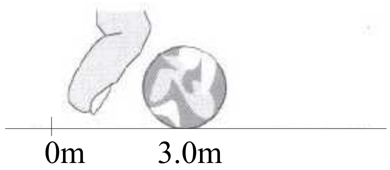
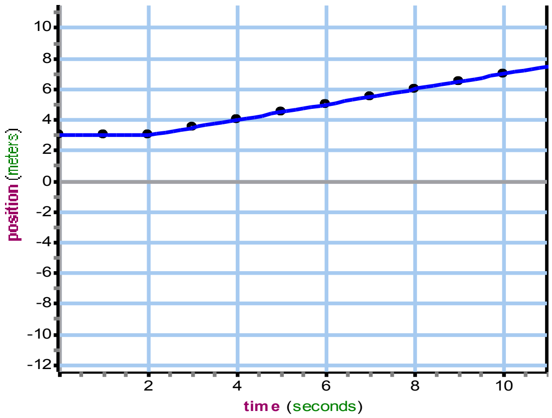
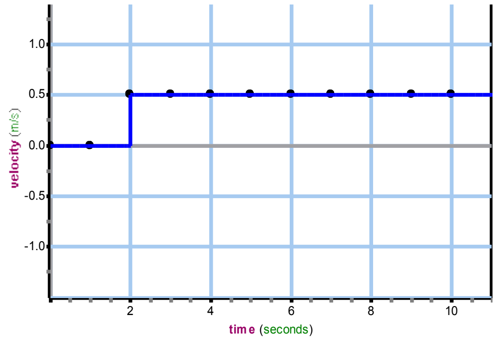
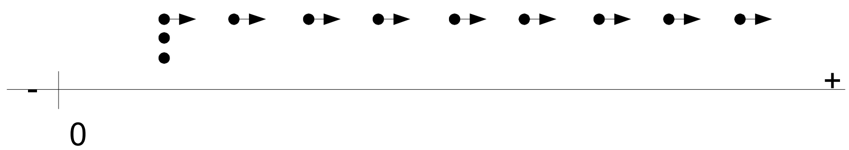
Motion Maps and Vector Addition

1. Consider a marble sitting at rest on a level floor at a position 3.0m from origin. At time t = 2s, the marble is bumped so that it rolls to the right with velocity +0.5m/s. (I have chosen the positive direction to be to the right the origin to be 3.0m to the left of the marble's initial position.) The following graphs and motion map represent this motion.



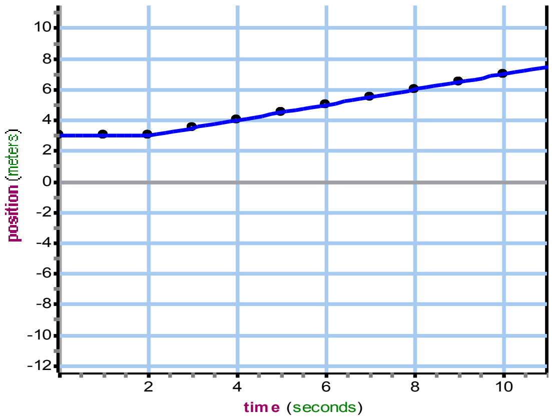


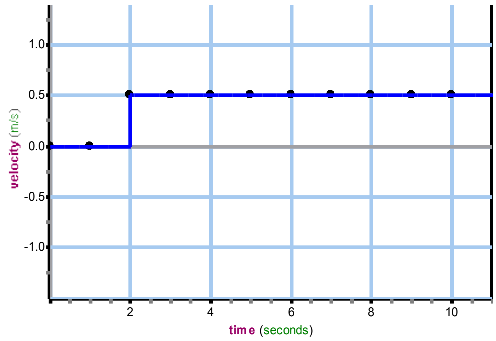


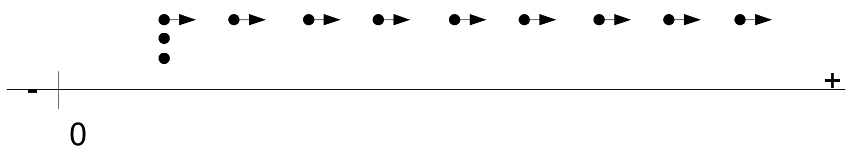


These graphs and motion map have been copied below questions A through E. To each graph and motion map, add the representation of the new motion.

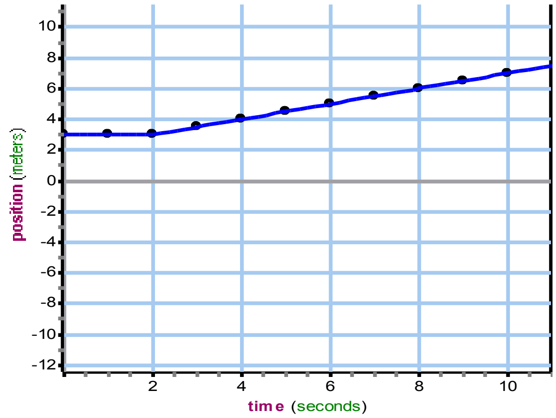
A. The marble is given the same bump as before, but at t = 4s instead of t = 2s.

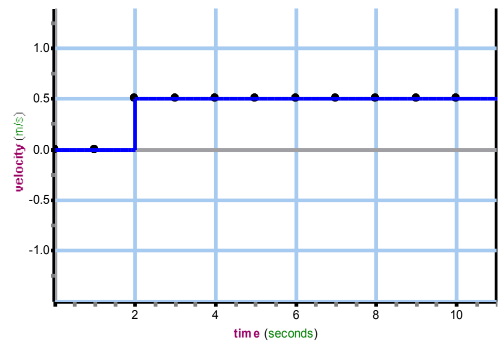


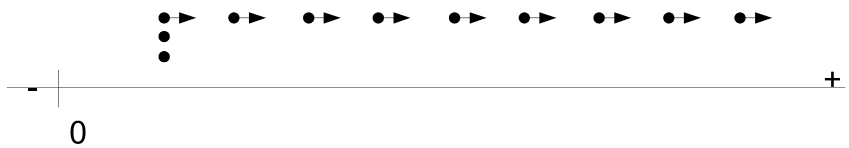




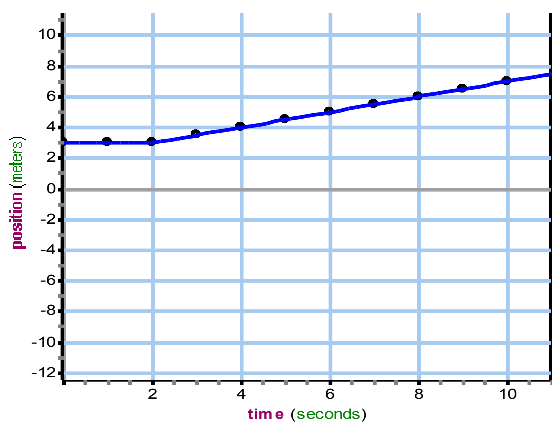
B. The marble is given an identical bump at t = 2s, but the bump is to the left.

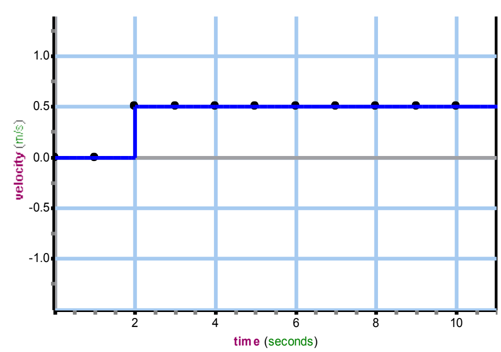


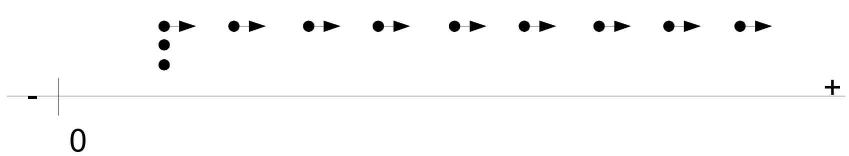




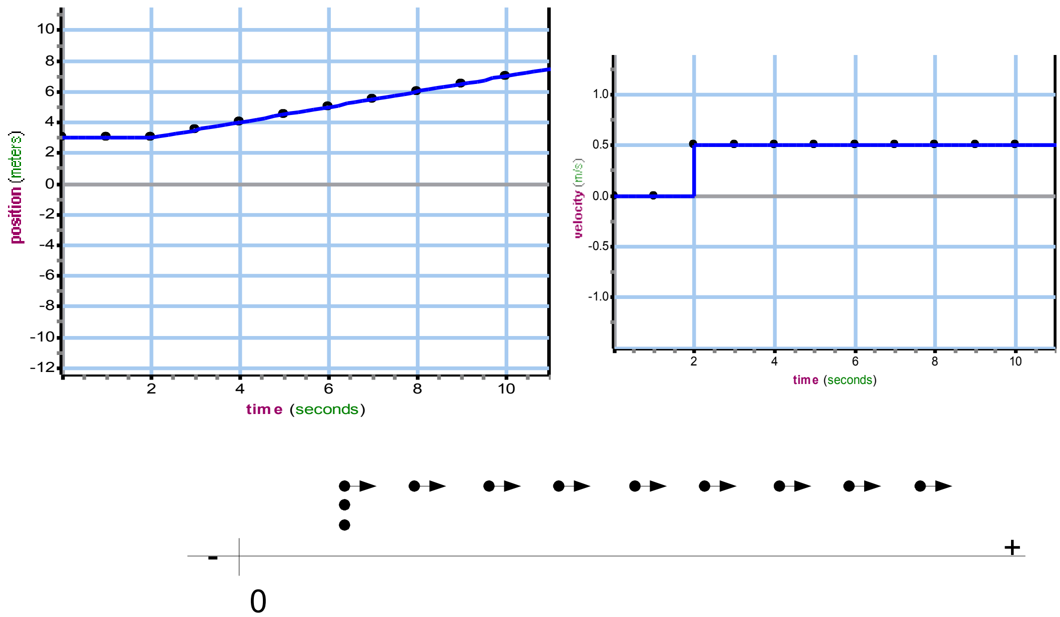
C. The marble is bumped exactly as the original, but this time the marble is located at x = -2m when the bump occurs (at t = 2s).



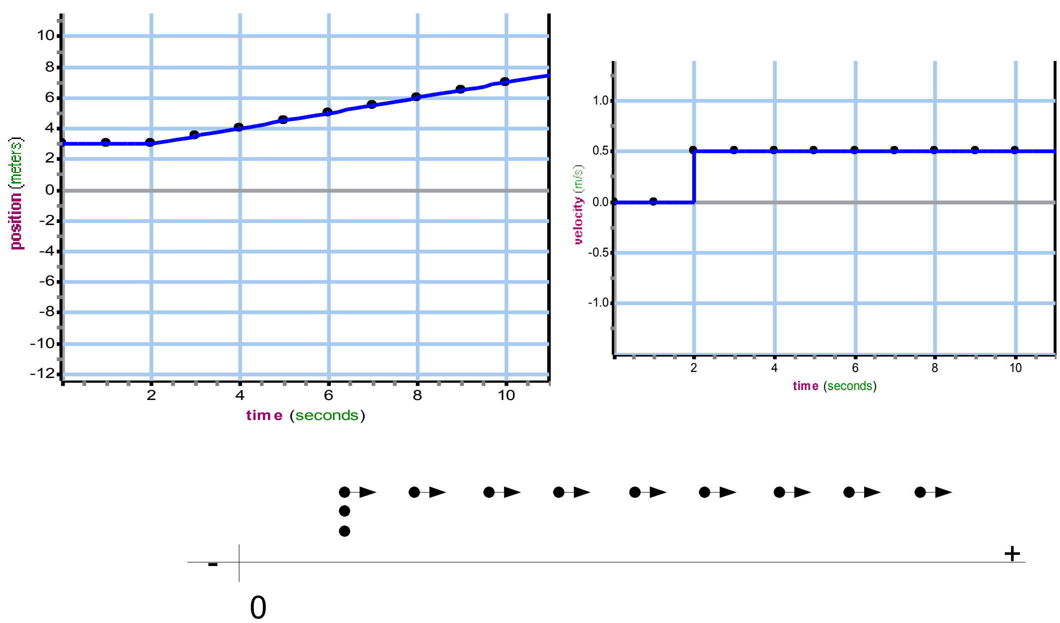




D. The marble is bumped to the right twice as hard as the original.



E. Everything is exactly the same as the original except that there is a wall located at x = 7m so that the marble suddenly reverses direction.

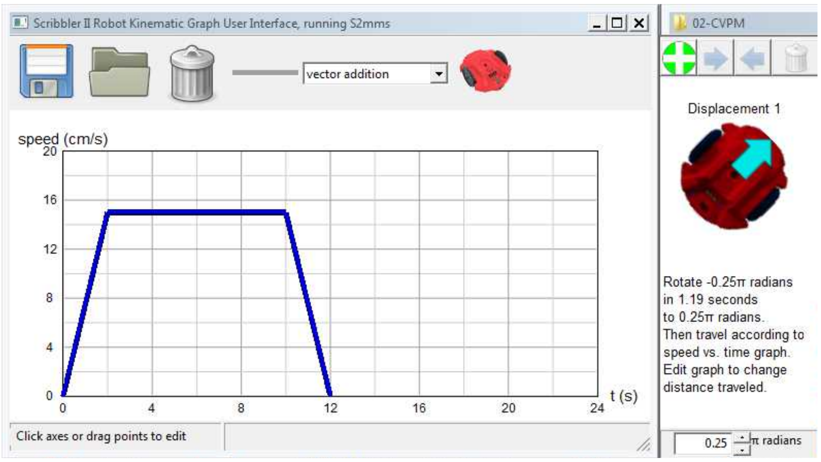


Refer to cases A through E above as evidence when answering the following questions.

F. If an object is moving away from the origin, is the velocity necessarily positive? Explain.

G. If an object is moving in the positive direction, is its position necessarily positive also? Explain.

H. If an object is moving in the positive direction, is its change in position necessarily positive also? Explain.



2. You will receive a robot program from your teacher. Choose "vector addition" from the menu to bring up something similar to the view above. When you send the program to the robot and run it, the robot will turn to the direction shown and then move according to the velocity vs. time graph, thus changing its position. A *displacement* is another word for change in position, which includes both a direction of travel and a distance traveled in that direction. Your program will have several displacements, each in a different direction. The displacements must now be specified by angles, as the use of + and – to denote forwards and backwards is insufficient when the motion is not restricted to a single one-dimensional track. Use the left and right arrows to scroll through the different displacements in order.

(a) Your task is to figure out exactly where your robot will end up. Place any diagrams, graphs or calculations on a whiteboard to share with the class. To test, place a penny on the ground to mark the starting point. Center the robot over the penny. You can peer down through the hole in the center to make sure the penny is right under the center. Then place a second penny at the position you predict the robot will stop. Then run the robot to test.

(b) Program the robot to turn once and travel straight to the final location. Use a dotted line to mark the path of the second robot on the same diagram as the first one. Also include any calculations. The path of this second robot is called the *net displacement*.

(c) Program the robot to move with the same set of displacements given to you by your teacher, but put them in a different order. i.e. do the second one first and the first one last or choose some other order of your devising. Predict: where will the robot end up if the displacements are in a different order? Test it and see. Add this new path to your visual representation. Can you explain why the result is true?

3. Practice to mastery. Make yourself new vector addition programs, working up to at least four segments. Each time, program a net displacement robot and check out different orders. Gradually or rapidly increase complexity, working to mastery at each step until you are confident that *everyone* in your group can draw the diagram, figure out where the robot will end up and also figure out the net displacement robot.

4. Olympic Event: A course has been set up in the room with a starting point, an ending point and several obstacles. Program your robot to get from the start to the end while avoiding the obstacles. Your score will be the number of centimeters between your robot's final position and the target, plus 3cm for each time your robot touches an obstacle. If your robot hits an obstacle and can no longer continue, it will receive the 3cm penalty, and the distance to the target will be measured from that point. The group with the lowest score will get 100 olympic points, the group with the next lowest will get 90 olympic points, etc. If you robot was unable to continue, you may earn 5 points back by correcting your measurements and calculations and making a second, more successful run. You may make any measurements of the course you want prior to the test, but you may not run your robot (on or off the course) until it is time to test.