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

$\Delta v =$ 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: $v_i = 0\ m/s$

$v_f = 160\ km/hr$

$t = 0.8\ s$

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

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

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

Step 2: Solve for average acceleration:

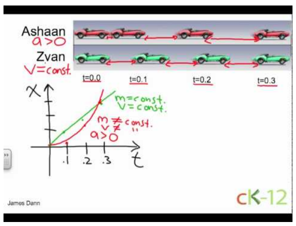
$a_{avg} = \frac{\Delta v}{t} = \frac{v_f - v_i}{t} = \frac{44.4\ m/s - 0\ m/s}{0.8\ s} = 56\ m/s^2$

Answer:

$$\boxed{\mathbf{56\ m/s^2}}$$

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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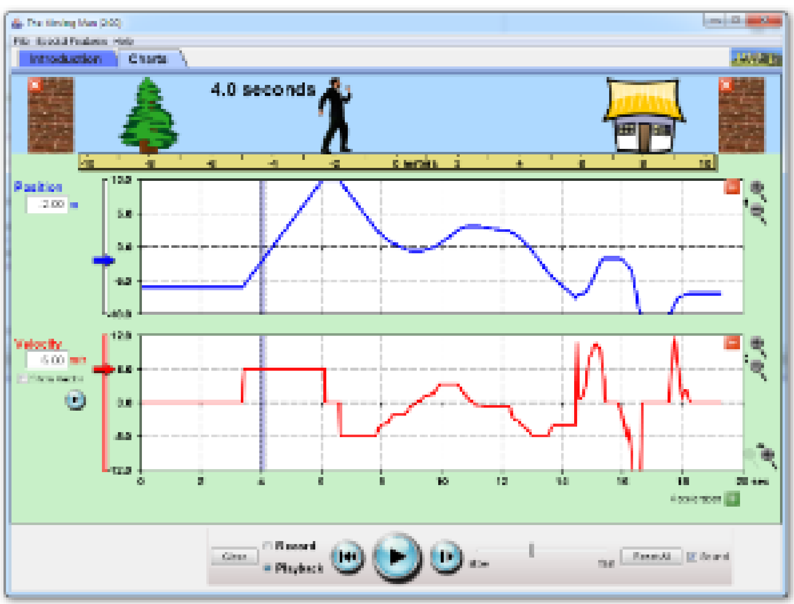


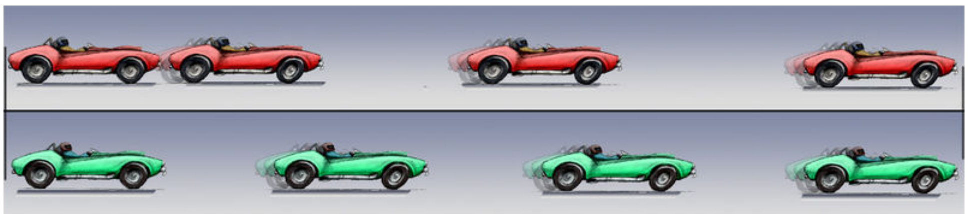
The Moving Man (PhET Simulation)

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 $3\ \text{m/s}^2$. 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 $t = 0.2$ s ? Explain.
   b. Who is accelerating? Explain.
   c. Who is going fastest at $t = 0.3$ 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 $t = 0.2$ 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