

Velocity and Acceleration

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CONCEPT

1

Velocity and Acceleration

Students will learn the meaning of acceleration, how it is different than velocity and how to calculate average acceleration.

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Key Equations

v = velocity (m/s)

v_i = initial velocity

v_f = final velocity

Δv = change in velocity = $v_f - v_i$

$$v_{avg} = \frac{\Delta x}{\Delta t}$$

a = acceleration (m/s^2)

$$a_{avg} = \frac{\Delta v}{\Delta t}$$

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 $5 m/s^2$ indicates that the velocity is increasing by $5m/s$ in the positive direction every second.
- Gravity near the Earth pulls an object downwards toward the surface of the Earth with an acceleration of $9.8 m/s^2 (\approx 10 m/s^2)$. 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 $1g = 9.8m/s^2$. So an object accelerating at $2g$'s is accelerating at $2 * 9.8m/s^2$ or $19.6m/s^2$
- *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.

Example 1 A Top Fuel dragster can accelerate from 0 to 100 mph (160 km/hr) in 0.8 seconds. What is the average acceleration in m/s^2 ?

Question: $a_{avg} = ? [m/s^2]$

Given: $v_i = 0 m/s$

$$v_f = 160 km/hr$$

$$t = 0.8 s$$

$$\text{Equation: } a_{avg} = \frac{\Delta v}{t}$$

Plug n' Chug: Step 1: Convert km/hr to m/s

$$v_f = (160 \frac{km}{hr}) \left(\frac{1,000 m}{1 km} \right) \left(\frac{1 hr}{3,600 s} \right) = 44.4 m/s$$

Step 2: Solve for average acceleration:

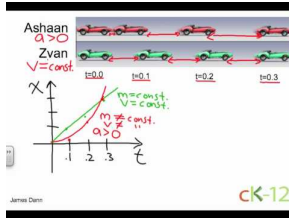
$$a_{avg} = \frac{\Delta v}{t} = \frac{v_f - v_i}{t} = \frac{44.4 \text{ m/s} - 0 \text{ m/s}}{0.8 \text{ s}} = 56 \text{ m/s}^2$$

Answer:

$$56 \text{ m/s}^2$$

Note that this is over $5\frac{1}{2}g$'s!

Watch this Explanation



MEDIA

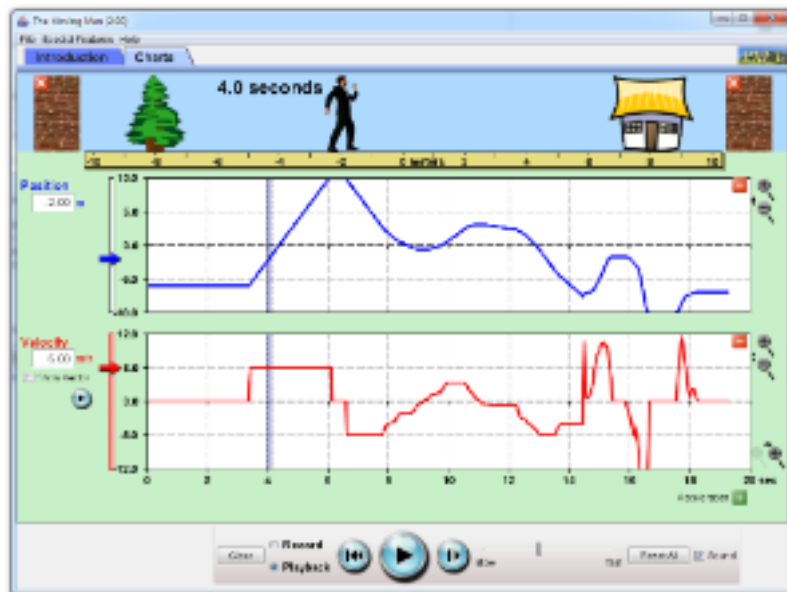
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Simulation



MEDIA

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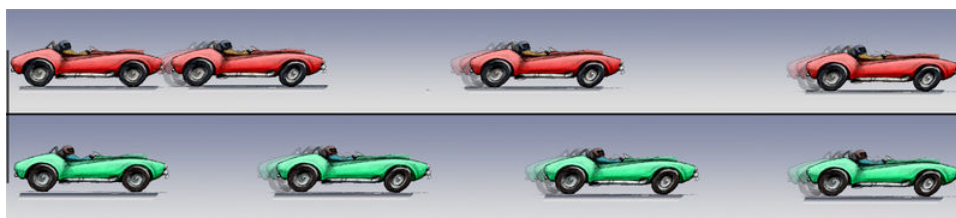


The Moving Man (PhET Simulation)

Time for Practice

1. Ms. Reitman's scooter starts from rest and accelerates at 2.0 m/s^2 .

- a. Where will the scooter be relative to its starting point after 7.0 seconds?
 - b. What is the scooter's velocity after 1s? after 2s? after 7s?
2. A horse is galloping forward with an acceleration of 3 m/s^2 . Which of the following statements is not necessarily true? You may choose more than one.
- a. The horse is increasing its speed by 3 m/s every second, from 0 m/s to 3 m/s to 6 m/s to 9 m/s.
 - b. The speed of the horse will triple every second, from 0 m/s to 3 m/s to 9 m/s to 27 m/s.
 - c. Starting from rest, the horse will cover 3 m of ground in the first second.
 - d. Starting from rest, the horse will cover 1.5 m of ground in the first second.
3. Below are images from a race between Ashaan (above) and Zyan (below), two daring racecar drivers. High speed cameras took four pictures in rapid succession. The first picture shows the positions of the cars at $t = 0.0$. Each car image to the right represents times 0.1, 0.2, and 0.3 seconds later.



- a. Who is ahead at $t = 0.2 \text{ s}$? Explain.
- b. Who is accelerating? Explain.
- c. Who is going fastest at $t = 0.3 \text{ s}$? Explain.
- d. Which car has a constant velocity throughout? Explain.
- e. Graph x vs. t and v vs. t . Put both cars on same graph; label which line is which car.
- f. Which car is going faster at $t = 0.2 \text{ s}$ (Hint: Assume they travel the same distance between 0.1 and 0.2 seconds)?

Answers

1. a. 49 m b. 2 m/s, 4 m/s, 14 m/s
2. discuss in class
3. See Video above

