles are involved and Maybe draw a picture
2. List what is given or can be inferred from the problem.
3. State what needed to be determined in the problem.
4. Find an equation or set of equations to solve the problem.
5. Substitute the knowns into the appropriate equation, and Solve
6. Check if the answer is reasonable: Does it make sense?

Practice and Practice

A plane starting from rest accelerates to $40\ m/s$ in $10\ s$. How far did the plane travel during this time?

Do it in class

Practice and Practice

To avoid an accident, a car decelerates at 0.50 m/s^2 for 3.0 s and covers 15 m of road. What was the car's initial velocity?

Do it in class

Practice and Practice

A cheetah is walking at 1.0 m/s when it sees a zebra 25 m away. What acceleration would be required to reach 20.0 m/s in that distance?

Do it in class

Practice and Practice

The left ventricle of the heart accelerates blood from rest to a velocity of +26 cm/s.

1. If the displacement of the blood during the acceleration is +2.0 cm, determine its acceleration (in cm/s^2).

2. How much time does blood take to reach its final velocity?

Do it in class

Practice and Practice

A dropped object near the earth will accelerate downward at 9.8 m/s^2. (Use -9.8 m/s^2) If the initial velocity is 1 m/s downward, what will be its velocity at the end of 3 s? Is it speeding up or slowing down?

Do it in class