

## 4.7 Acceleration (Calculating)

\*Use Hot Wheels!

- Define acceleration.
- Give examples of acceleration.
- Describe how it feels to accelerate.

### Defining Acceleration

**Acceleration** is a measure of the change in velocity of a moving object. It measures the rate at which velocity changes. Velocity, in turn, is a measure of the speed and direction of motion, so a change in velocity may reflect a change in speed, a change in direction, or both. Both velocity and acceleration are vectors. A vector is any measurement that has both size and direction. People commonly think of acceleration as an increase in speed, but a decrease in speed is also acceleration. In this case, acceleration is negative and called deceleration. A change in direction without a change in speed is acceleration as well.

## 4.8 Calculating Acceleration from Velocity and Time

- Explain how to calculate average acceleration when direction is constant.
- Identify the SI unit for acceleration.
- Solve simple acceleration problems.

### Calculating Average Acceleration in One Direction

Calculating acceleration is complicated if both speed and direction are changing or if you want to know acceleration at any given instant in time. However, it's relatively easy to calculate average acceleration over a period of time when only speed is changing. Then acceleration is the change in velocity (represented by  $\Delta v$ ) divided by the change in time (represented by  $\Delta t$ ):

$$acceleration = \frac{\Delta v}{\Delta t} \Rightarrow \vec{a} = \frac{\vec{v}_f - \vec{v}_o}{t}$$

### Guidance

- Acceleration is the rate of change of velocity. So in other words, acceleration tells you how quickly the velocity is increasing or decreasing. An acceleration of  $5 \text{ m/s}^2$  indicates that the velocity is increasing by  $5 \text{ m/s}$  in the positive direction every second.
- Gravity near the Earth pulls an object downwards toward the surface of the Earth with an acceleration of  $9.8 \text{ m/s}^2 (\approx 10 \text{ m/s}^2)$ . In the absence of air resistance, all objects will fall with the same acceleration. The letter  $g$  is used as the symbol for the acceleration of gravity.
  - When talking about an object's acceleration, whether it is due to gravity or not, the acceleration of gravity is sometimes used as a unit of measurement where  $1g = 9.8 \text{ m/s}^2$ . So an object accelerating at  $2g$ 's is accelerating at  $2 * 9.8 \text{ m/s}^2$  or  $19.6 \text{ m/s}^2$
- *Deceleration* is the term used when an object's *speed* (i.e. magnitude of its velocity) is decreasing due to acceleration in the opposite direction of its velocity.

# Calculating Acceleration

Focus on reading and finding the quantities given and asked from the problem

## Guided Practice (no direction changes)

A car is initially traveling 20 m/s [E]. It then accelerates to 32 m/s [E] in 3.5 seconds.

Calculate the acceleration of the car.

**\*Reread question and set up the frame of reference and coordinate system\***

W,-  $\longleftrightarrow$  E,+ Frame of reference is relative to the road or a stationary observer outside of the car - this will most often be the case.

**\*Reread question and list known/wanted quantities - make quantities relative to positive direction if necessary\***

Note: If given no position information then assume that  $\vec{d}_o = \text{zero}$

$$\vec{v}_o = 20 \text{ m/s [E]} \quad \vec{v}_f = 32 \text{ m/s [E]}$$

$$t = 3.5 \text{ s} \quad \vec{a} = ?$$

**\*Check for a formula using only the known and wanted quantities\***

$$\vec{a} = \frac{\vec{v}_f - \vec{v}_o}{t}$$

**\*Substitute values and solve for the unknown\***

$$a = \frac{32 - 20}{3.5} = \frac{12}{3.5}$$

$$a = 3.4 \text{ m/s}^2$$

units in at the end

**\*Check answer conceptually - does its value and direction make sense?\***

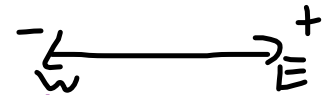
## Calculating Acceleration

### Guided Practice (no direction changes)

Solving for final velocity - Pair Up

A car is initially moving 15 m/s [E] and accelerates at 3.5 m/s<sup>2</sup> [E] for 9.2 seconds.

Calculate the car's final velocity.



\*Reread question and list known/wanted quantities\*

$$\vec{v}_0 = 15 \text{ m/s [E]} \quad \vec{v}_f = ?$$

$$\vec{a} = 3.5 \text{ m/s}^2 \text{ [E]}$$

$$t = 9.2 \text{ s}$$

$$\vec{a} = \frac{\vec{v}_f - \vec{v}_0}{t}$$

$$3.5 \times 9.2 = \frac{v_f - 15}{9.2} \times 9.2$$

$$32.2 = v_f - 15$$

$$47.2 \text{ m/s} = v_f$$

## Calculating Acceleration

### Guided Practice (no direction changes)

Solving for initial velocity

A plane accelerates to 175 m/s [E] under an acceleration of 15 m/s<sup>2</sup> [E] in 5.0 seconds. Calculate the initial velocity of the plane.

\*Reread question and list known/wanted quantities\*



$$\vec{v}_f = 175 \text{ m/s [E]} \quad \vec{v}_0 = ?$$

$$\vec{a} = 15 \text{ m/s}^2 \text{ [E]}$$

$$t = 5.0 \text{ s}$$

$$\vec{a} = \frac{\vec{v}_f - \vec{v}_0}{t}$$

$$15 \overset{\times 5}{=} \frac{175 - v_0}{5} \overset{\times 5}{}$$

$$75 \overset{-175}{=} 175 - v_0 \overset{-175}{}$$

$$\overset{-1}{-100} = \overset{-1}{-v_0}$$

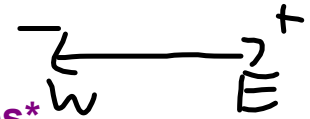
$$100 \text{ m/s} = v_0$$

## Calculating Acceleration

### Guided Practice (no direction changes)

Solving for time - weakest student performance on this type

Calculate how long it would take person to accelerate from rest to 22 m/s [E] averaging an acceleration of 1.8 m/s<sup>2</sup> [E].



\*Reread question and list known/wanted quantities\*

$$t = ? \quad \vec{a} = 1.8 \text{ m/s}^2 \text{ [E]}$$

$$\vec{v}_0 = 0 \text{ m/s [E]} \quad \vec{a} = \frac{\vec{v}_f - \vec{v}_0}{t}$$

$$\vec{v}_f = 22 \text{ m/s [E]}$$

$$1.8 = \frac{22 - 0}{t}$$

$$1.8 t = 22$$

$$t = \frac{22}{1.8}$$

$$t = 12.2 \text{ s}$$

## Attachments

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moving-man\_all.jar