Chapter 2.
Motion in One Dimension

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Introduction

Introduction

Objectives:

After completing this module, you should be able to

- Define and apply concepts of
  distance, displacement,
  average and instantaneous velocity,
  average and instantaneous acceleration.

- Solve problems involving initial and final velocity, acceleration, displacement, and time.
- Demonstrate your understanding of directions and signs for velocity and displacement.

Outline:

- Displacement and average velocity

- Instantaneous velocity

- Acceleration (average and instantaneous)

- Motion with constant acceleration
  Free Fall

- Velocity and displacement by integration

Uniform Velocity and Acceleration in One Dimension:

- Motion is along a straight line (horizontal, vertical or slanted).

- The cause of motion will be discussed later. Here we only treat the changes.

- The moving object is treated as though it were a point particle.

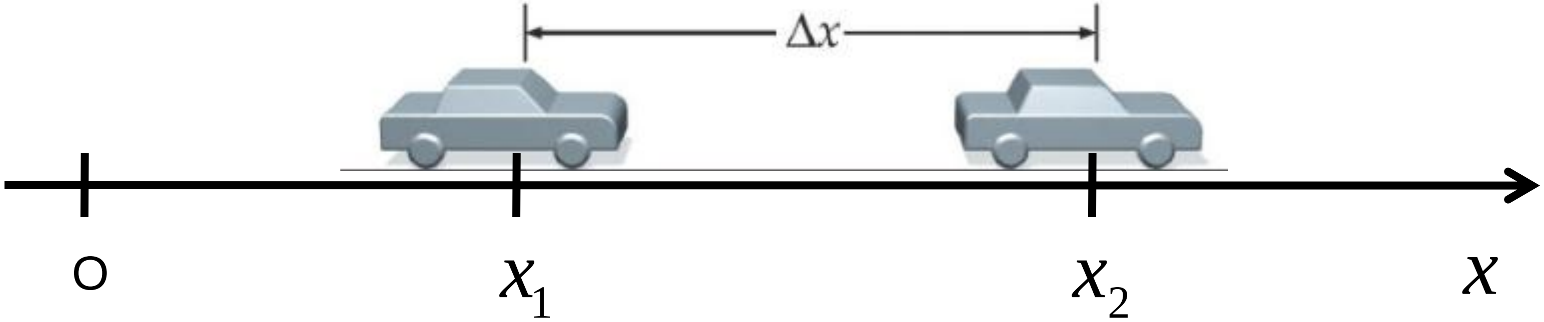
1. Displacement and Average Velocity

Any measurement of position, distance, or speed must be made with Respect to a REFERENCE FRAM.

•A frame of reference is an extended object whose parts are at rest relative each other.

• Displacement

Displacement is defined as *the change in position*



$$\Delta x = x_2 - x_1 \quad (1)$$

1. Displacement and Average Velocity

Example 1.

An ant starts at x = 20 cm on a piece of graph paper and walks along the x axis to x = - 20 cm. It then turns around and walks back to x = -10 cm. What is the ant's displacement and total distance traveled?

$$\Delta x = x_3 - x_1 = -10 - 20 = -30 \quad (cm)$$

The negative signs indicate that ant is moving to the left (negative direction).

1. Displacement and Average Velocity

Example 1.

An ant starts at x = 20 cm on a piece of graph paper and walks along the x axis to x = - 20 cm. It then turns around and walks back to x = -10 cm. What is the ant's displacement and total distance traveled?

Total distance (S): S= S12 + S23 = 40 + 10 = 50 (cm)

1. Displacement and Average Velocity

Average Velocity: $$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1} \quad (m/s) \qquad (2)$$

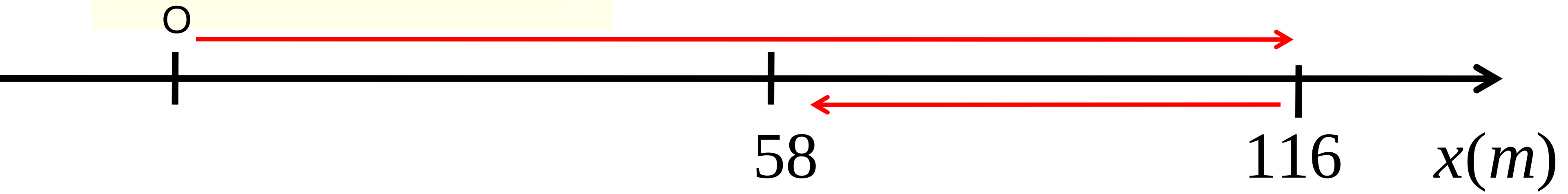
Average Speed: $$Speed = \frac{S}{\Delta t} = \quad (m/s) \qquad (3)$$

Example 2.

7. (II) A horse canters away from its trainer in a straight line, moving 116 m away in 14.0 s. It then turns abruptly and gallops halfway back in 4.8 s. Calculate (*a*) its average speed and (*b*) its average velocity for the entire trip, using "away from the trainer" as the positive direction.

1. Displacement and Average Velocity

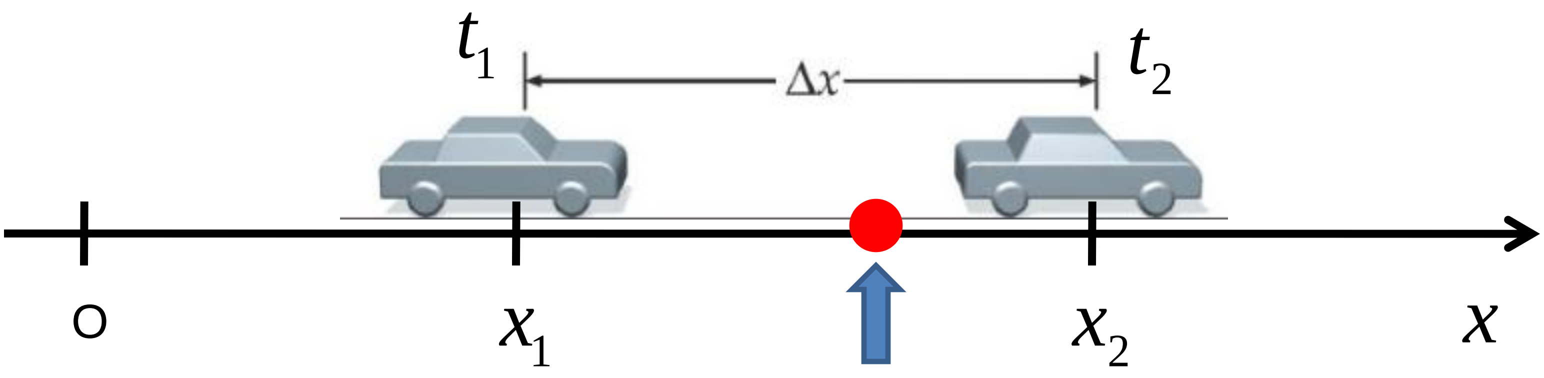
Example 2.



Average Speed: $$Speed = \frac{S}{\Delta t} = \frac{116+58}{14+4.8} = 9.5 \quad (m/s)$$

Average Velocity: $$\overline{v} = \frac{\Delta x}{\Delta t} = \frac{58-0}{18,4} = 3.15 \quad (m/s)$$

2. Instantaneous Velocity



What is the velocity at any instant time?

We have the average velocity

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{x_2 - x_1}{t_2 - t_1} \quad (2)$$

To get instantaneous velocity, the eq. (2) is to be evaluated in the limit of Δt becoming extremely small, approaching zero.

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt} \quad (4)$$

2. Instantaneous Velocity

$$v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt} \quad (4)$$

The instantaneous velocity is defined as the derivative of x with respect to t .

Example 3.

16. (II) The position of a ball rolling in a straight line is given by $x = 2.0 - 3.6\,t + 1.1\,t^2$, where x is in meters and t in seconds. (*a*) Determine the position of the ball at $t = 1.0$ s, 2.0 s, and 3.0 s. (*b*) What is the average velocity over the interval $t = 1.0$ s to $t = 3.0$ s? (*c*) What is its instantaneous velocity at $t = 2.0$ s and at $t = 3.0$ s?

3. Acceleration

Bugatti Veyron:
0 km/h-100 km/h: 2,5 s

Lamborghini Aventador
0 km/h-100 km/h: 2,8 s

3. Acceleration

Acceleration specifies how rapidly the velocity of an object is changing.

Average acceleration:

Average acceleration is defined as the change of velocity divided by the time taken to make this change.

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{t_2 - t_1} \quad (m \setminus s^2)$$

3. Acceleration

Example 4.

A car Toyota Camry accelerates along a straight road from at rest to 100 km/h in 7.3 s. What is the magnitude of it's average acceleration?

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{(100/3.6)-0}{7.3} = 3.8 \quad (m \backslash s^2)$$

Example 5.

What is the average acceleration of Bugatti veyron?

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{(100/3.6)-0}{2.5} = 11.1 \quad (m \backslash s^2)$$

3. Acceleration

Instantaneous acceleration:

Instantaneous acceleration is defined as the *limiting value of average acceleration as we let Δt approach zero*.

$$a = \lim_{\Delta t \to 0} \frac{\Delta v}{\Delta t} = \frac{dv}{dt} \quad (m \backslash s^2)$$

Example 6.

The position of a particle is given by the following equation:

$$x = (2.00\,\mathrm{m/s^3})t^3 + (2.50\,\mathrm{m/s})t.$$

What is the acceleration of the particle at $t = 2\ s$?

4. Motion at Constant Acceleration
Free Fail

Thank for your attention!