IB Moving Plots

Here you will use a 60Hz tape timer to make position and velocity v time graphs of an object in free fall. (or nearly in free fall) If you need help with this there is a website for this lab with videos

Getting a Tape:

1. **You and one partner** will need a mass, a spark timer kit and some masking tape. You may work in a group larger than two to gather data, just get a different tape for every two people at least.
2. Cut a 1.3 m length of expensive silver timer tape, and feed it from the top through the tape timer, so that about 5 cm or so sticks through the bottom. Have one person stand up on a chair holding the tape near the other end (way up high), and have the other person clip the 0.5 kg mass to the other end. (If it slides off, try putting a bit of masking tape on the timer tape on that end) Pull the mass up as high as you can, turn the timer on, wait until the mass stops swinging, and have the person on the chair release the mass so it falls into the sandbox on the floor.

Analyzing the Tape:

1. Tape a meter stick to the table, and tape your timer tape next to it at both ends so the first clear dot is at the 0 cm end of the meter stick.
2. Write down, measuring to the nearest millimeter, where the dots fall on the meter stick. These numbers should increase from 0 to almost 100. Do not measure between the dots.
3. In Google Sheets, make a column that is labeled Time (s), and have it be every 60th of a second. (0, 0.01666, 0.03333, 0.05000, 0.06666, etc.) There is a quick way to do this that I will show in the video. In the second column labeled Position (cm) type in your positions of your dots, starting with the first dot at 0 cm, and ending with a number close to 100 cm. In your third column labeled Velocity (cm/s), make a formula that is the distance traveled in the last 1/60th of a second, divided by the elapsed time (1/60th s) This will look like "=(B3-B2)*60". You will have one fewer of these than positions, and this will start next to the second position.
4. Make **two** nice **x-y scatter** graphs: (Vertical vs. Horizontal)
    a. Distance (cm) vs time (s) – choose the smooth line graph, label the axes etc., and make it a separate sheet. Right click on the series when you are done, choose "Add Trendline" and put a second order polynomial model on your data. Click the box "Display equation on chart"
    b. Velocity (cm/s) vs. time (s) – choose the points only, and you could put this graph on the same page as the data to save paper. Add a "Linear" trend line to this graph, displaying the equation on the graph.

Write up:

Tangent Lines: Pick a smooth part of the distance vs. time graph. •Draw a long tangent line with a ruler to a smooth part of the curve. The line should go off the plot frame at both ends. •By using the coordinates read from your axes of where your tangent line enters and exits the plot frame, find the slope of the line you drew. Show this calculation on the graph itself. •Your tangent line is tangent at a certain point in time. Read this from the time axis of your graph. How does that slope compare the velocity at that time you calculated in the data table? (Compare the slope of the tangent line to the velocity at that time read from the values you calculated in step 4 above – the velocity column.)

Do this for two points on the graph. Each person should do their very own tangent line.

Acceleration: You have found the acceleration of the mass two different ways:

Excel polynomial model on position graph: Excel will show your equation in the form $y = Ax^2 + Bx + C$. Our formula is $s = ut + {}^1/_2at^2$ where u = 0, so from the Excel polynomial, C and B should be 0 or thereabouts (don't worry if they are not) but most importantly, A (The coefficient of x^2) will be ${}^1/_2a$ - half the acceleration of the mass. So double A, (the coefficient of x^2) and you have the acceleration from this model.

Slope of velocity graph: This one is easy – the slope of the velocity vs. time graph **is** the acceleration.

•Write a sentence where you state what the acceleration is using both ways of calculation, and compare them. Are they close?