Calculating Acceleration from Velocity and Time

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CHAPTER 1

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.

This cyclist is in constant motion as he competes in an off-road mountain bike race. Both his speed and his direction keep changing. Velocity is a measure that represents both speed and direction. Changes in velocity are measured by **acceleration**. Acceleration reflects how quickly velocity is changing. It may involve a change in speed, a change in direction, or both.

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 Δv) divided by the change in time (represented by Δt):

$$\text{acceleration} = \frac{\Delta v}{\Delta t}$$

Accelerating on a Bike

Look at the cyclist in the **Figure** 1.1. With the help of gravity, he speeds up as he goes downhill on a straight part of the trail. His velocity changes from 1 meter per second at the top of the hill to 6 meters per second by the time he

reaches the bottom. If it takes him 5 seconds to reach the bottom, what is his average acceleration as he races down the hill?

$$\begin{aligned}\text{acceleration} &= \frac{\Delta v}{\Delta t} \\ &= \frac{6 \text{ m/s} - 1 \text{ m/s}}{5 \text{ s}} \\ &= \frac{5 \text{ m/s}}{5 \text{ s}} \\ &= \frac{1 \text{ m/s}}{1 \text{ s}} \\ &= 1 \text{ m/s}^2\end{aligned}$$

In words, this means that for each second the cyclist travels downhill, his velocity (in this case, his speed) increases by 1 meter per second on average. Note that the answer to this problem is expressed in m/s^2, which is the SI unit for acceleration.

FIGURE 1.1

Q: The cyclist slows down at the end of the race. His velocity changes from 6 m/s to 2 m/s during a period of 4 seconds without any change in direction. What was his average acceleration during these 4 seconds?

A: Use the equation given above for acceleration:

$$\begin{aligned}\text{acceleration} &= \frac{\Delta v}{\Delta t} \\ &= \frac{6 \text{ m/s} - 2 \text{ m/s}}{4 \text{ s}} \\ &= \frac{4 \text{ m/s}}{4 \text{ s}} \\ &= \frac{1 \text{ m/s}}{1 \text{ s}} \\ &= 1 \text{ m/s}^2\end{aligned}$$

Summary

- To calculate average acceleration when direction is not changing, divide the change in velocity by the change in time using the formula:

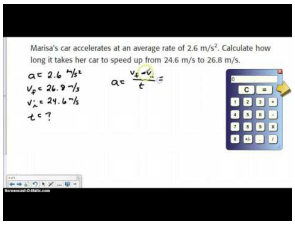
$$\text{acceleration} = \frac{\Delta v}{\Delta t}$$

- The SI unit for acceleration is m/s^2.

Review

1. Write the equation for acceleration without a change in direction.
2. What is the SI unit for acceleration?
3. During the final 5 seconds of a race, a cyclist increased her velocity from 4 m/s to 7 m/s. What was her average acceleration during those last 5 seconds?

Resources



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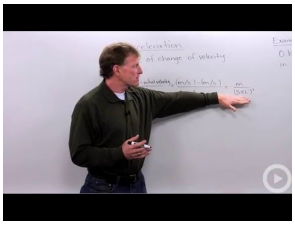

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References

1. Richard Greenwood (Flickr: rsgca). Bicyclist accelerating on a downhill stretch . CC BY 2.0