Constant velocity

In this experiment, you will video analysis to study uniform motion. A video camera takes a picture every 1/30 s; therefore, the time interval Δt from one frame of video to the next frame of video is 1/30 or $0.033\overline{3}$ s. If you know the length of something in the video, such as a meterstick, then you can create a coordinate system with each pixel of the video corresponding to position on a x,y Cartesian coordinate system. A computer program can then quite easily record and graph position as a function of time for moving objects in the video.

Let's first apply it to a familiar situation of uniform motion.

Experiment–Uniform Motion

1. Download the file "constant-velocity-fast.mov" and the file "constant-velocity-slow.mov" by right-clicking on the link and choose "Save As..." and save it to your desktop.
2. Open Logger Pro software on your computer.
3. Go to Insert→Movie... to import your video.
4. If the video is too small to see, click once on the video and grab the corner of the video window and expand.
5. At this point, it's nice to lay out the video, data table, and graph so that you can clearly see everything. Go to Page→Auto Arrange... to organize the screen.
6. Note the video controls at the bottom of the video pane. Go ahead and play the video, step it forward, backward, etc. in order to learn how the video controls work.
7. Navigate to the first frame in which you will make measurements of the position of the moving object.
8. You now need to define the origin of the coordinate system. Click the icon with three red dots in order to expand the sidebar used for video analysis.
9. In the sidebar of the video pane, click the appropriate icon to show the coordinate system (you can hover the mouse over each icon to see what they do). Click and drag on the video to place the origin of the coordinate system at the location where you would like to define (0,0).
10. Now, you must calibrate distances measured in the video. In the sidebar, click on the icon of the ruler to set the scale for the video. Notice the calibration object in the video, such as a meterstick or a cart track, and click and drag across the length of the object. You will notice a line drawn across the object. Enter its length in the resulting pop-up box.
11. Now, you must add markers to the video to mark the position of the ball. Click on the icon red dot and cross hairs to add a point to the video. You will now be in an editing mode to add points.
12. You are ready to mark the object in each frame.
    (a) Pick a point on the object that is clearly visible. For rigid objects, it does NOT have to be the center of mass; however, this is often the easiest point to use for a ball.
    (b) Click once on that point. You'll notice that the video will then advance one frame and a maker will be left behind at the location where you clicked.
    (c) If the object is moving slowly so that it hasn't moved very far, then your marks might be too close together. You may advance the video 10 frames (or whatever you decide is best).
    (d) Click again on the same object. You'll notice another marker added to the pane, and the video will again advance one frame.
    (e) If you advance the video before N number of frames, then do this again. Be consistent so that each mark is made N number of frames apart, even if they are consecutive frames (i.e. N=1).

(f) Continue doing this until you have made marks in each frame of the video that you wish to analyze.

13. Logger Pro will calculate data for t, x, y, x-velocity, and y-velocity. In this situation, we are only concerned about the x vs. t graph and x-velocity vs. t graph.

Analysis

View the graph of x-position vs. time. (Note that you can click on the label on the vertical axis to change what is being plotted. Do this, and select x.)

Describe the shape of the graph. Is it uniform motion or not? How can you tell by simply looking at the graph?

Look at the marks on the video. From these marks alone, how can you tell if the object's motion is uniform motion or not?

Fit a linear function to the data and record the resulting equation for x(t).

What is the velocity of the steel ball?

Now, we will consider the x-velocity vs. time graph.

Before looking at the x-velocity vs. time graph, predict what it will look like. Sketch your prediction below.

Click on the vertical axis label on the graph and change it to x-velocity. Does the graph match what you predicted?

Do a linear curve fit to this data. What does this slope and intercept mean in this case?