MYP Year 10 Physics P Bonifacio

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Worksheet	Investigation	Constant acceleration motion

- You will investigate:

1. **uniformly accelerated motion** by taking data with the "*The Moving Man*" PhET simulation
2. how the data can be organized into a **Space-Time diagram**
3. the **time law for uniformly accelerated motion**

Read carefully the following instruction and complete the worksheet in detail.

Background knowledge: acceleration and velocity law

For an object moving along a straight direction the acceleration is defined as:

$$acceleration = (change\ in\ velocity)/(change\ in\ time)$$

In symbols

$$a = \frac{\Delta v}{\Delta t}$$

Where the symbol Δ (read delta) means "change in".

The units of the acceleration are found from the equation above:

$$[a] = \left(\frac{m}{s}\right) \div s = \frac{m}{s^2}$$

➔ Mathematically you can find the velocity of the motion at any time using the formula

$\boldsymbol{v = a\,t + v_0}$	**Constant acceleration motion**

Where:

v = velocity (vertical axis)

t = time (horizontal axis)

a = acceleration (it is the slope or gradient of the line)

v_0 = initial velocity, i.e. the velocity at time $t = 0$

The above formula will give a straight line in a velocity Vs Time graph.

But what about the position of the uniformly accelerated object and its Space-Time diagram? This worksheet will let you investigate this.

Instructions

Part a.

- Open "The Moving Man" software
- Set an acceleration of $0.50\frac{m}{s^2}$
- Remove the walls by clicking on the red crosses
- Run the animation for 20 seconds so that the data are recorded by the software
- Now press on *playback* so that you can see the animation as slowly as you want
- Click on the box velocity vector and playback the animation. While you do that notice how the red arrow representing the velocity gets longer and longer as the velocity increases
- Now you are ready to record your data into an *Excel* spreadsheet :

  Create a table with three columns where you will **record the values of time, position and velocity** every 1 second

  Remember to indicate the units, your table will look something like this (**make sure you include time t = 0 as well**):

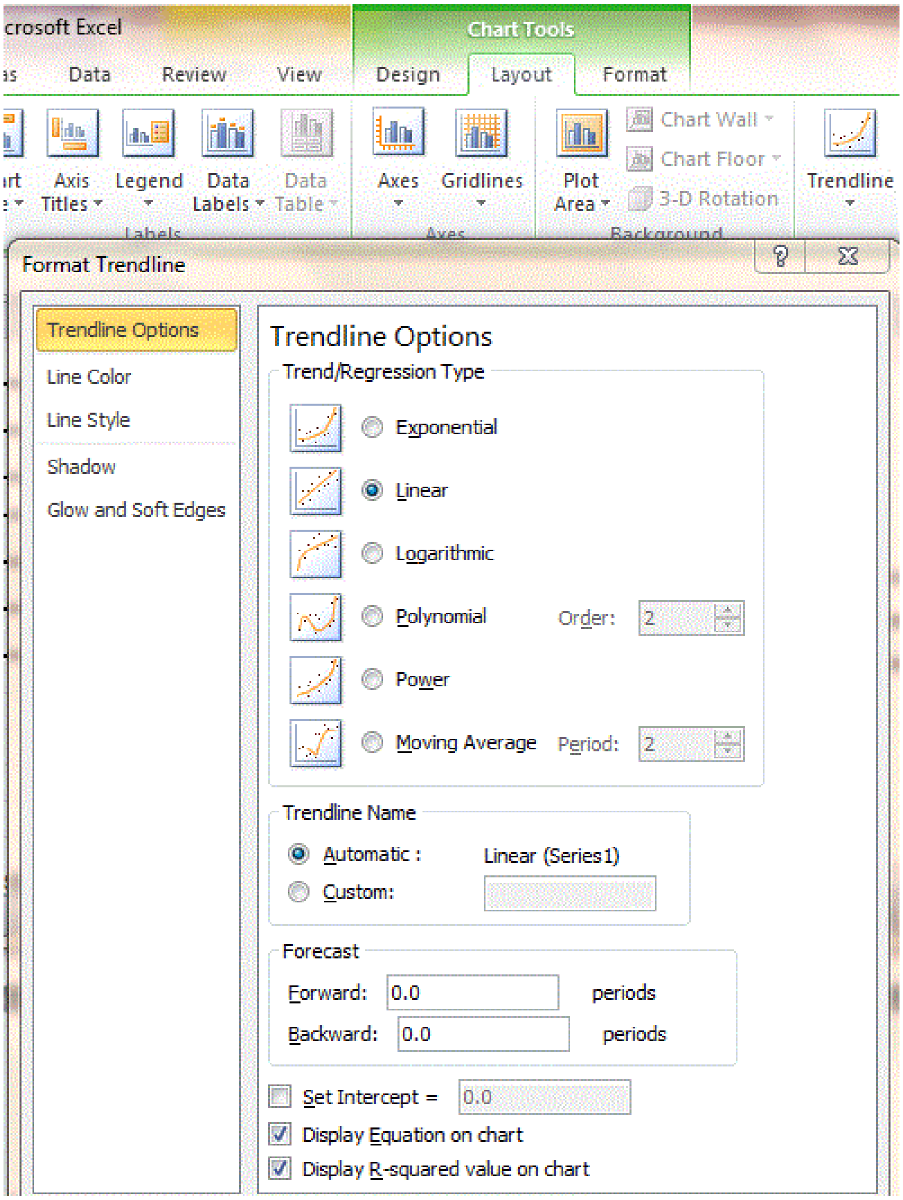
t (s)	**x (m)**	**v (m/s)**
0	0	0
0.5	0.06	0.25
1	0.25	0.50

  Your table will continue up to t = 20 seconds
- Now use Excel to plot a Velocity VS Time graph:

  Velocity v will go on the vertical axis

Time t will go on the horizontal axis

- Do the data align along a straight line as they should?
- Use Excel to display a best fit straight line (trend line, linear fit)



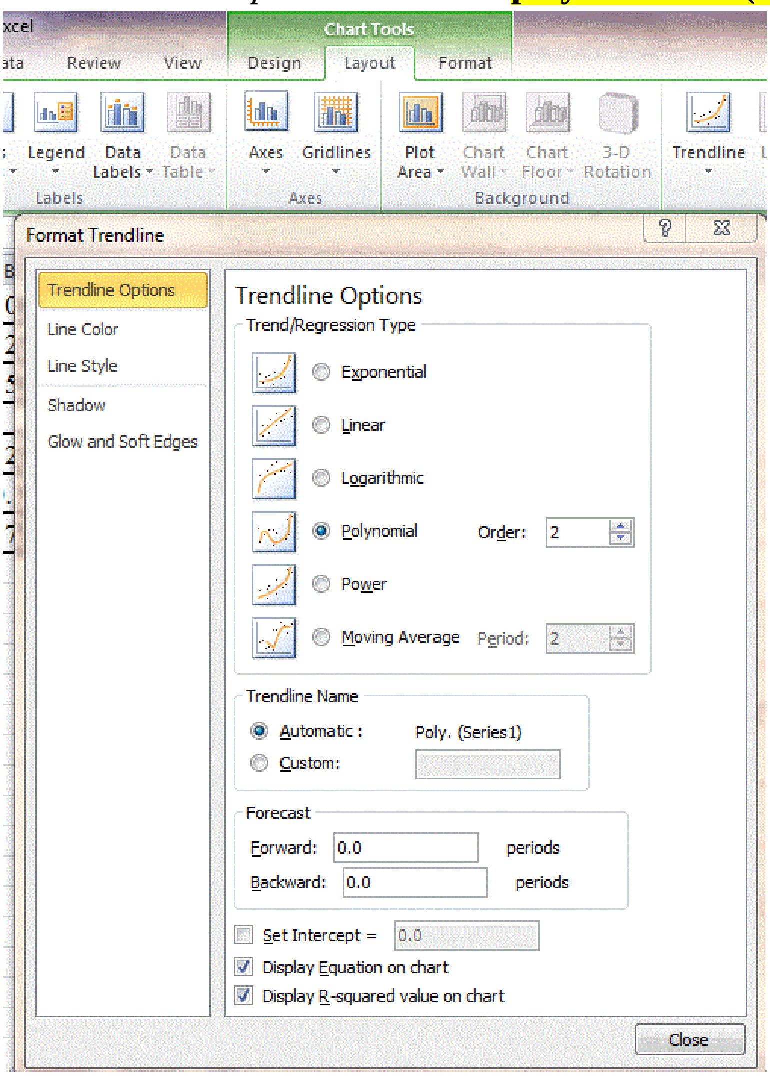
- Use Excel to display the **equation on chart** and the **R-squared** value:
- Is the fit good?
- What is the slope of the line?
- Does this slope agree with what you expected? Why?

- Now use Excel to plot a Space-Time graph (Position Vs Time):

Position x will go on the vertical axis

Time t will go on the horizontal axis

- Do the data align along a straight line?
- Try to add a linear fit trend line. What is the value of the R-squared? Is this value indicating that the linear fit is good or bad?
- With Excel try to add now a different kind of fit: click on *trendline*, *more trendline options* and select **polynomial fit (order 2)**



- Polynomial fit of order 2 means that Excel will try to fit your data with a curve of equation like:

$$y = Ax^2 + Bx + C$$

Remembering your maths, which kind of curve is this?

Of course for you the symbols should be more like

$$x = At^2 + Bt + C$$

Since you have **time in the horizontal axis and position in the vertical axis.**

- What is the value of the R-squared now?
- What does this indicate about the quality of the fit?
- Use *Excel* to display the equation of the curve on the chart. **Re-Write it here using the right symbols [*remember excel calls x and y the horizontal and vertical axis, while for you they are called t and x*]**
- **Can you see any number in your equation that is closely related to the acceleration of the motion? (remember this was set to $\boldsymbol{a = 0.5\ m/s^2}$)**

Part b.

In this part of your investigation you will study Space-Time graphs for uniformly accelerated motions and you will try to understand how the graphs can be connected to the properties of the motion, i.e. acceleration, initial position and velocity. Your final goal will be to discover the time law for the uniformly accelerated motion

- You will now **re-run the simulation from scratch 4 more times**. For each simulation you will choose the initial parameters (i.e. acceleration, initial velocity and initial position) as shown in the table below

Simulation Number	$a\ \left(\frac{m}{s^2}\right)$	$v_0 (m/s)$ Initial velocity	$x_0\ (m)$ Initial position
1	1	0	0
2	2	0	0
3	-0.5	-1	10
4	1	1	-8

The **initial velocity $\boldsymbol{v_0}$ and position $\boldsymbol{x_0}$** are the velocity and position that the man has at time $t = 0$ and can be set by adjusting the controls in the corresponding color before the simulations are run.

- For each of the 4 simulations record the data for **position, velocity** and **time** from t = 0 up to t = 20 seconds. **Record the data every 1 second**. Build and show the corresponding data table for each simulation as done in part A.
- For each data table use Excel to plot the corresponding **Space-Time diagram**
- For each diagram use Excel to show a **polynomial order 2 fit** to the data. In your diagram show the equation on chart and the corresponding **R-squared**. Are the fits good?
- Complete now the table below, by pasting the equations found by Excel in the last column (**remember to change y into x and x into t**):

Simulation Number	$\boldsymbol{a}\left(\frac{\boldsymbol{m}}{\boldsymbol{s^2}}\right)$	$\boldsymbol{v_0(m/s)}$ Initial velocity	$\boldsymbol{x_0}$ $\boldsymbol{(m)}$ Initial position	**Polynomial fit equation**
1	1	0	0	
2	2	1	0	
3	-0.5	-1	10	
4	1	2	-8	

- Do you now see any clear link between the coefficients of your equations and the values of the acceleration, initial velocity and initial position?
- Are you now able to complete the table below?

	Constant Velocity Motion	**Constant Acceleration Motion**
Time Law	$x = v\,t + x_0$	……?…..
Velocity Law	$v = constant$	$v = a\,t + v_0$

Remember: x_0 indicates the initial position and v_0 indicates the initial velocity