Kinematics Video Analysis Activity

Physics

Objective: Students will recognize and understand the mathematical and physical connections between motion graphs, the kinematics equations (the "Big 4"), and the actual motion of moving objects.

Instructions:

1. Set up a laptop with Logger Pro loaded.
2. Using the camera on the laptop (or your phone if you are able to quickly and easily transfer the video), film yourself dropping something relatively small and bright colored (so it shows up easily). If you use a crumpled tissue or piece of paper, the air resistance will slow it down to make the filming easier (don't over-crumple, though, or it won't accelerate enough). Make sure to have a ruler in the background of your video to set the scale.
3. Add data points, scale, and set the origin and zero time to convenient points in the video.
4. On the resulting graph, click on the vertical axis and select "Y" to isolate the vertical position of the object.
5. Click on the "curve fit" button on the toolbar. On the window that appears, select a range of points that appear to be valid data (i.e., after you've let go of the object but before it strikes something else). Choose the "quadratic" option below the data points and click "Try fit" and then "OK".
6. The resulting screen will tell you the coefficients for a quadratic equation (a function in the form $y = ax^2 + bx + c$). Make sure to write down these coefficients as you will need them later.
7. Now click on the vertical axis again and select "Y – velocity" to generate a graph that shows the vertical velocity of your object as a function of time.
8. Again, use the "curve fit" button to add a line to your graph. This time, though, select the "linear" option below the data points before plotting the line.
9. The resulting screen will tell you the coefficients for a linear equation (a function in the form $y = mx + b$). Again, write down the coefficients as you will need them later.

Questions:

1. The position graph you looked at first matched up with a quadratic equation. Which of the Big 4 kinematics equations is a quadratic? Which of our six variables (x_0, x, v_0, v, a, and t) correspond to the different variables and coefficients of that Big 4 equation?
2. In other words … what do the coefficients of the position graph quadratic equation tell you?

3. The velocity graph you next looked at matched up with a linear equation. Which of the Big 4 kinematics equations is a linear equation? Which of our six variables correspond to the different variables and coefficients of that Big 4 equation? In other words … what do the coefficients of the velocity graph linear equation tell you?
4. Now that you understand how the video analysis can give you values for all the kinematics variables, you are ready for …

Prediction:
Repeat the steps above – this time, though, instead of dropping an object, toss it across the field of view of the camera. The path the object travels should form a parabola: it should be a curve that opens downward (like a frown). Using the coefficients from the quadratic equation (for the object's vertical position), use the Big 4 to predict the final downward velocity of the object. Use the coefficients from the linear equation (for the object's velocity) to verify your prediction.

Extension:
Experiment with different kinds of motion. Try walking across the camera's field of view while slowing down. Examine the horizontal motion of an object tossed across the camera's field of view. Toss an object straight up in the air and investigate the resulting motion and kinematics variables. Think about the fact that the objects that are moving are doing so in two dimensions (both horizontal and vertical).