"Make It So, Number One"[1]

Spaceship
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Analysis of motion can be difficult enough, but engineers and technicians are often required to do something even more difficult—*to make things move in prescribed ways*. Examples include the motion of trains, elevators, machine tools, conveyor belts, security cameras and more. While a race driver or a movie character may have the single-minded goal of getting to the finish line as quickly as possible, most planned motions involve many other considerations such as the safety and comfort of passengers, the cost of energy, prevention of excess wear and more.

Task: In this activity you will construct and test sequences of mathematical functions which create specified motions, where the specifications are provided as graphs.

Additional Materials: Meter sticks or tape, motion detector and software

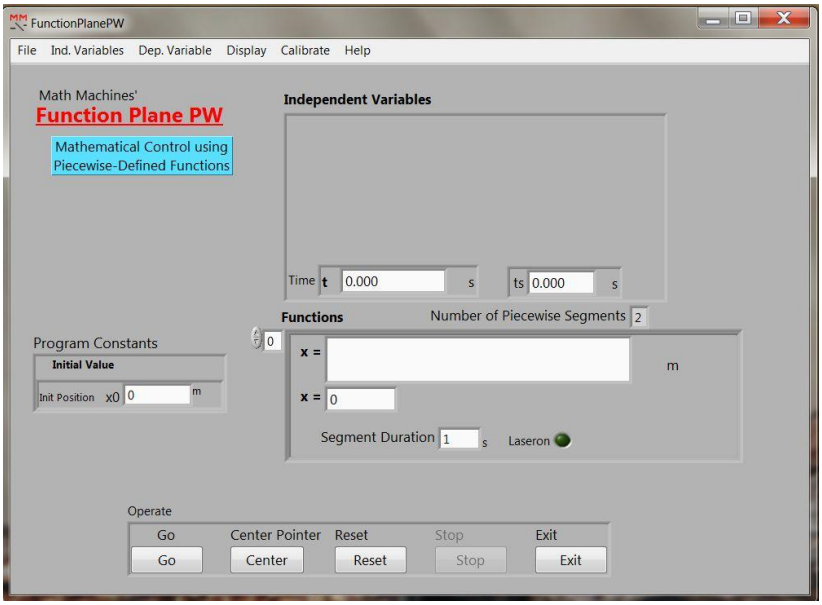
Math Machines Program:

Function Plane - Piecewise

Activity File: PosMatch

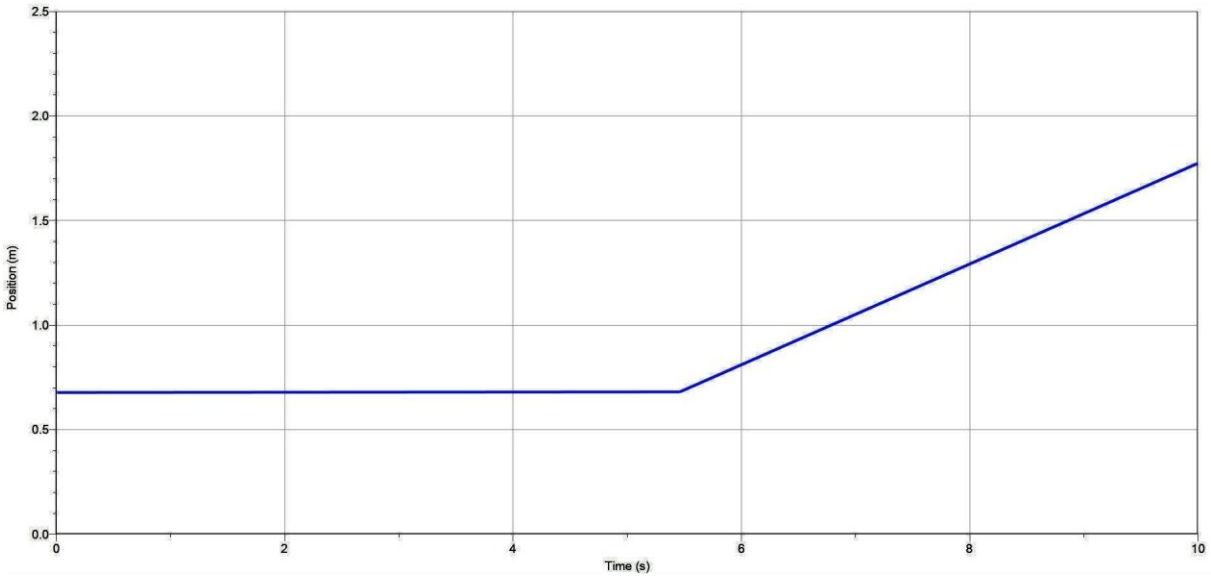
Load Activity File: PosMatch

This activity uses a Class II diode laser, similar to those used in many barcode scanners. Never look directly into the laser beam and never allow it to shine into anyone's eyes.



[1] Words spoken by Captain Pike to his unnamed and unseen female First Officer in the pilot episode of *Star Trek.* The characters changed as the series developed, but the phrase endured.

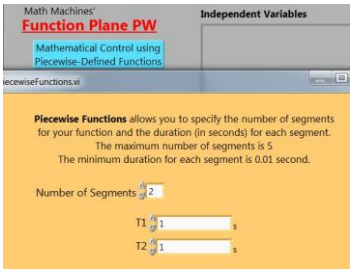
1. Determine a sequence of functions, x = f(t) to produce the motion shown in Graph 1 below.



   a. What is the initial position, x0, for this entire motion? ____
   Enter the value above and in the appropriate box of the control program.

   b. How many distinct segments are needed to produce this motion? _____
   Enter the value above. Also use the "File/Run Options/Piecewise Functions" menu to set this value in the control program.

   c. What is the duration (in seconds) for each of the required segments? Enter the values below and in the control program.



      T1 = _____ s

      T2 = _____ s

   d. What are the functions, x = f(ts), which will create each of these motions? Enter each equation? Enter the functions here and in the control program.

      Notes:

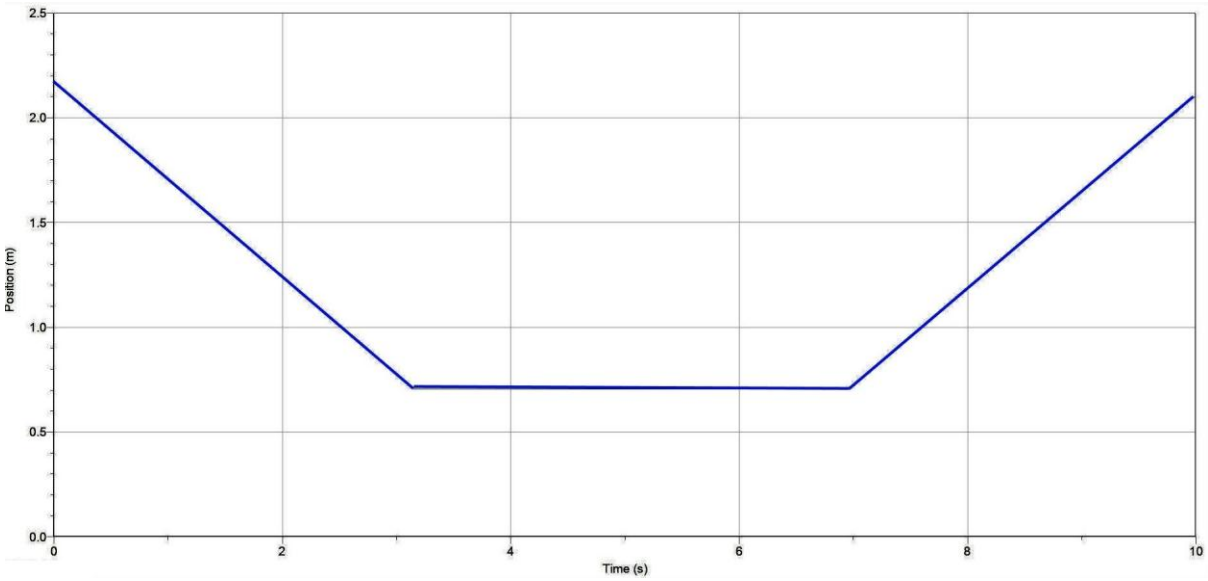
      i. As in many computer programs, the first function is labeled "0," the next as "1," etc.
      ii. You can use either "t" or "ts" as the independent variable for time.
      "t" is the elapsed time since the start of the entire motion.
      "ts" is the elapsed time since the start of that segment.
      iii. You can use "x0" as a constant in your functions. For the first function, the value of x0 is the value you set in step "1a" above. For the next function, x0 for the new function is the value at the end of the previous function.

      First segment x = _____

      Second segment x = _____

   e. Test your answer by using the laser dot to guide a person in front of the motion detector. Evaluate the results.

2. Determine a sequence of functions, x = f(t) to produce the motion shown in Graph 2 below.



a. What is the initial position, x0, for this entire motion? ____
Enter the value above and in the appropriate box of the control program.

b. How many distinct segments are needed to produce this motion? _____
Enter the value above. Also use the "File/Run Options/Piecewise Functions" menu to set this value in the control program.

c. What is the duration (in seconds) for each of the required segments? Enter the values below and in the control program. (Add lines as needed.)

T1 = _____ s

T2 = _____ s

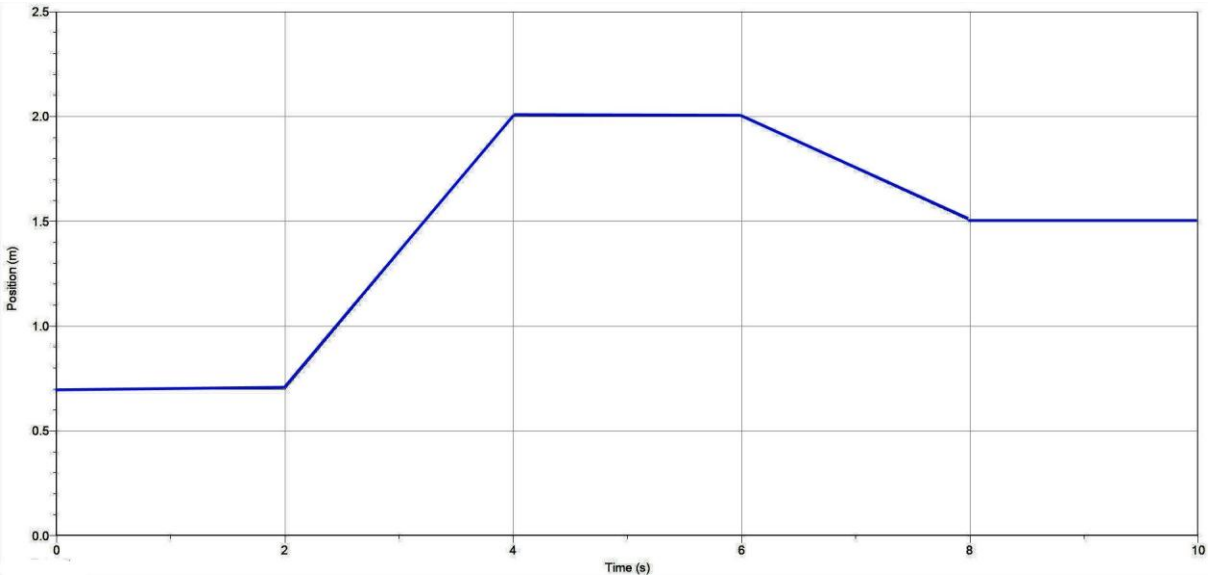
d. What are the functions, x = f(ts), which will create each of these motions? Enter each equation? Enter the functions here and in the control program.

First segment x = _____

Second segment x = _____

e. Test your answer by using the laser dot to guide a person in front of the motion detector. Evaluate the results.

3. Determine a sequence of functions, x = f(t) to produce the motion shown in Graph 3 below.



a. What is the initial position, x0, for this entire motion? ____
Enter the value above and in the appropriate box of the control program.

b. How many distinct segments are needed to produce this motion? _____
Enter the value above. Also use the "File/Run Options/Piecewise Functions" menu to set this value in the control program.

c. What is the duration (in seconds) for each of the required segments? Enter the values below and in the control program. (Add lines as needed.)

T1 = _____ s

T2 = _____ s

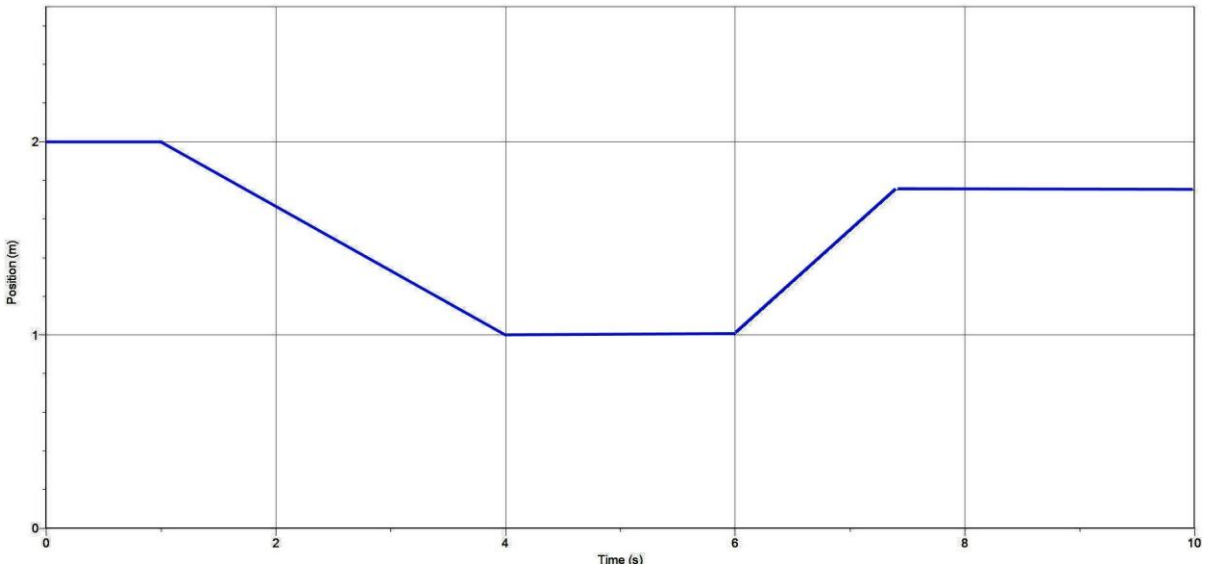
d. What are the functions, x = f(ts), which will create each of these motions? Enter each equation? Enter the functions here and in the control program.

First segment x = _____

Second segment x = _____

e. Test your answer by using the laser dot to guide a person in front of the motion detector. Evaluate the results.

4. Determine a sequence of functions, x = f(t) to produce the motion shown in Graph 4 below.



a. What is the initial position, x0, for this entire motion? ____
Enter the value above and in the appropriate box of the control program.

b. How many distinct segments are needed to produce this motion? _____
Enter the value above. Also use the "File/Run Options/Piecewise Functions" menu to set this value in the control program.

c. What is the duration (in seconds) for each of the required segments? Enter the values below and in the control program. (Add lines as needed.)

T1 = _____ s

T2 = _____ s

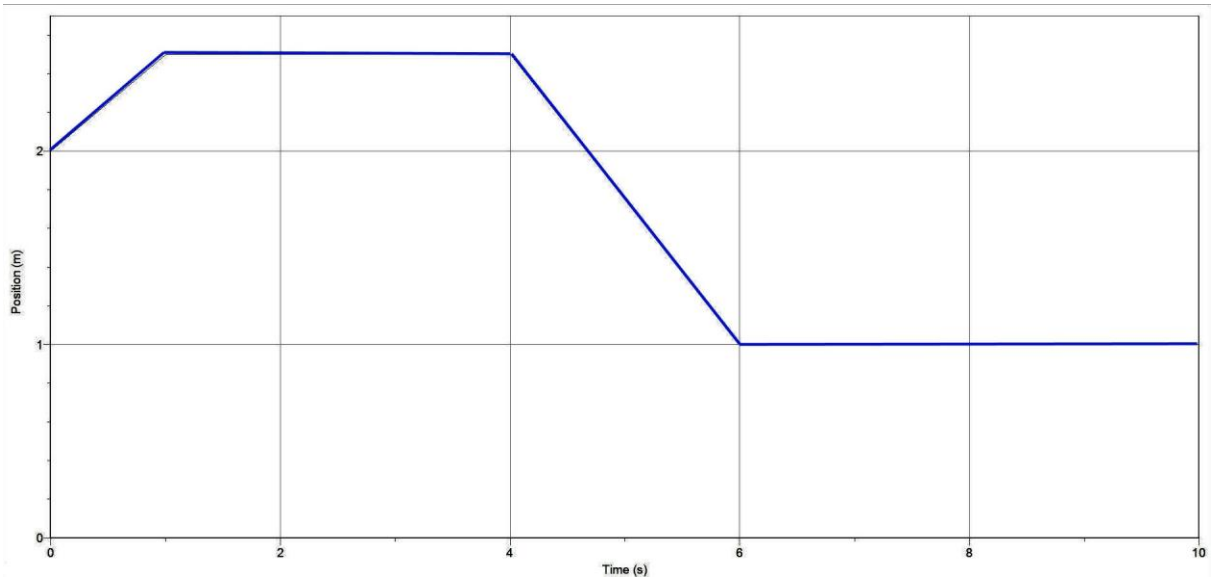
d. What are the functions, x = f(ts), which will create each of these motions? Enter each equation? Enter the functions here and in the control program.

First segment x = _____

Second segment x = _____

e. Test your answer by using the laser dot to guide a person in front of the motion detector. Evaluate the results.

5. Determine a sequence of functions, x = f(t) to produce the motion shown in Graph 5 below.



a. What is the initial position, x0, for this entire motion? ____
Enter the value above and in the appropriate box of the control program.

b. How many distinct segments are needed to produce this motion? _____
Enter the value above. Also use the "File/Run Options/Piecewise Functions" menu to set this value in the control program.

c. What is the duration (in seconds) for each of the required segments? Enter the values below and in the control program. (Add lines as needed.)

T1 = _____ s

T2 = _____ s

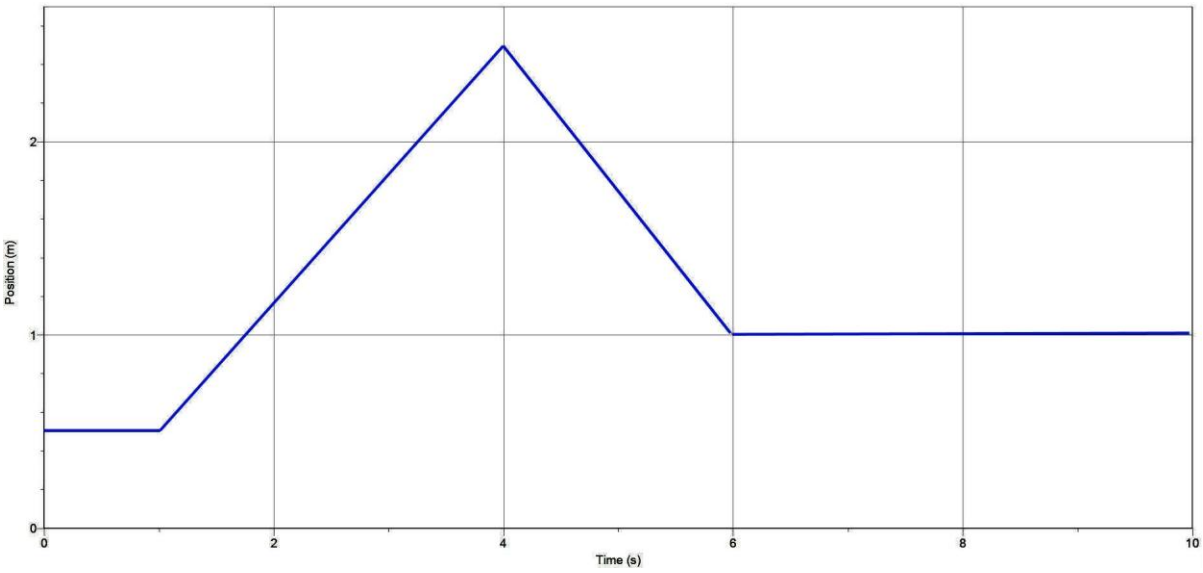
d. What are the functions, x = f(ts), which will create each of these motions? Enter each equation? Enter the functions here and in the control program.

First segment x = _____

Second segment x = _____

e. Test your answer by using the laser dot to guide a person in front of the motion detector. Evaluate the results.

6. Determine a sequence of functions, x = f(t) to produce the motion shown in Graph 6 below.



a. What is the initial position, x0, for this entire motion? ____
Enter the value above and in the appropriate box of the control program.

b. How many distinct segments are needed to produce this motion? _____
Enter the value above. Also use the "File/Run Options/Piecewise Functions" menu to set this value in the control program.

c. What is the duration (in seconds) for each of the required segments? Enter the values below and in the control program. (Add lines as needed.)

T1 = _____ s

T2 = _____ s

d. What are the functions, x = f(ts), which will create each of these motions? Enter each equation? Enter the functions here and in the control program.

First segment x = _____

Second segment x = _____

e. Test your answer by using the laser dot to guide a person in front of the motion detector. Evaluate the results.

