Physics Notes

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October 19-23

2020

Acceleration

2.1 Acceleration (P2.2A)

When an object's velocity changes, it accelerates. **Acceleration** shows the change in velocity in a unit time. So, Acceleration is the rate of change of velocity.

Acceleration
acceleration = change in velocity/time interval $$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$$ or $$\vec{a} = \frac{(\vec{v}_2 - \vec{v}_1)}{t_2 - t_1}$$ Acceleration units: (km/h)/s or (m/s)/s = m/s^2. Acceleration can be both positive and negative.

In this equation

$\vec{a}$: the object's uniform acceleration

Δt: time interval over which the object's velocity changed

$\vec{v_2}$: The object's final velocity at the end of the time interval

$\vec{v_1}$: the object's initial velocity at the beginning of the time interval

Example: if a car moves from the rest to 5 m/s in 5 seconds, its average acceleration is:

$$a = \frac{5m/s}{5s} = 1m/s^2$$

<u>What to do?</u>

1. Study sample problem below.
2. Do practice exercises numbers 1, 2, 3.
3. Show your work and submit.
4. Answers are shown below (in blue) to verify your work.
5. When submitting, write the section number, Example:

   Section 2.1 (Acceleration) Exercises numbers 1, 2, 3.

Sample Problems:

1. A car accelerates at a constant rate from 40 km/h [E] to 90 km/h [E] in 5.0 s. What is its acceleration?

$$\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$$
$$= \frac{90 \text{ km/h[E]} - 40 \text{ km/h[E]}}{5.0 \text{ s}}$$
$$= \frac{50 \text{ km/h[E]}}{5.0 \text{ s}}$$
$$= 10 \text{ (km/h)/s[E]}$$

The car is accelerating at a uniform rate of 10 (km/h)/s [E]. This means that its velocity increases by 10 km/h [E] each second.

2. A runner starting from rest reaches a velocity of 9.6 m/s in 2.0 s. What is the average acceleration?

$$\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$$
$$= \frac{9.6 \text{ m/s} - 0}{2.0 \text{ s}}$$
$$= 4.8 \text{ (m/s)/s, or } 4.8 \text{ m/s}^2 \text{ in a positive direction}$$

This means that on the average, her velocity increases by 4.8 m/s each second

3.A baseball player running at 8.0 m/s [W] slides into third base coming to rest in 1.6 s. What is his average acceleration?

$$\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$$

$$= \frac{0 - 8 \text{ m/s[W]}}{1.6 \text{ s}}$$

$$a = \frac{-8.0 \text{ m/s[W]}}{1.6 \text{ s}}$$

$$= -5.0 \text{ m/s}^2\text{[W], or } 5.0 \text{ m/s}^2\text{[E]}$$

When an object slows down, its acceleration is in the opposite direction to its velocity. Although we usually call slowing down deceleration, it is easier to think of it as an acceleration in the opposite direction to the velocity.

Practice.

1. A cyclist accelerate from 5.0 m/s [S] to 15 m/s [S] in 4.0 s. What is his acceleration?
2. A jet plane accelerates from rest to 750 km/h in 2.2 min. What is is average acceleration?
3. A runner accelerates from 0.52 m/s to 0.78 m/s in 0.5 s. What is her acceleration?
4. A driver entering the outskirts of a city takes her foot off the accelerator so that her car slows down from 90 km/h to 50 km/h in 10 s. Find the car's average acceleration.

5. A boy rolls a ball up a hill giving it a velocity of 4.5 m/s[N]. Five second later, the ball is rolling down the hill with a velocity of 1.5 m/s [S]. What is the ball's acceleration?

Answers:

1. 2.5 m/s^2 [S]
2. 3.4 x 10^2 (km/h)/min
3. 0.52 m/s^2
4. - 0.4 (km/h)/s
5. 1.2 m/s^2 [S]

Sample Problems

1. A car accelerates at a constant rate from 40 km/h[E] to 90 km/h[E] in 5.0 s. What is its acceleration?

$$\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$$

$$= \frac{90 \text{ km/h[E]} - 40 \text{ km/h[E]}}{5.0 \text{ s}}$$

$$= \frac{50 \text{ km/h[E]}}{5.0 \text{ s}}$$

$$= 10 \text{ (km/h)/s[E]}$$

The car is accelerating at a uniform rate of 10 (km/h)/s[E]. This means that its velocity increases by 10 km/h[E] each second.

2. A runner starting from rest reaches a velocity of 9.6 m/s in 2.0 s. What is her average acceleration?

$$\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$$

$$= \frac{9.6 \text{ m/s} - 0}{2.0 \text{ s}}$$

$= 4.8$ (m/s)/s, or 4.8 m/s^2 in a positive direction

This means that on the average, her velocity increases by 4.8 m/s each second.

3. A baseball player running at 8.0 m/s[W] slides into third base, coming to rest in 1.6 s. What is his average acceleration?

$$\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$$

$$= \frac{0 - 8 \text{ m/s[W]}}{1.6 \text{ s}}$$

$$a = \frac{-8.0 \text{ m/s[W]}}{1.6 \text{ s}}$$

$= -5.0$ m/s^2[W], or 5.0 m/s^2[E]

Sample problem 3 shows that when an object slows down, its acceleration is in the opposite direction to its velocity. Although we usually call slowing down **deceleration**, it is easier to think of it as an acceleration in the opposite direction to the velocity.

Practice

1. A cyclist accelerates from 5.0 m/s[S] to 15 m/s[S] in 4.0 s. What is his acceleration?
2. A jet plane accelerates from rest to 750 km/h in 2.2 min. What is its average acceleration?
3. A runner accelerates from 0.52 m/s to 0.78 m/s in 0.50 s. What is her acceleration?
4. A driver entering the outskirts of a city takes her foot off the accelerator so that her car slows down from 90 km/h to 50 km/h in 10 s. Find the car's average acceleration.
5. A boy rolls a ball up a hill giving it a velocity of 4.5 m/s[N]. Five seconds later the ball is rolling down the hill with a velocity of 1.5 m/s[S]. What is the ball's acceleration?

Numerical Answers to Practice Problems

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1. **2.5 m/s^2[S]**
2. **3.4×10^2 (km/h)/min**
3. **0.52 m/s^2**
4. **−4.0 (km/h)/s**
5. **1.2 m/s^2[S]**