

Simple Harmonic Motion

Overview

- A Smart Cart with Smart Vector Display is attached to a spring on an incline.
- Mark the equilibrium point.
- View and compare the velocity, acceleration, and force vectors as the cart oscillates.

Equipment

QTY	PART #	DESCRIPTION
1	ME-1240 or ME-1241	Smart Cart (Red or Blue)
1	ME-1246	Smart Cart Vector Display
1	ME-9493	Dynamics Track (1.2 m)*
1	ME-6757A	250 g Cart Mass (Set of 2)
1	ME-8999	Dynamics System Spring Set
1	ME-8971	Dynamics Track End Stops (pair)
1	ME-8972	Dynamics Track Feet (only one needed)

*Although this demonstration is written using the 1.2 m dynamics track, any dynamics track can be used.

Teacher Tips

1. Prior to class time, charge the Smart Cart and the Smart Vector Display.
2. While performing these demonstrations, always stand behind the apparatus (or to one side) so the students can see the demonstration. You, however, will not be able to see the Vector Display so you may want to practice while standing in front so you can see.
3. We set the force sensor to read zero at equilibrium, even though the spring force is not zero; the net force is zero.

Preparation

1. Put end stops on the ends of the track and install one track foot to act as a marker for the equilibrium point.
2. Connect a rod clamp to the track and use the rod stand to incline the track to about 15 degrees.



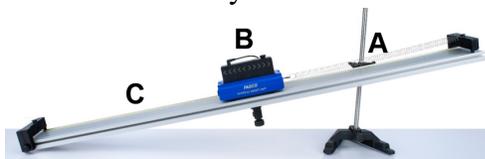
3. Attach the hook to the Smart Cart force sensor. Attach the Smart Cart Vector Display to the Smart Cart on the side opposite the accessory port. Connect the Vector Display to the Smart Cart accessory port using the connecting cable.
4. Hook one end of a spring on the top post of the endstop and connect the other end of the spring to the hook on the Smart Cart. Put one 250 g mass in the cart.
5. Let the cart come to rest at equilibrium and then position the track foot at the center of the cart to act as a marker of the equilibrium point.
6. Open the configuration file called “15Simple_Harmonic” in Capstone or SPARKvue. Turn on the Smart Cart and connect it wirelessly.
7. While the cart is sitting at equilibrium, zero the Smart Cart’s force sensor in the software.

Demonstration

1. On the first page in the software, the Vector Display is set to show velocity. Point this out to the students. Ask them to watch the velocity vector when the cart oscillates.
2. Start recording. Push the cart up the incline about 20 cm and then let it go. Let it oscillate through two periods and then stop recording.
3. Stop the cart and ask the questions:

Question #1

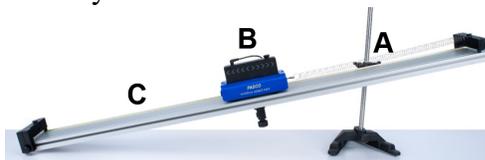
The cart is set to show the velocity vector. Where is the cart when it has its maximum velocity?



- A. At the highest point
- B. At equilibrium
- C. At the lowest point
- D. Both A and C

Question #2

The cart is set to show the velocity vector. Where is the cart when it has zero velocity?

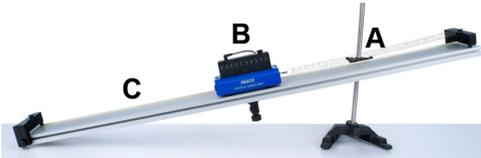


- A. At the highest point
- B. At equilibrium
- C. At the lowest point
- D. Both A and C

- Without starting recording, repeat the oscillation so the students can check their answers.
- Now go to page two in the software. The Vector Display will now display acceleration measured from the wheels of the cart.
- Before showing the oscillation, ask the questions:

Question #3

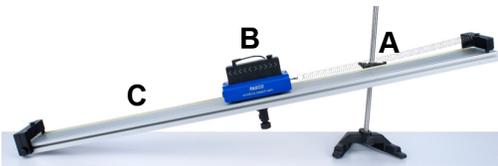
The cart is set to show the acceleration vector. Where is the cart when it has its maximum acceleration?



- At the highest point
- At equilibrium
- At the lowest point
- Both A and C

Question #4

The cart is set to show the acceleration vector. Where is the cart when it has zero acceleration?

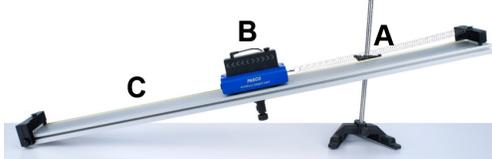


- At the highest point
- At equilibrium
- At the lowest point
- Both A and C

7. Perform the oscillation and note the answers to questions 3 and 4. Stop the cart and then ask this question:

Question #5

The cart is set to show the acceleration vector. When the cart is traveling from point B to point A, which is true?

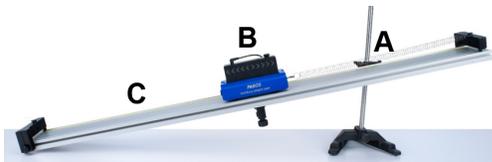


- A. Both the acceleration and velocity point toward B.
- B. Both the acceleration and velocity point toward A.
- C. The acceleration points toward B and the velocity points toward A.
- D. The acceleration points toward A and the velocity points toward B.

8. In the software, switch to page 3 where the Vector Display is set to show force. When the cart is at rest at equilibrium, the force should read zero. If it does not, zero the sensor.
9. Before performing the oscillation, ask the question:

Question #6

The cart is set to show the force vector. Where is the cart when it has its maximum force?



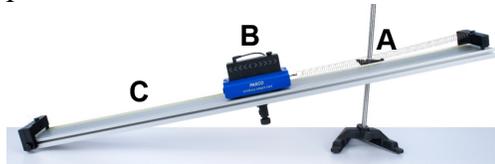
- A. At the highest point
- B. At equilibrium
- C. At the lowest point
- D. Both A and C

10. Perform the oscillation and answer question #6. Stop the cart with your hand and then push it to Position A to show the force is maximum and pointed toward equilibrium. Then move it to Position C to show the force is maximum in the opposite direction, still pointed toward equilibrium.

11. Stop the cart and ask the question:

Question #7

The cart is set to show the force vector. When the cart is traveling from point B to point A, which is true?



- A. The force, acceleration, and velocity point toward A.
- B. The force and acceleration point toward B and the velocity points toward A.
- C. The force and acceleration point toward A and the velocity points toward B.
- D. The force and velocity point toward A and the acceleration points toward B.
- E. The force and velocity point toward B and the acceleration points toward A.

12. Perform the oscillation and answer question #7.

13. In the software, go to page 4 which shows a graph of Velocity, Acceleration, and Force vs. Time. Use the multi-coordinate tool to show the velocity, acceleration, and force at points A, B, and C.

Capstone Configuration File: 15Simple_Harmonic.cap

1. Wirelessly connect to a Smart Cart with a connected Vector Display.
2. Turn off the Acceleration and Gyro sensors on the Smart Cart.
3. Set the sample rate for the Force and Position sensors to 50 Hz.
4. On the first page, configure the Vector Display to show velocity on the 0.5 m/s range.
5. On the second page, configure the Vector Display to show acceleration on the 1 m/s² range.
6. On the third page, configure the Vector Display to show force on the 1 N range. On the Sampling toolbar, select Force so the Zero button is visible for the force.
7. On the fourth page, construct a graph with three plot areas: Velocity vs. Time, Acceleration vs. Time, and Force vs. Time. In the graph properties, under data options, choose to Show New Runs from Prior Pages.
8. Lock all pages in the workbook.