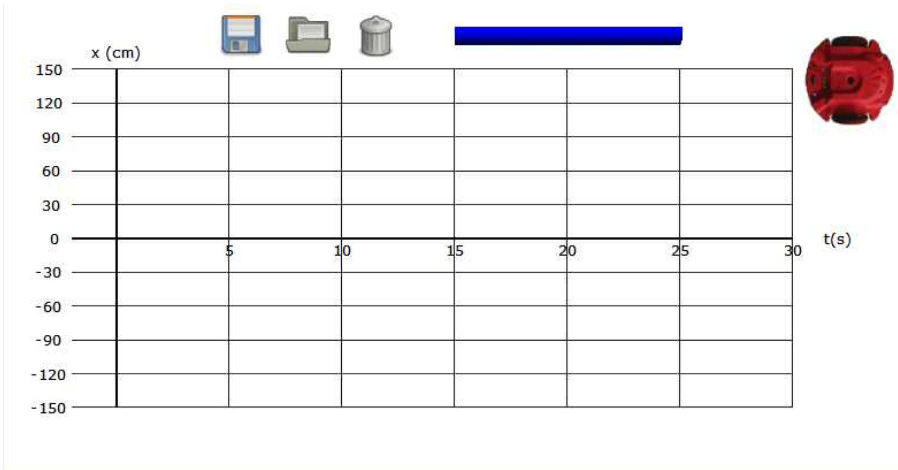
Velocity vs. Time Graphs and Synchronized Robotics

1. (a) You will a receive a robot programmed by your teacher. Carefully observe it's motion, and then *in as few tries as possible*, attempt to program a second robot to exactly match the motion of the first.



(b) What was the robot's position at the beginning of the first segment?

What was it's position at the end of the first segment?

How much did the robot's position change during the first segment?

What was the robot's speed during the first segment?

What direction did the robot travel?

(c) What was the robot's position at the beginning of the middle segment?

What was it's position at the end of the middle segment?

How much did the robot's position change during the middle segment?

What was the robot's speed during the middle segment?

What direction did the robot travel?

(d) What was the robot's position at the beginning of the third segment?

What was it's position at the end of the third segment?

How much did the robot's position change during the third segment?

What was the robot's speed during the third segment?

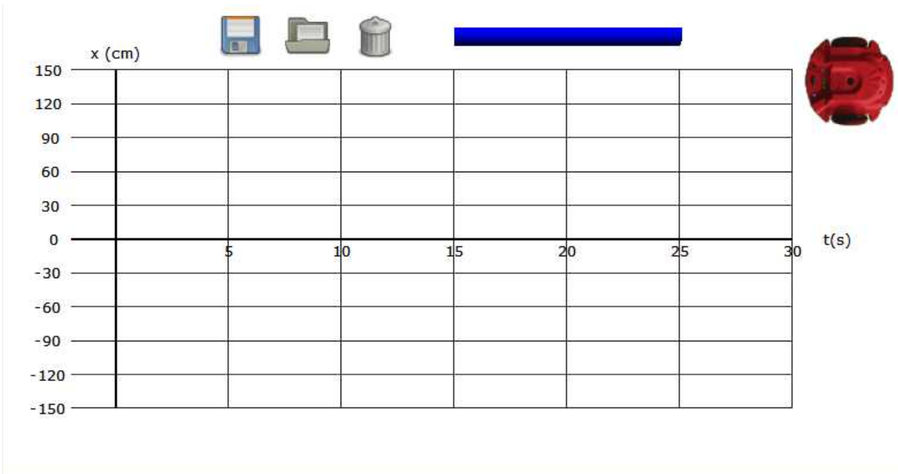
What direction did the robot travel?

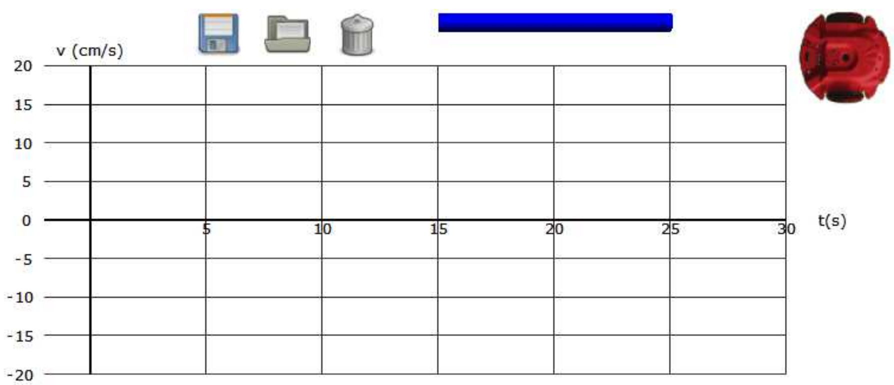
(e) *Velocity* is speed with a direction. When motion is just back and forth along one line, + and – signs are sufficient to indicate direction. Determine the robot's average *velocity* for the whole motion. Show your work and use units.

Program your second robot to move with the average velocity so that it starts and ends at the same place as the first robot. Run the two robots side by side to verify.

(f) What was the robot's average speed? Is this the same as the average velocity?

2. (a) Use PvsT_GUI to program one robot to move with a single constant velocity for some length of time. Use VvsT_GUI to program your second robot with a *velocity vs. time graph* so that it's motion matches the first one. One hint about VvsT_GUI: Line segments on the graph can be close to vertical, but never completely vertical.



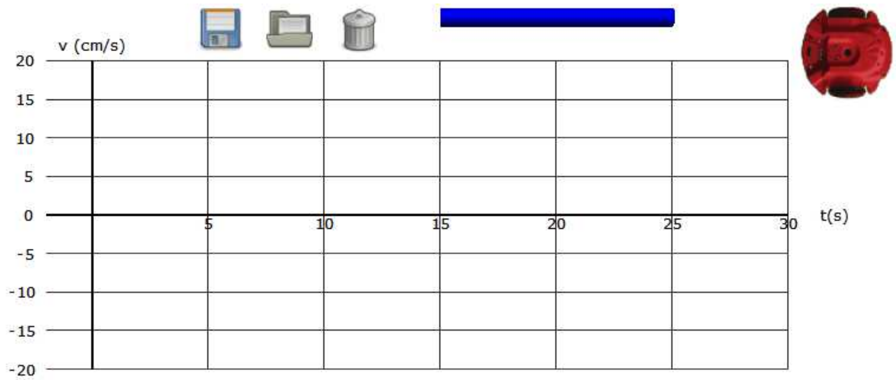


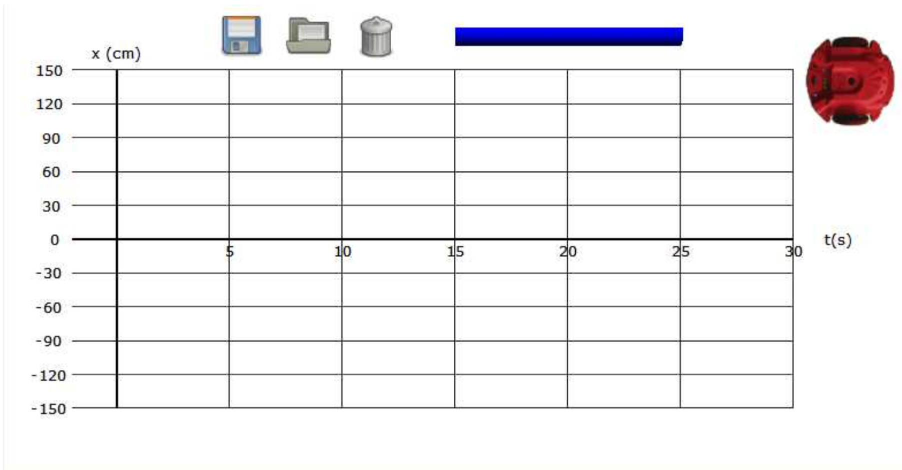
Practice programming one-segment velocity vs. time graphs to match one-segment position vs. time graphs, including both directions of motion until *everyone* in your group has mastered this skill. Then write a summary about what you need to do to make the velocity vs. time graph.

(b) Increase the complexity as gradually or rapidly as everyone in your group needs, working to mastery at each step until you are confident that *everyone* in your group not only knows how to match any four-segment position vs. time graph by programming a second robot with a velocity vs. time graph, but can also describe what the robot will do just by looking at the position vs. time graph.

(c) Summarize your method. What steps do you have to follow to create a velocity vs. time graph that matches a multi-segment position vs. time graph?

3. (a) Program your first robot with a one-segment velocity vs. time graph. Using information from that graph, program your second robot with a position vs. time graph so that it's motion matches the first.





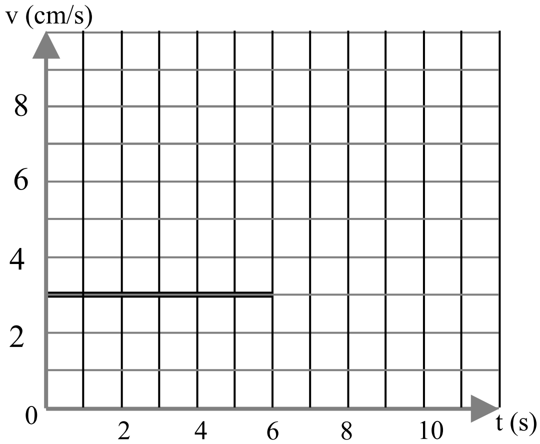
Practice to mastery, including both directions of motion, and summarize your method.

(b) Gradually or rapidly increase complexity, working to mastery at each step until you are confident that *everyone* in your group not only knows how to match any four-segment velocity vs. time graph by programming a second robot with a position vs. time graph, but can also describe what the robot will do just by looking at the velocity vs. time graph.

(c) Summarize your method. What steps do you have to follow to create a position vs. time graph that matches a multi-segment velocity vs. time graph?

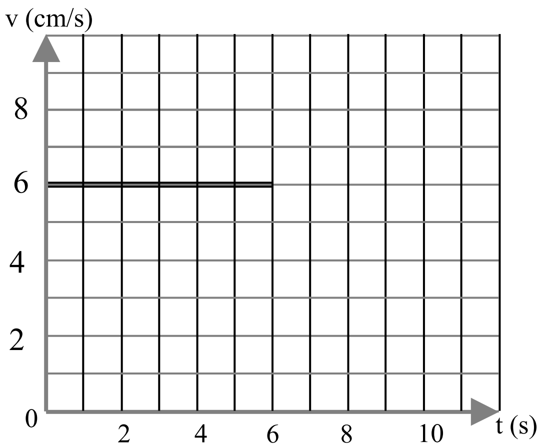
(d) Create one complicated or tricky example to use as part of an exercise for the rest of the class. Give your teacher a copy of the position vs. time graph and velocity vs. time graph, and have a robot prepared to demonstrate the motion to the class. Don't let the other groups see your exercise!

4. For each velocity vs. time graph below, calculate the change in position of the object. Then count the number of graph squares between each graph and the horizontal axis. Write both answers in the blanks to the right of each graph.



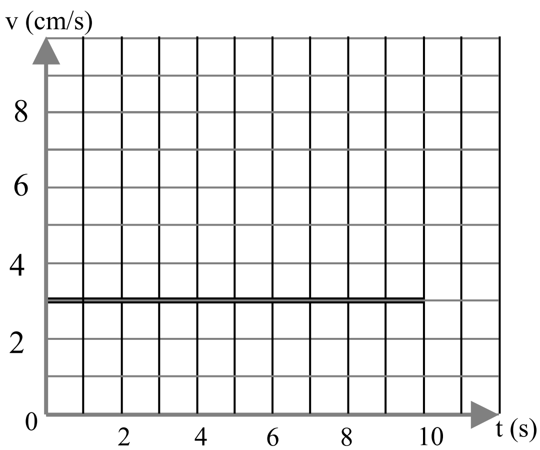
A. Δx = _________ number of squares = __________

Show work below. Include units.



B. Δx = _________ number of squares = __________

Show work below. Include units.

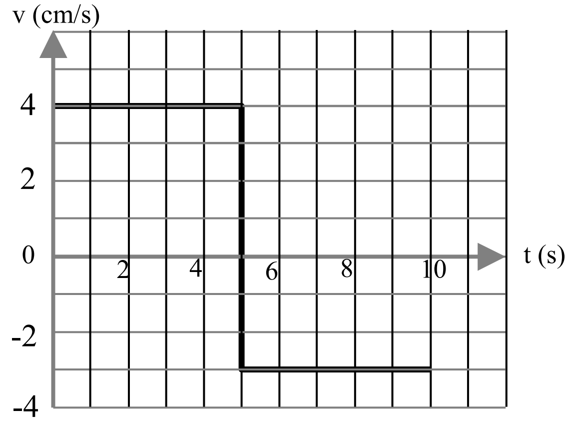


C. Δx = _________ number of squares = __________

Show work below. Include units.

D. What does the area of one square on the graph indicate? Calculate that "area" using the units from the graph.

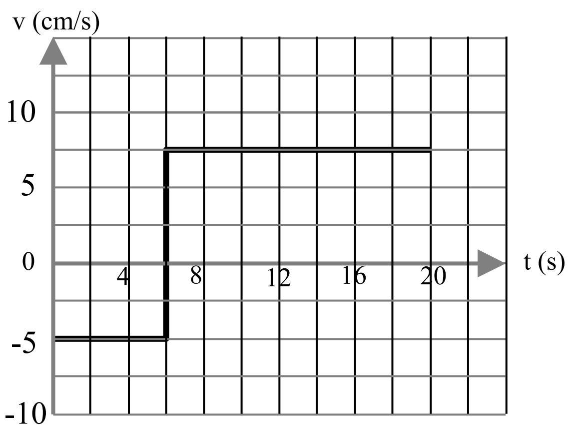
E. In what ways is finding the change in position similar to finding the "area under the curve?" In what ways is it different?



F. Calculate the total change in position for the whole 10 seconds shown on the graph.

Count the number of squares between the graph and the horizontal axis for each segment of the graph.

If we want the "area under the curve" to continue to equal the change in position, what new rules must we make?



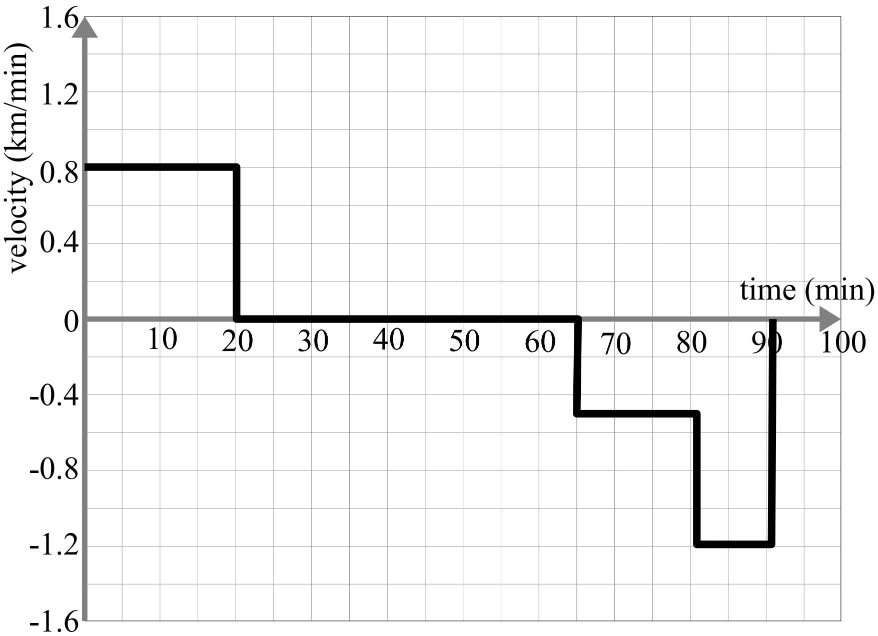
G. Calculate the total change in position for the whole 20 seconds shown on the graph.

Count the number of squares between the graph and the horizontal axis for each segment of the graph.

What does one square of area represent on this graph? Show work and use units.

Does the area under the curve still equal the change in position?

5. The graph below shows the velocity vs. time graph for John's car as he starts from Chick-Fil-A, where he got coffee and a biscuit, travels to school, attends his class, and returns home.



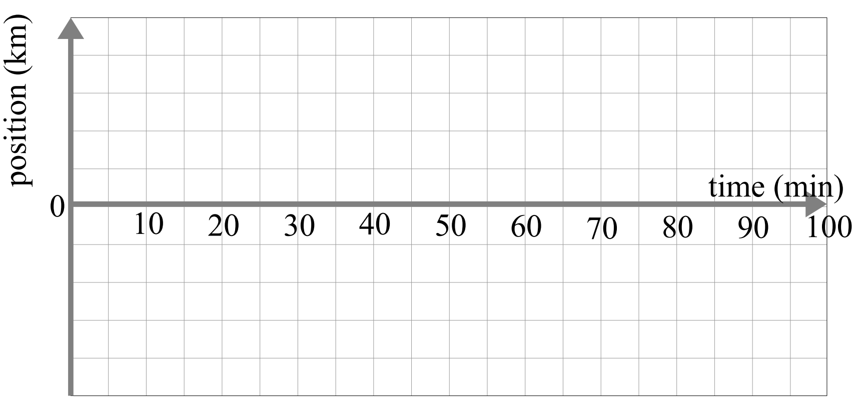
(a) Describe this motion in words. (i.e. *Only* words, no numbers.)

(b) Sketch the shape of the position vs. time graph that describes this motion.

(c) Determine the change in position from t = 5min to 20min. Annotate the velocity vs. time graph to show visually how the change in position shows up on it. Show your work and use units.

(d) Determine the change in position from t = 65min to 75min. Annotate the velocity vs. time graph to show visually how the change in position shows up on it. Show your work and use units.

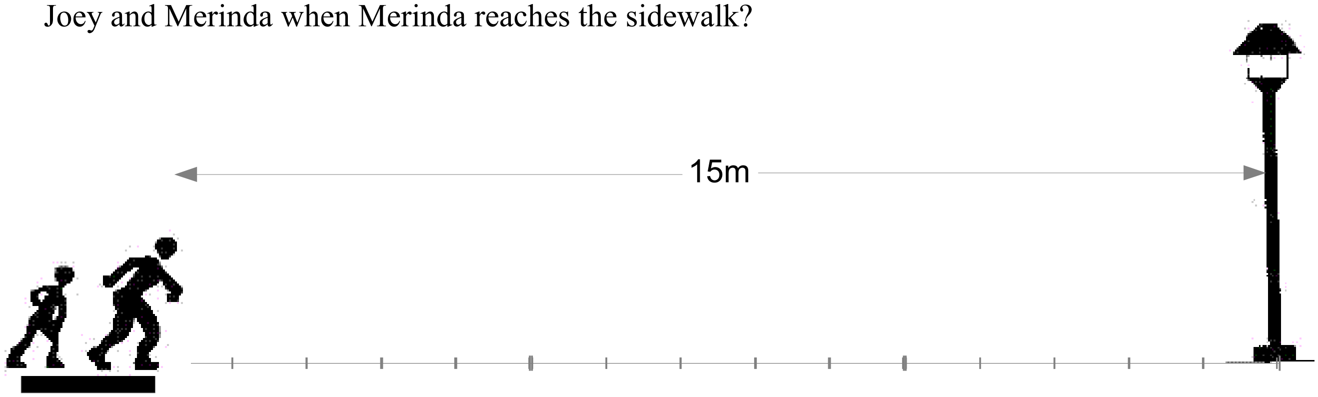
(e) Construct a <u>quantitative</u> position-time graph for the motion. **Be sure to accurately number the scale on the position axis.**



(f) How far is John's house from Chick-Fil-A?

(g) Determine the car's average velocity. Show your work and use units. Add an average velocity line to your position and velocity graphs.

6. (a) Merinda and her little brother Joey are having a footrace from the edge of a road to a street lamp and back. At t = 0 seconds, Merinda starts. She runs 2.5m/s all the way to the street lamp and back. Joey is not yet ready at t = 0 seconds. He doesn't start running until t = 2.0 seconds, and runs 1.5m/s all the way to the street lamp and back. (a) Represent this situation using position and velocity graphs. Obtain a graphical estimate and if possible a precise calculation of the following. (b) While Joey is still running towards the street lamp, Merinda will pass him on her way back to the sidewalk. At what time and how far from the sidewalk will this happen? (c) Where is Joey when Merinda reaches the street lamp? (d) How far apart are Joey and Merinda when Merinda reaches the sidewalk?



NOTE: Your answers can be verified with the robots by using 7.62cm/s for Merinda's speed, 4.57cm/s for Joey's speed, and multiplying your times by 10. At this scale, each floor tile represents 1m. If you are the first group done, program Merinda's and Joey's robots so the class can see the test.

7. Olympic Event: Einstein has been captured and is held captive in a castle. Your task is to program your robot to travel to the castle, rescue Einstein and bring him safely back to the starting point. To do so, you will have to avoid the robotic sentries pacing back and forth across your path. (Note: Consider a rectangle bounded by the starting point, the castle, and the left and right extremes of the sentries' motion. Your rescuebot must remain entirely inside this rectangle and move forwards and backwards in a single straight line during the rescue.) Once your robot reaches the castle, it must remain stationary within a half-robot's length of the castle long enough for you to rescue Einstein and place him on your robot. When conducting the rescue, the sentries will be started simultaneously with your robot. You may observe the starting and ending points and the sentries and make as many measurements and calculations as you need prior to programming your robot. Your score will be determined by adding your total time plus 5 seconds times the number of times your robot changes speed. The initial start and final stop do not count. The group with the lowest total score will receive 100 Olympic points, the group with the next lowest score will receive 90 points, etc. If your robot fails to avoid the sentries, you may recalculate and try again, but a 10 second penalty will be added to your final score for every time you have to recalculate. Your final whiteboard presentation must include both position and velocity graphs and demonstrate your understanding of how to use slope and area under the curve.