KINEMATICS IN ONE DIMENSION

Mechanics

Unit 1

TA name: Vivek Khichar Due Date: 2/12/21 11:59pm

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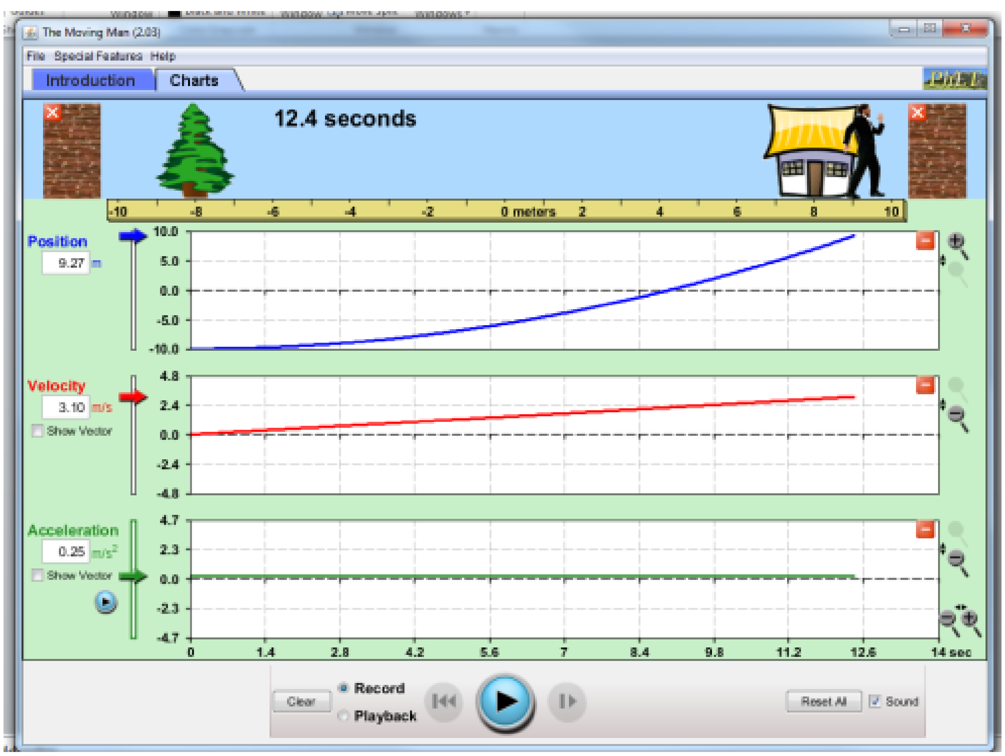
Simulation created by the Physics Education Technology Project (PhET)
The University of Colorado at Boulder

Go to: https://archive.cnx.org/specials/e2ca52af-8c6b-450e-ac2f-9300b38e8739/moving-man/



Investigating Motion: Distance, Velocity, and Acceleration through Time

Objective:

This activity is intended to enhance your physics education. We offer it as a virtual lab online. We think it will help you make connections between predictions and conclusions, concepts and actions, equations and practical activities. We also think that if you give this activity a chance, it will be fun! This is an opportunity to learn a great deal. Answer all questions as you follow the procedure in running the simulation.

Learn about position, velocity, and acceleration graphs. Move the little man back and forth with the mouse and plot his motion. Set the position, velocity, or acceleration and let the simulation move the man for you.

Introduction:

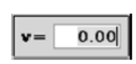
Kinematics is a part of mechanics dealing with mathematical description of motion. It does not concern the causes of the motion or change in motion. Kinematics equations describe motion using variable quantities like position, velocity, acceleration, and time.
The following basic kinematics equations are used to model one dimensional motion:

$$x = x_0 + \bar{v}(t - t_0)$$
$$v = v_0 + \bar{a}(t - t_0)$$
$$v^2 = v_0^2 + 2\bar{a}(x - x_0)$$
$$x = x_0 + v_0(t - t_0) + \frac{1}{2}\bar{a}(t - t_0)^2$$

Where all quantities with subscript "0" are initials and quantities with "_" on top of letters are averages.
In this simulation, you will learn how the graphs represent the motion of the moving man and use data from the graphs to solve equations that can be used to predict the motion of the moving man.

Procedure:

1. Open The Moving Man
   https://archive.cnx.org/specials/e2ca52af-8c6b-450e-ac2f-9300b38e8739/moving-man/

2. Take five minutes to play; move the man with your mouse and observe the three graphs. Set some values. Have fun. You can type exact values into the magnitude boxes. 

3. Clear the graphs between runs 

 with the button.

4. Set the man's velocity to 2m/s, the position at -10m, and acceleration remains at 0 m/s^2. Click the play button and observe all graphs for 10 seconds.
   a. What is the position at t=3s (the initial position)?
      x_0=_____1.0m
   b. What is the position at t=4s (the final position)?
      x=______3.0m
   c. Calculate the average velocity for an elapsed time.
      The man's average velocity is 2.0m/s

d. Read the velocity at t=4s from the velocity graph and compare the value with the calculated average velocity above.

Velocity (t=4s) from graph: 2.0m/s. This is the same value as I calculated.

5. Set the man's velocity to 0m/s, the position at -10m, and acceleration remains at 0.5 m/s^2. Click the play button and observe all graphs for 8 seconds.
   e. What is the position at t=3s (the initial position)?
   x_0=___-7.75m
   f. What is the position at t=4s (the final position)?
   x=____-6.0m
   g. Calculate the acceleration for an elapsed time.
   a=______0.5m/s^2
   h. Read the acceleration at t=4s from the acceleration vs. time graph and the value with the acceleration calculated.
   a=______0.5m/s^2
   i. Calculate the velocity at 4s. Use the acceleration calculated from c.
   v=______2.0m/s
   j. Read the velocity at t=4s from the velocity vs. time graph and compare the value with the velocity calculated.
   The graph shows 2.0m/s and my calculated value was also 2.0m/s

6. Set the man's velocity to 6m/s, the position at -9m, and acceleration remains at -1.0 m/s^2. Click the play button and observe all graphs for 12 seconds.
   a. What are the positions at t=3s and t=9s?
   x(at 3s)=___4.5m, x(at 9s)=___4.5m
   b. What are the velocities at t=3s and t=9s?
   v(at 3s)=___3.0m/s, v(at 9s)=__-3.0m/s
   c. Turn on the vectors and observe how the directions of the vectors behave. Did you see the change in direction with the velocity, acceleration or both? Explain
   The acceleration vector stayed the same but over time the velocity vector changed direction.____

   ____
   d. Calculate the velocity at t=6s. What is the physical meaning of your result?
   The man's velocity is 0. This means that he is about to change direction. As he was running, he was slowing down because of his acceleration and at 6s his velocity became 0. 6s is the "peak" of his position graph meaning this is the furthest right he will be.____
   e. Write the quadratic equation which represents the position vs. time graph you obtained.
   x = -0.5m/s^2(t_0-t)^2 + 6m/s(t_0-t) - 9m. I kept the units in the equation.
7. Set the man's velocity to -6m/s, the position at 9m, and acceleration remains at 1.0 m/s^2. Click the play button and observe all graphs for 12 seconds.
   a. What are the positions at t=3s and t=9s?
   x(at 3s)=__-4.5m, x(at 9s)=__-4.5m
   b. What are the velocities at t=3s and t=9s?

v(at 3s)=___-3.0m/s,   v(at 9s)=___3.0m/s

c. Turn on the vectors and observe how the directions of the vectors behave. Did you see the change in direction with the velocity, acceleration or both? Explain
The acceleration vector stayed the same while the velocity vector slowly switched directions. This is because over time acceleration effects velocity.____________

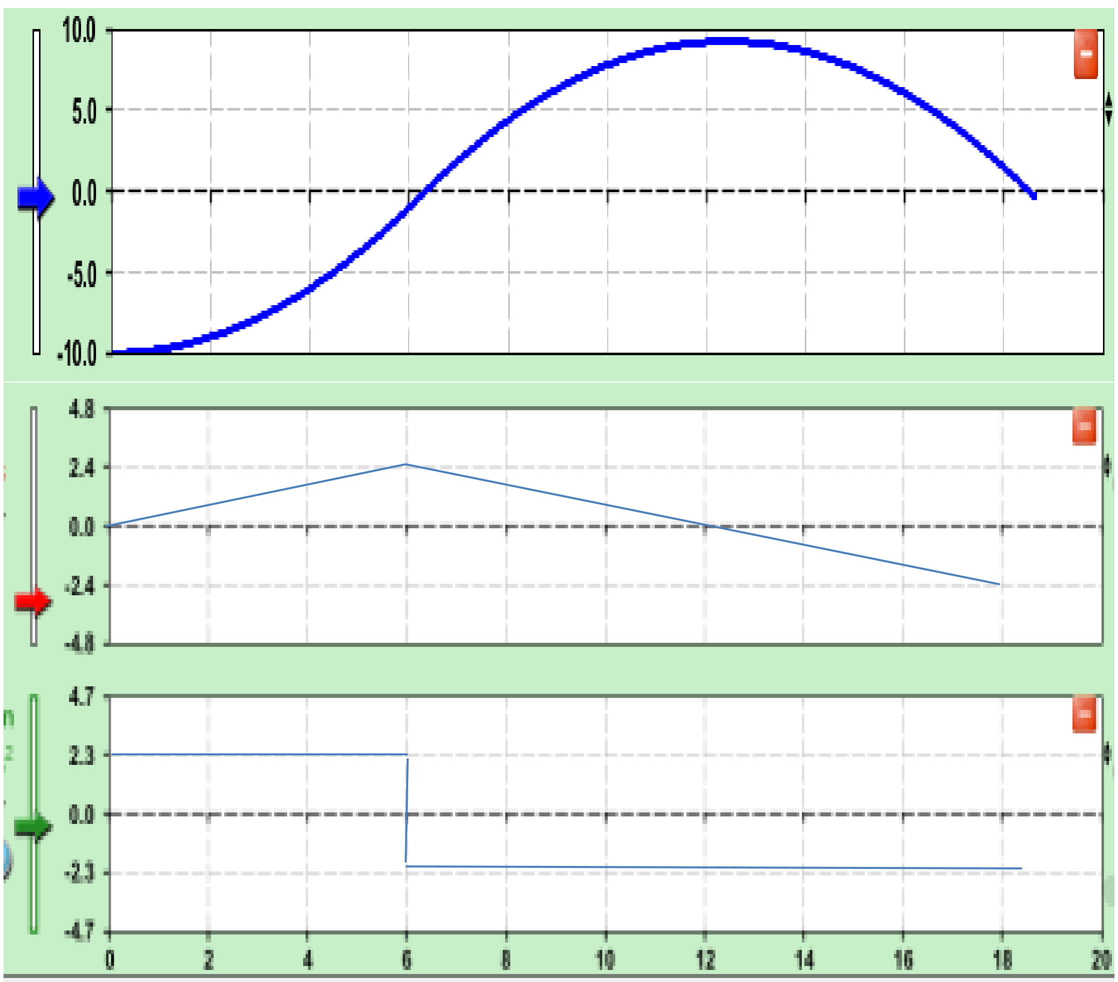
d. Calculate the velocity at t=6s. What is the physical meaning of your result?
At t=6s the velocity is 0. This means that the man has finally come to a stop and will start accelerating to the right.______________________________

e. Write the quadratic equation which represents the position vs. time graph you obtained.
x = 0.5m/s^2(t_o-t)^2 - 6m/s(t_o-t) + 9m.

8. Explain how the position, velocity, and acceleration graphs of question 4 are different from the same graphs of question 5. Hint: compare same type of graphs, for example position with position.
While the position graph in question 4 is linear, the position graph and in question 5 is parabolic because of the added acceleration. Similarly the velocity in question 4 is constant while the velocity in question 5 is increasing. While both questions have a constant acceleration, question 4 has no acceleration while question 5 has slight acceleration.____

9. To get the man to stop at home starting from a tree, I set the velocity to ________4.0 and acceleration to__________-0.5.

10. Try to reproduce the position vs. time graph shown below and draw the corresponding Velocity vs. time and acceleration vs. time graphs.

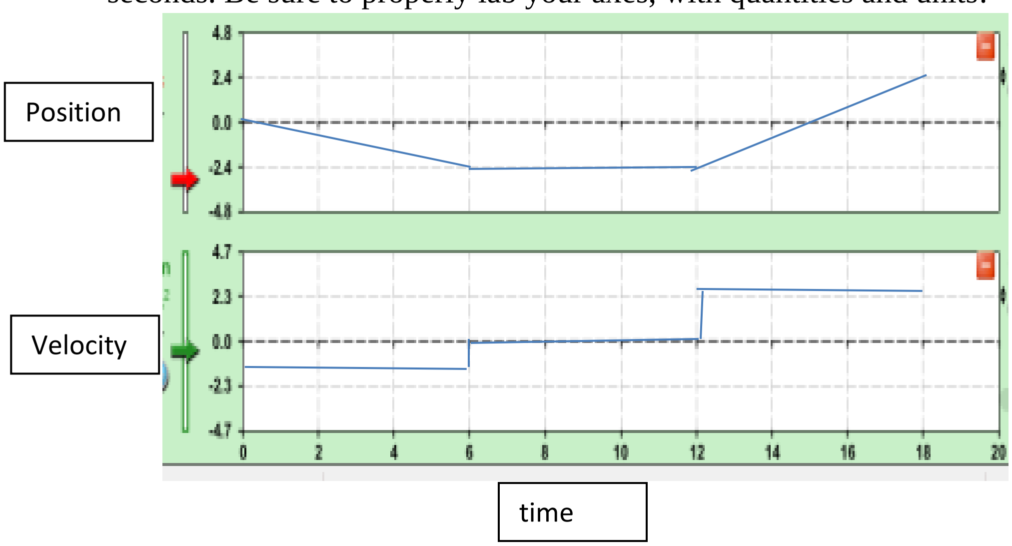


11. Remove the walls (click on “x” sign on walls and setup this scenario:
    a. A car travelling 5m/s slams on its brakes, creating an acceleration of $-2m/s^2$. How far did the car travel after it applied its brakes? x =____6.25m.
    b. How long does it take for the same car to stop? t =____2.5s.

Follow up questions:

1. When velocity and acceleration have the same sign, the object is (a) not moving (b) speeding up (c) slowing down **B**
2. When velocity and acceleration have the opposite sign, the object is (a) not moving (b) speeding up (c) slowing down **C**
3. Consider the braking car. When the speed was doubled, the distance to a stop was (a) less than double (b) double (c) more than double **C**
4. Draw a position-time and velocity-time graphs that would best depict the following scenario:

   A man starts at the origin, walks back slowly and steadily for 6 seconds. Then he stands still for 6 seconds, then walks forward steadily about twice as fast for 6 seconds. Be sure to properly lab your axes, with quantities and units!



5. Consider two cars, a 700kg Porsche and a 600kg Honda Civic. The Porsche is speeding along at 40 m/s (mph) and the Civic is going half the speed at 20 m/s. If the two cars brake to a stop with the same constant acceleration, are either the amount of time required to come to a stop, or the distance traveled prior to stopping influenced by their initial velocity?

   Yes. It takes more time to slow down from 40m/s than from 20m/s. Because it takes more time to stop, the initial velocity has more time to move the car.