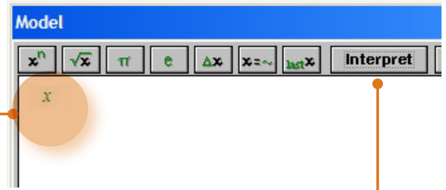
Exploring position-time graphs when a particle moves on the Ox axis

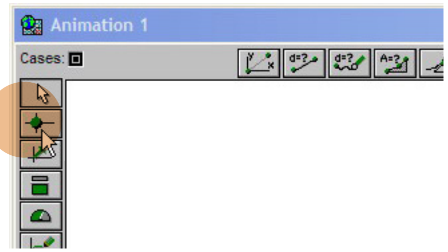
1. Run Modellus.

2. Write *x* on the Model Window.

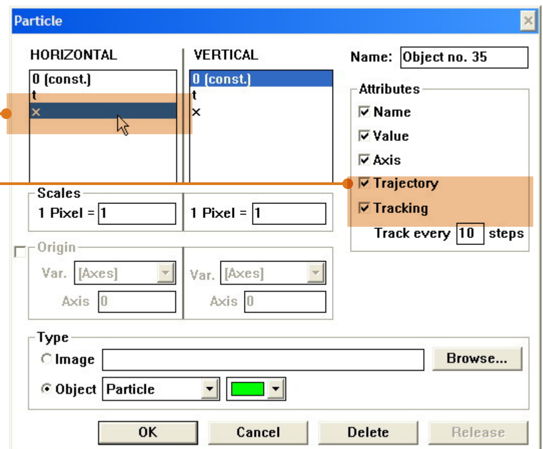
3. Press the **Interpret** button on the Model Window.



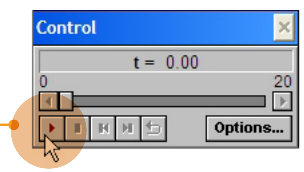
4. Place a particle on the Animation Window using the **Create Particle** button.



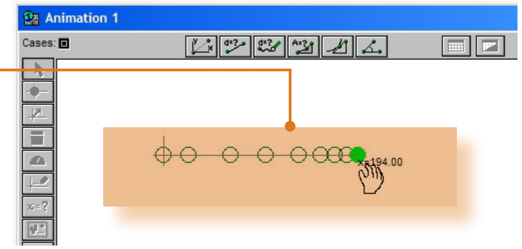
5. Give the following properties to the particle:



6. Run the Model using the Start Button.



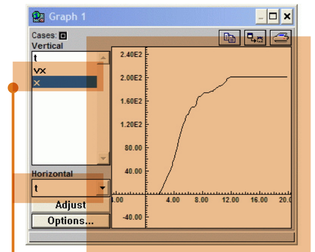
7. Move the particle to the right... fast... and then slow...



8. In what portions of the trajectory is the particle moving "faster"? How do you know, analysing the stroboscopic record?

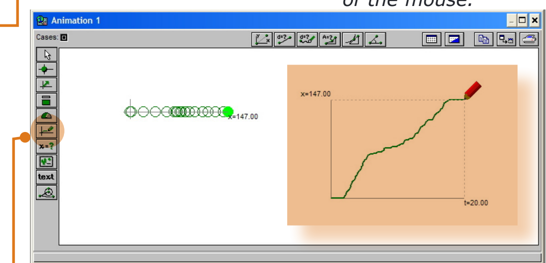
9. In what portions of the trajectory is the particle moving "slower"? Where does the evidence come from?

10. Analyse the graph of the horizontal coordinate *x* as a function of time:



TIP: *to edit/change the properties of an object on the Animation Window use the right button of the mouse.*

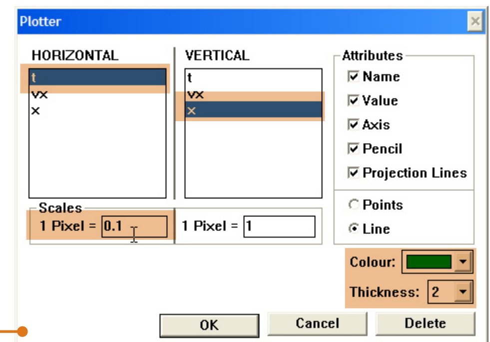
11. How can one "see" on the graph when the particle is moving faster? And slower?



12. Create a graph on the Animation Window to represent *x* as a function of *t* (use 1 Pixel = 0.1 to the horizontal scale). Run the Model again and move the particle. Discuss how does the graph "show" the speed of the motion.

Use the Plotter Button to create a graph on the Animation window.

Give these properties to the Plotter.



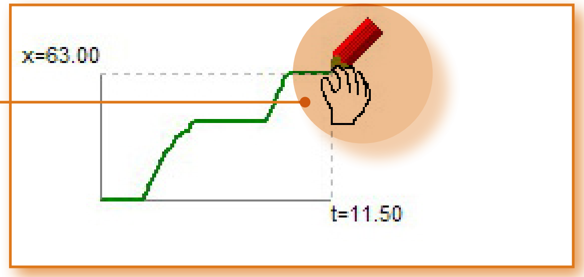
Exploring position-time graphs when a particle moves on the Ox axis: how does the particle move?

1. Run the model once more but instead of moving the particle move the "pencil" of the graph. See what happens to the particle...

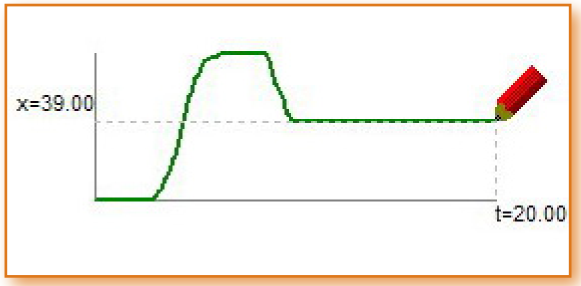
2. Analyse the following graphs and discuss how the particle moved...

TIP: *Run the Model and place the mouse over the origin of the graph. Move the pen...*

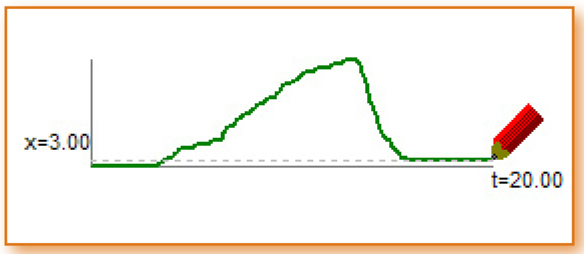
A.



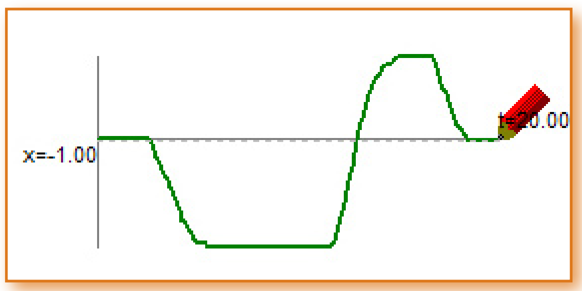
B.



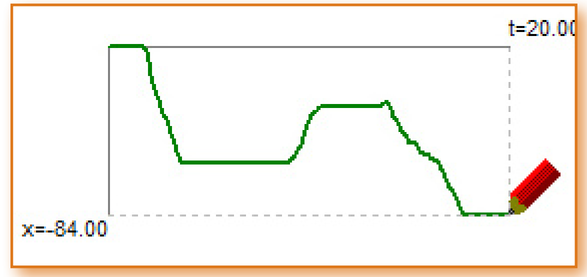
C.



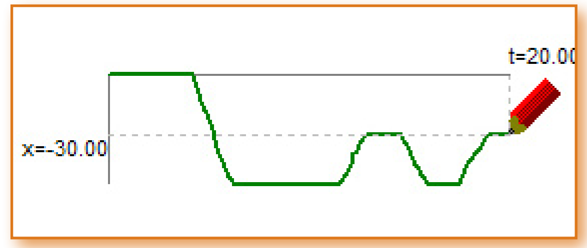
D.



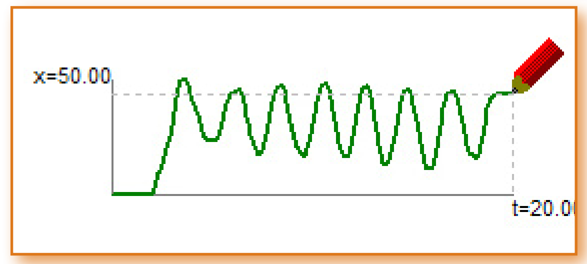
E.



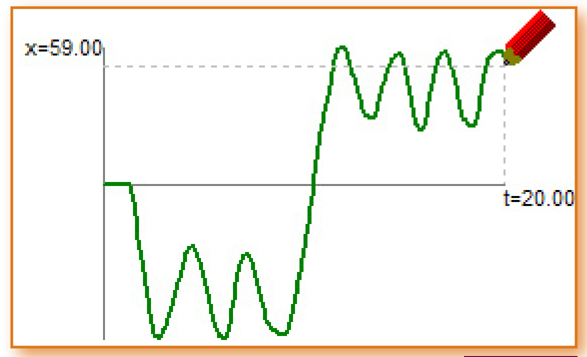
F.



G.

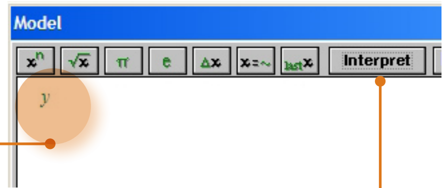


H.



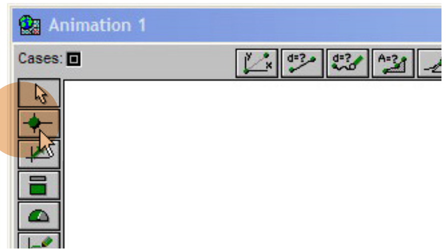
Exploring position-time graphs when an particle moves on the *y* axis

1. Run Modellus or create a New Model (menu File/New).



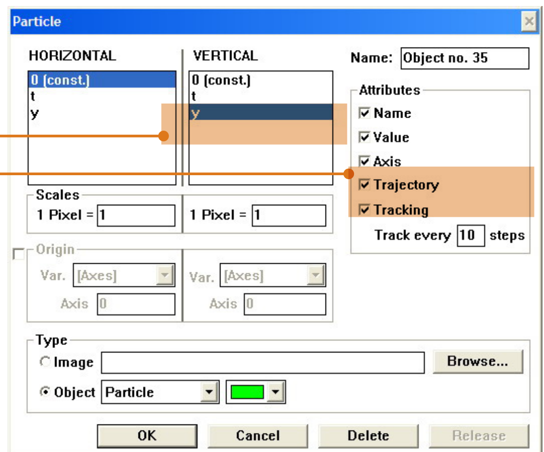
2. Write *y* on the Model Window.

3. Press the **Interpret** button on the Model Window.

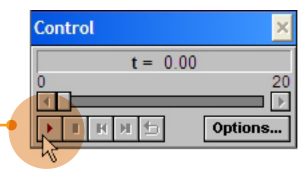


4. Place a particle on the Animation Window using the **Create Particle** button.

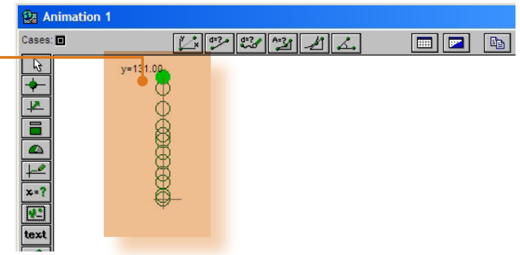
5. Give the following properties to the particle:



6. Run the Model using the Start Button.

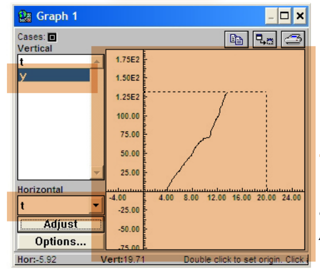


7. Move the particle up, very slow... and then faster...



8. In what portions of the trajectory is the particle moving “faster”? How do you know, analysing the stroboscopic record?

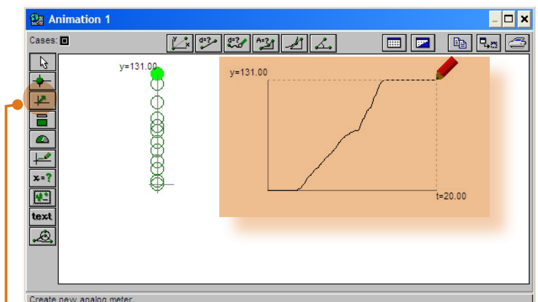
9. In what portions of the trajectory is the particle moving “slower”? Where does the evidence come from?



10. Analyse the graph of the vertical coordinate *y* as a function of time:

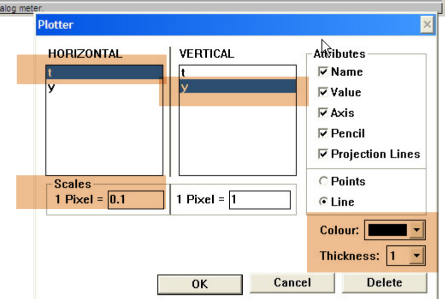
TIP: *to edit/change the properties of an object on the Animation Window use the right button of the mouse.*

11. How can one “see” on the graph when the particle is moving faster? And slower?



12. Create a graph on the Animation Window to represent *y* as a function of *t* (use 1 Pixel = 0.1 to the horizontal scale). Run the Model again and move the particle. Discuss how does the graph “show” the speed of the motion.

Use the Plotter Button to create a graph on the Animation window.



Give these properties to the Plotter.

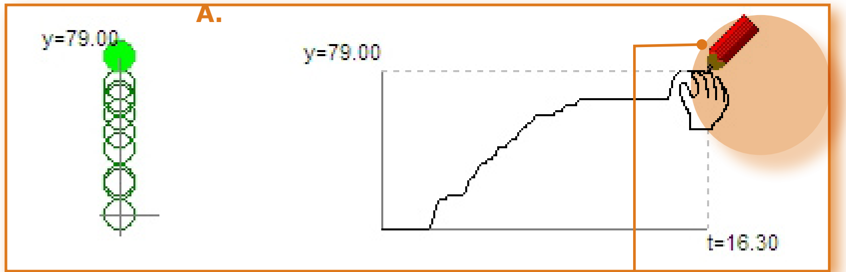
☐ OK ☐ I need to do this again... ☐ I need tutor support

Exploring position-time graphs when a particle moves on the *Oy* axis: how does the particle move?

1. Run the model once more but instead of moving the particle move the "pencil" of the graph. See what happens to the particle...

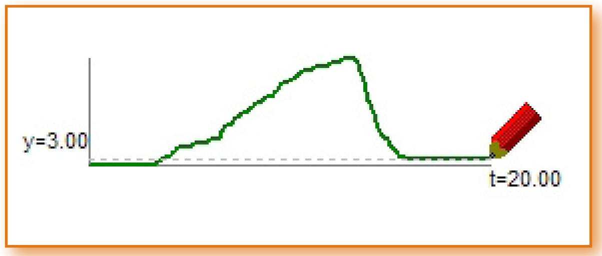
2. Analyse the following graphs and discuss how the particle moved...

A.

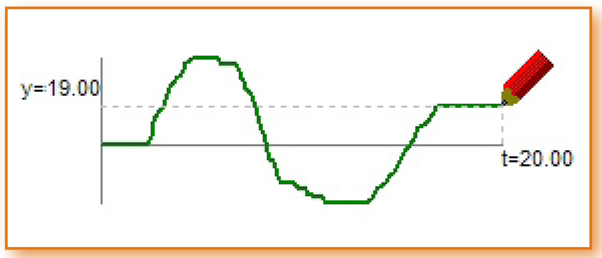


TIP: Run the Model and place the mouse over the origin of the graph. Move the pen...

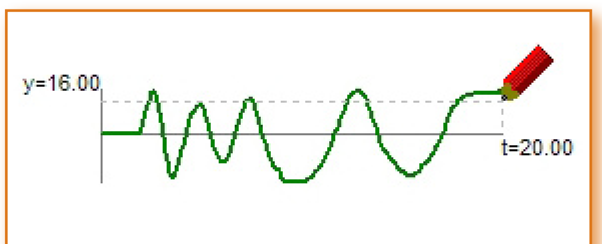
B.



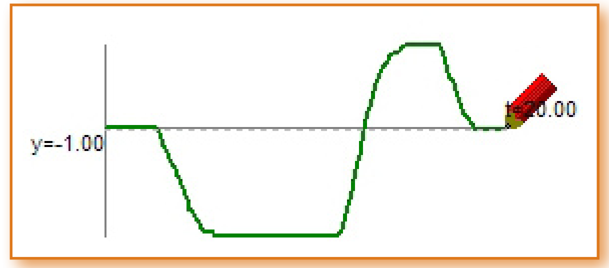
C.



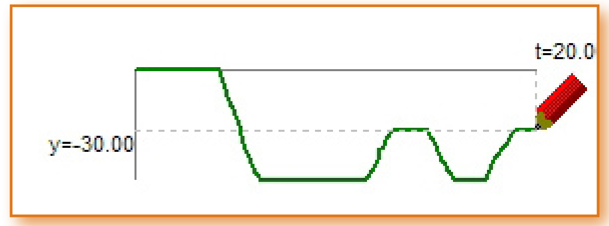
D.



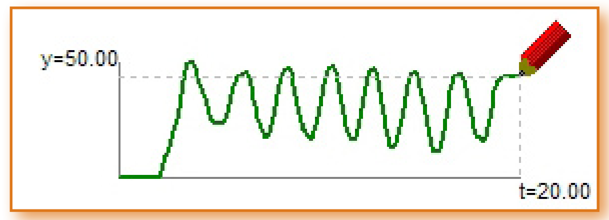
E.



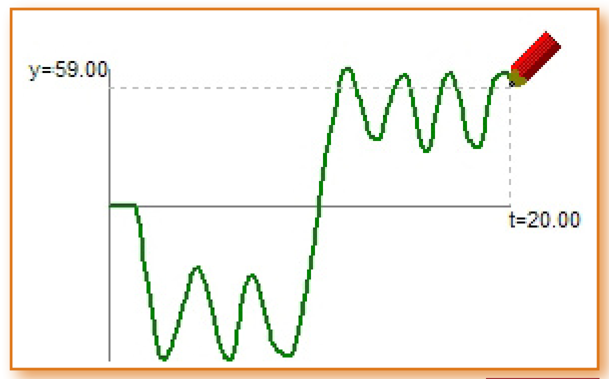
F.



G.



H.



Exploring position-time graphs with linear functions (I)

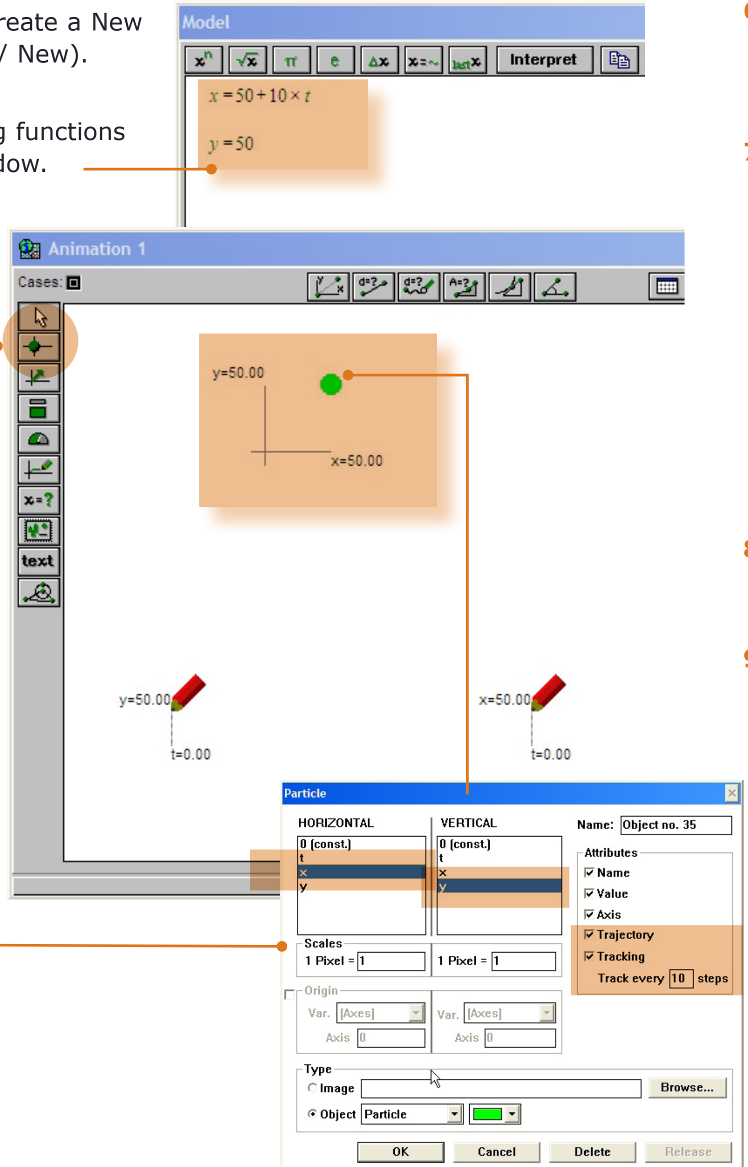
1. Run Modellus or create a New Model (menu File / New).

2. Write the following functions on the Model Window.

3. Press the Interpret button on the Model Window.

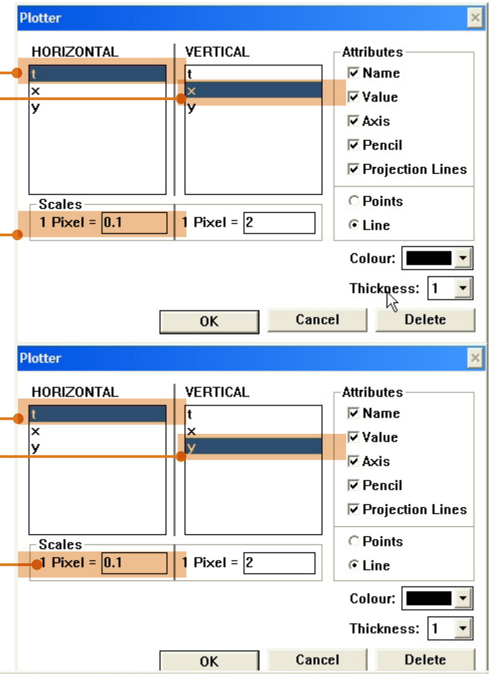
4. Create a particle on the Animation Window using the Create Particle button.

5. Give the following properties to the particle:



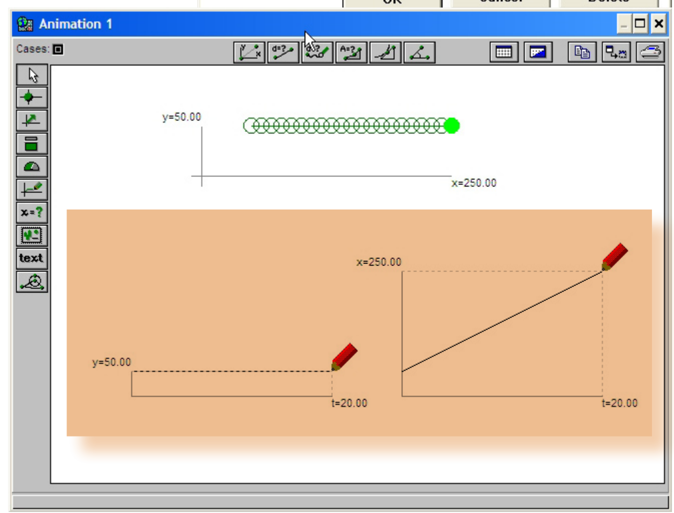
6. Create two graphs on the Animation Window using the Create New Plotter button.

7. Give the following properties to the plotters:



8. Run the Model using the Start Button.

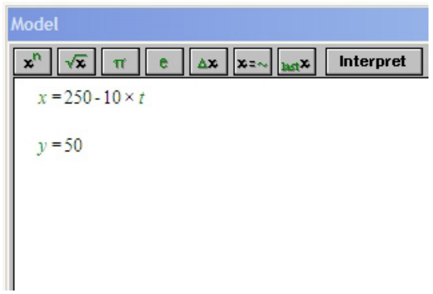
9. Analyse the trajectory and the graphs. Do the graphs make sense? Explain your reasoning.

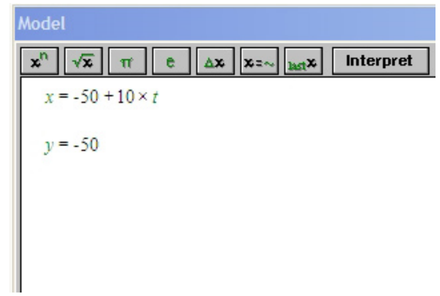


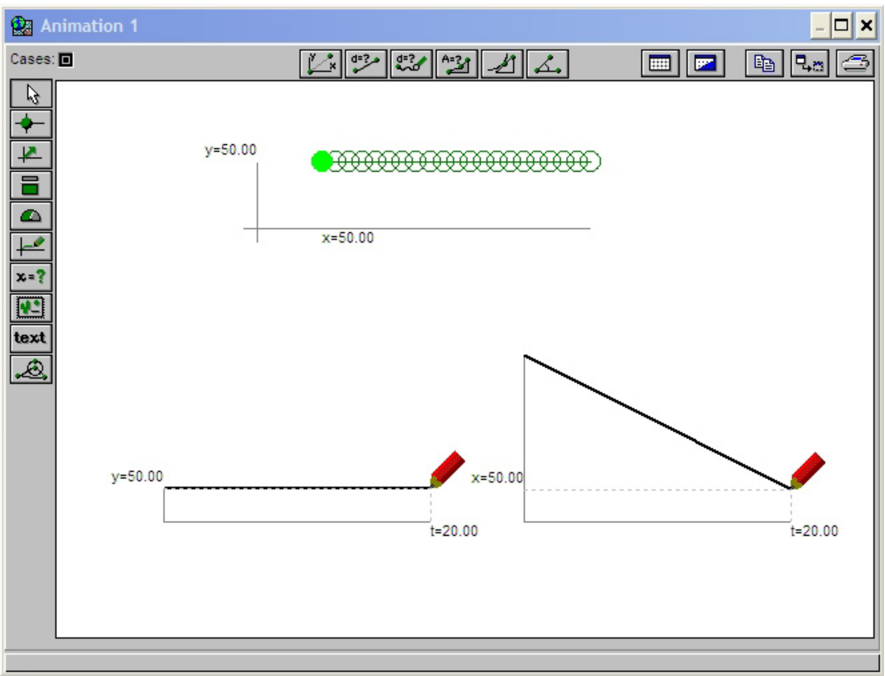
Exploring position-time graphs with linear functions (II)

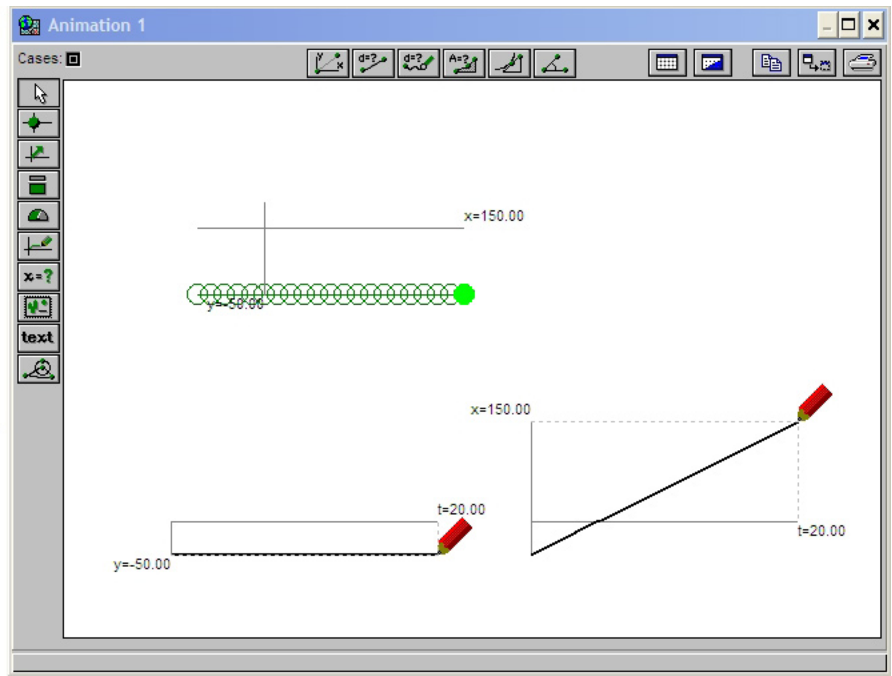
1. Change the model in order to obtain the following trajectories and graphs.

2. Analyse the functions, the trajectories and the graphs.





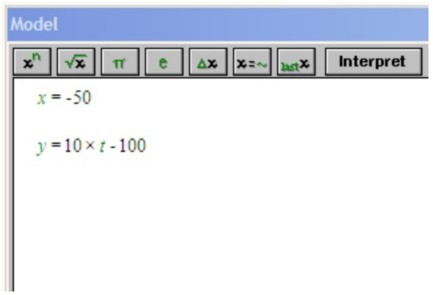


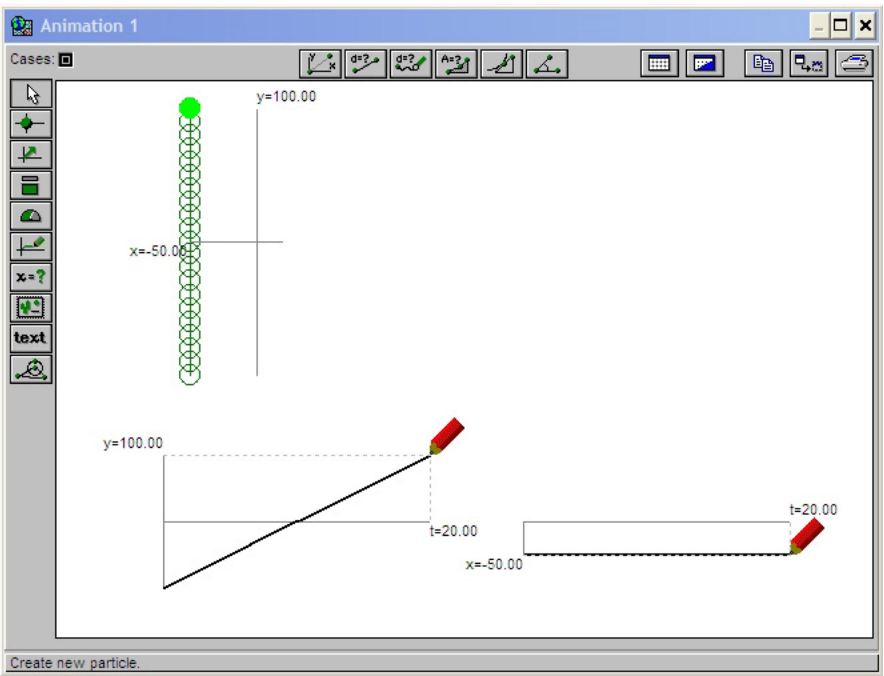


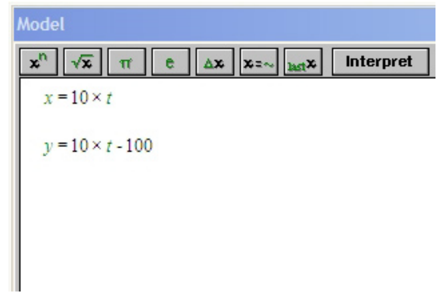
Exploring position-time graphs with linear functions (III)

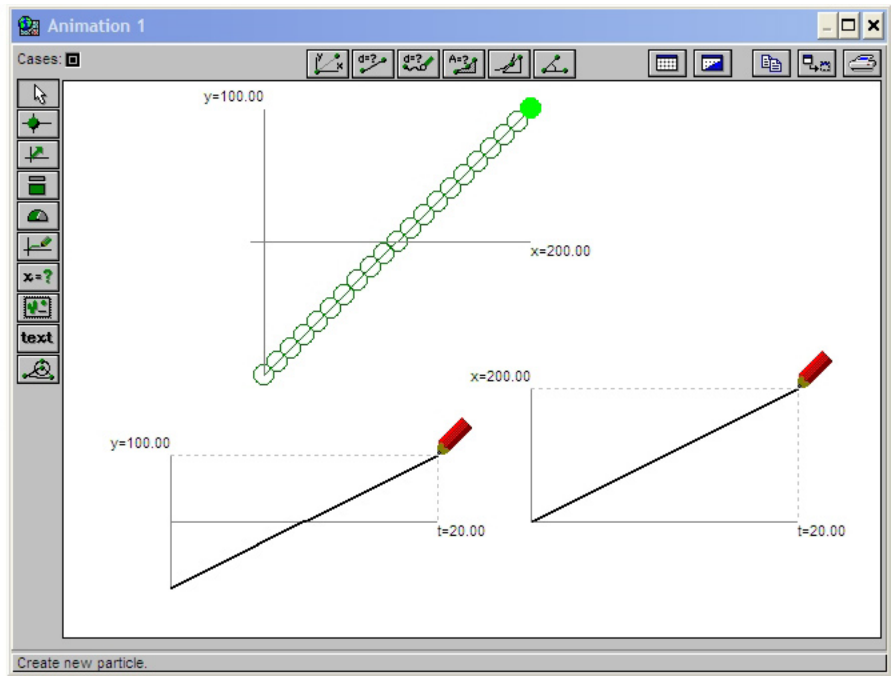
1. Change the model in order to obtain the following trajectories and graphs.

2. Analyse the functions, the trajectories and the graphs.





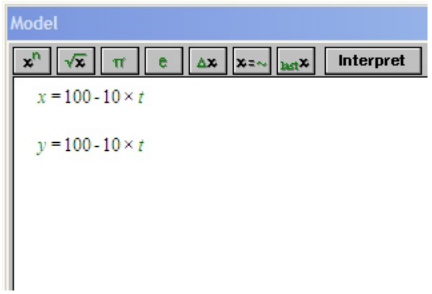


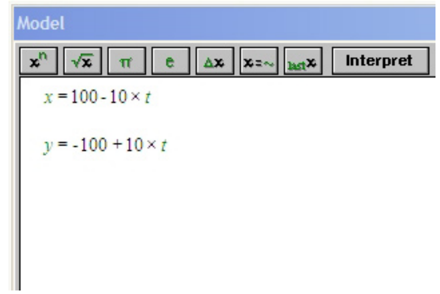


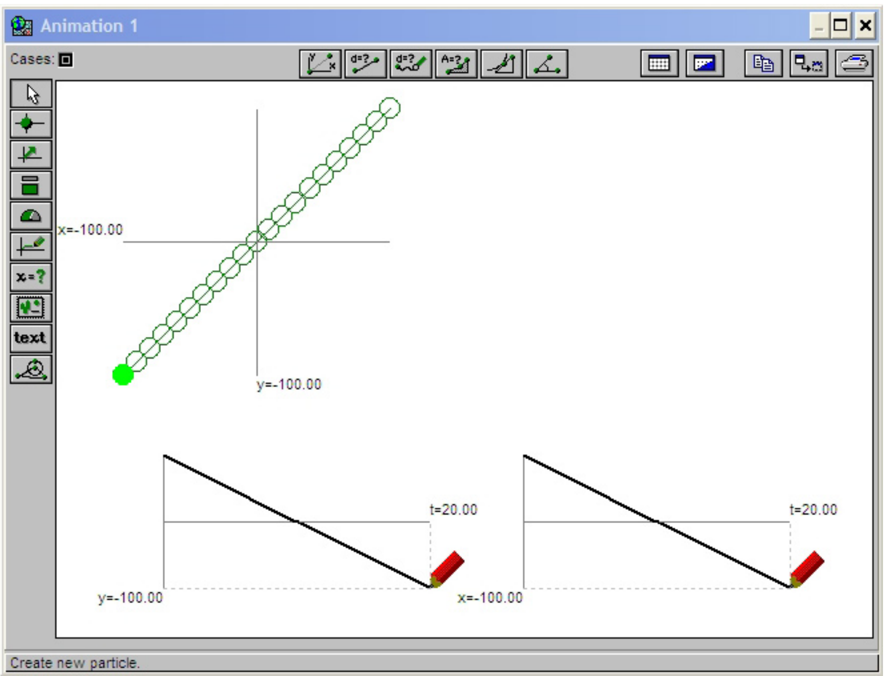
Exploring position-time graphs with linear functions (IV)

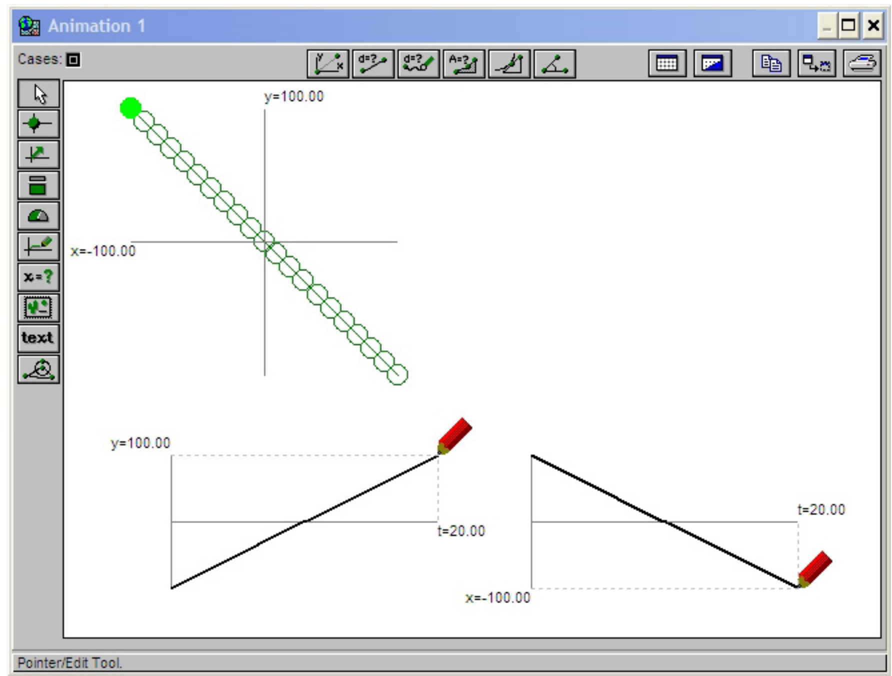
1. Change the model in order to obtain the following trajectories and graphs.

2. Analyse the functions, the trajectories and the graphs.





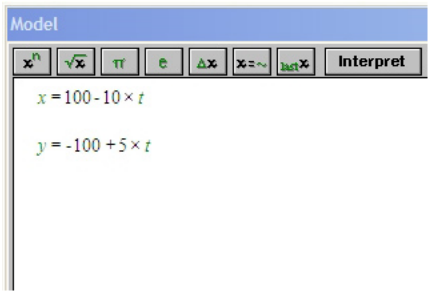


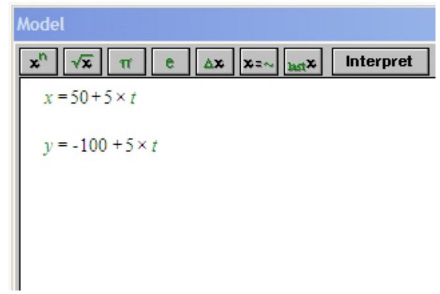


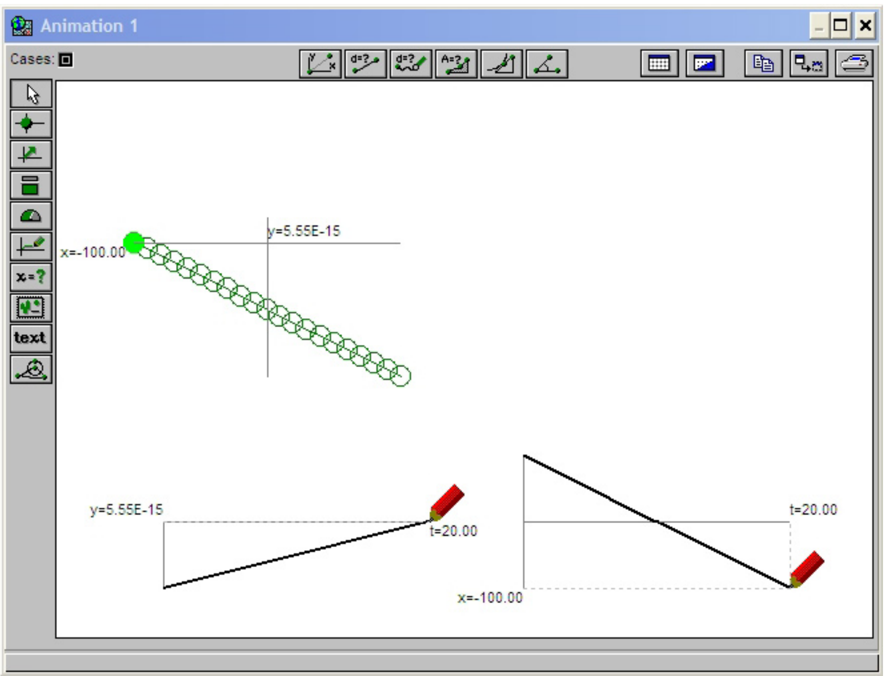
Exploring position-time graphs with linear functions (V)

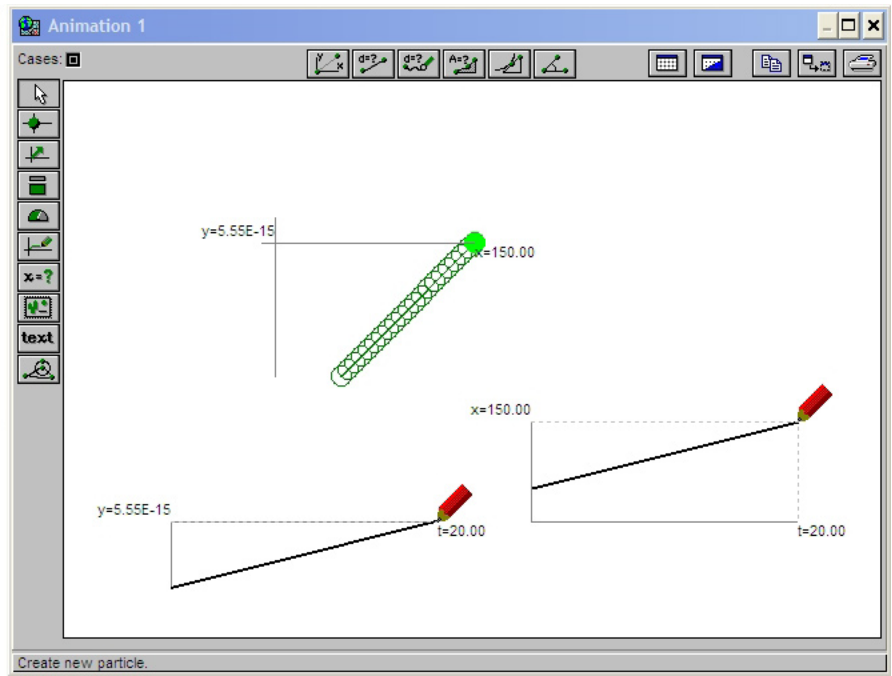
1. Change the model in order to obtain the following trajectories and graphs.

2. Analyse the functions, the trajectories and the graphs.







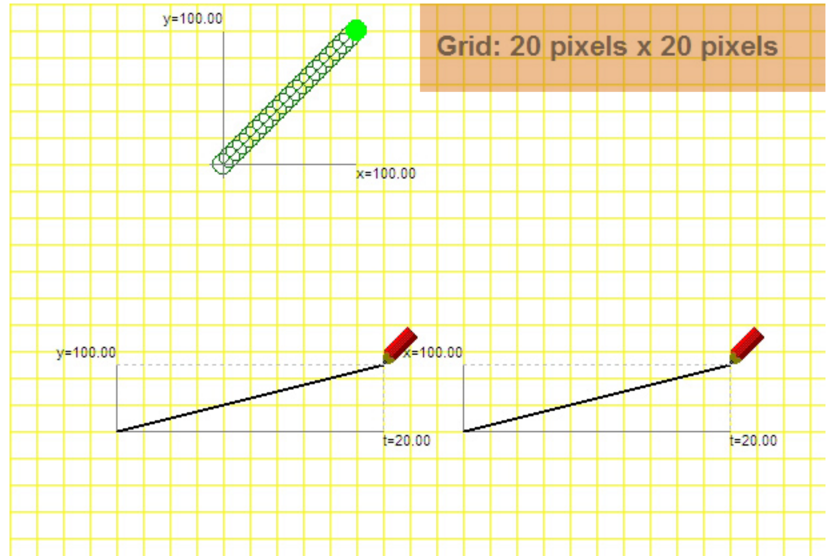


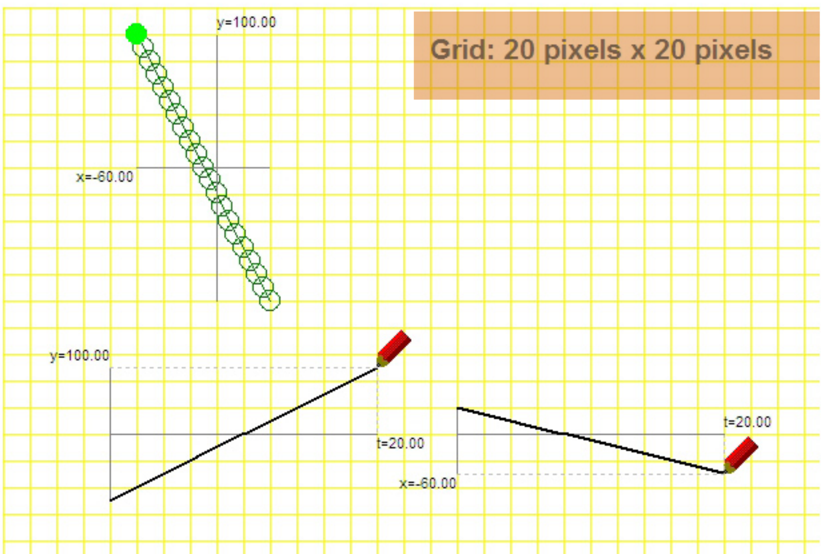
 ☐ OK ☐ I need to do this again... ☐ I need tutor support

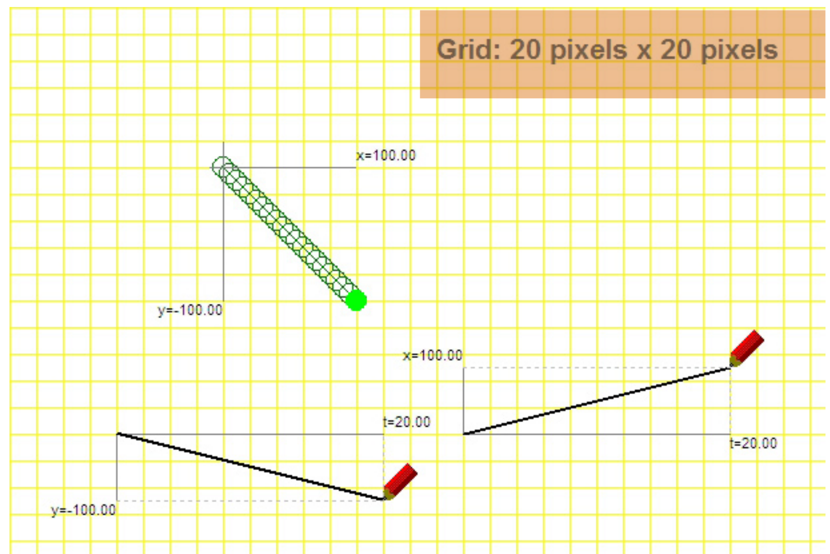
Can you deduce the functions from the graphs? (I)

1. Try to create models to obtain the following trajectories and graphs.

2. Look carefully at the slope of the graphs and the initial conditions.





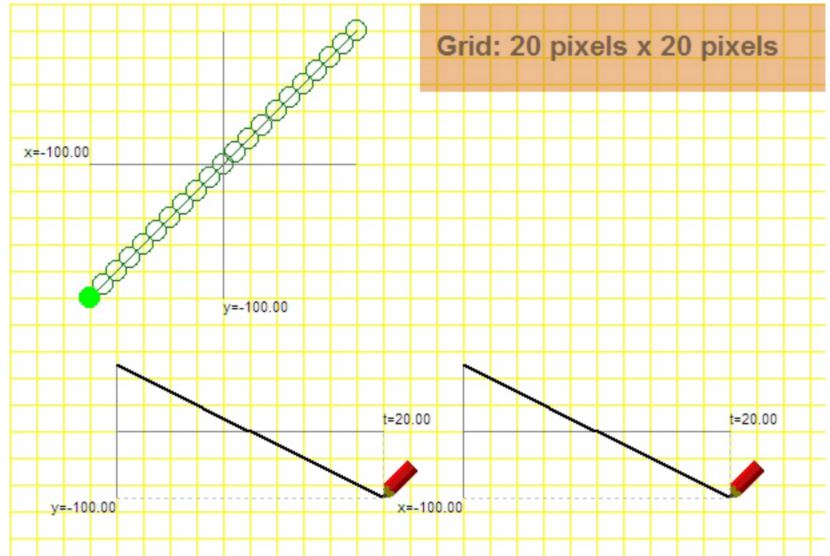


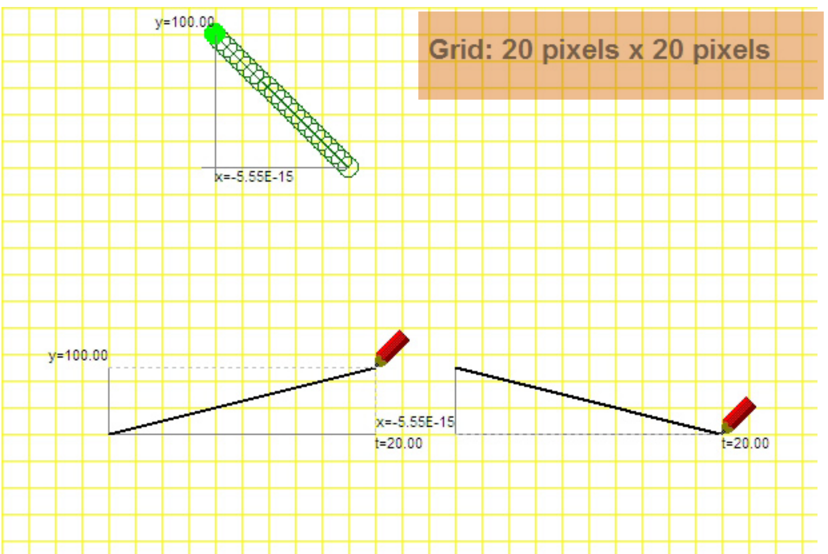
 ☐ OK ☐ I need to do this again... ☐ I need tutor support

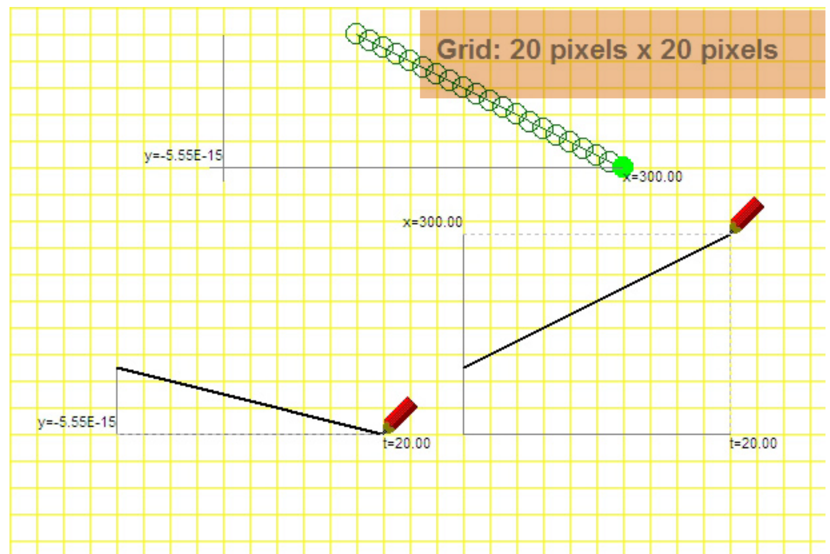
Can you deduce the functions from the graphs? (II)

1. Try to create models to obtain the following trajectories and graphs.

2. Look carefully at the slope of the graphs and the initial conditions.



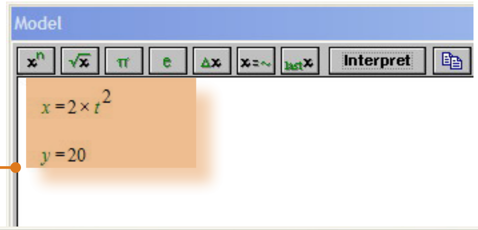




Exploring position-time graphs with quadratic functions (I)

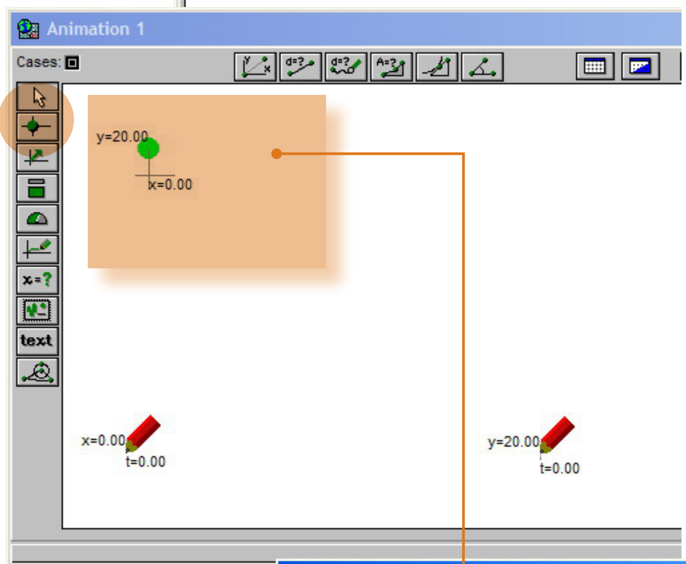
1. Run Modellus or create a New Model (menu File / New).

2. Write the following functions on the Model Window.

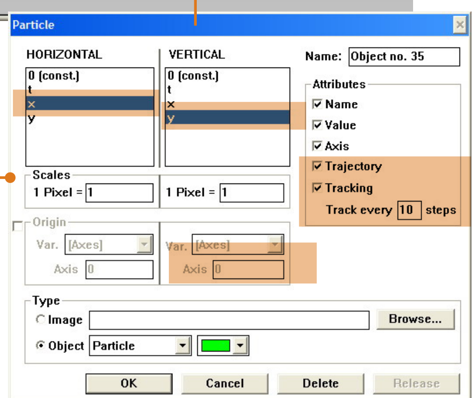


3. Press the Interpret button on the Model Window.

4. Create a particle on the Animation Window using the Create Particle button.

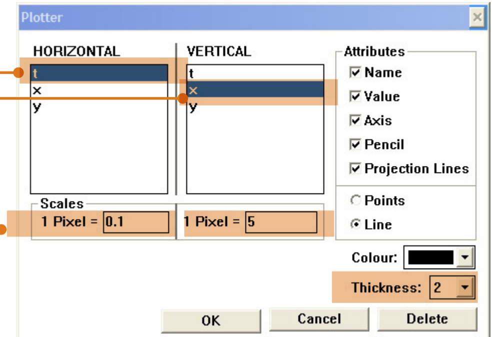


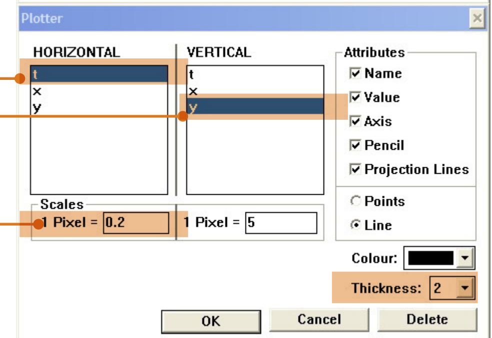
5. Give the following properties to the particle:



6. Create two graphs on the Animation Window using the Create New Plotter button.

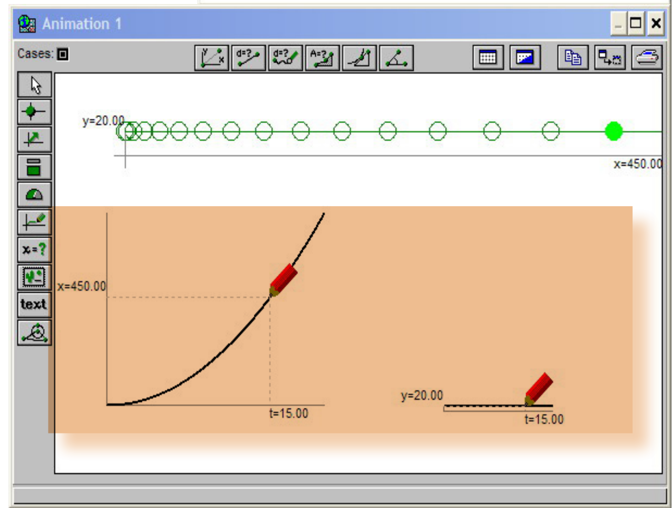
7. Give the following properties to the plotters:





8. Run the Model using the Start Button.

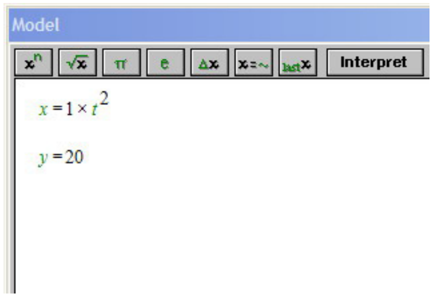
9. Analyse the trajectory and the graphs. Do the graphs make sense? Explain your reasoning.

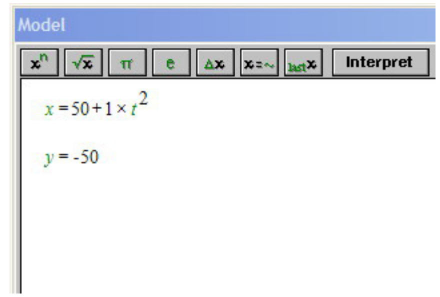


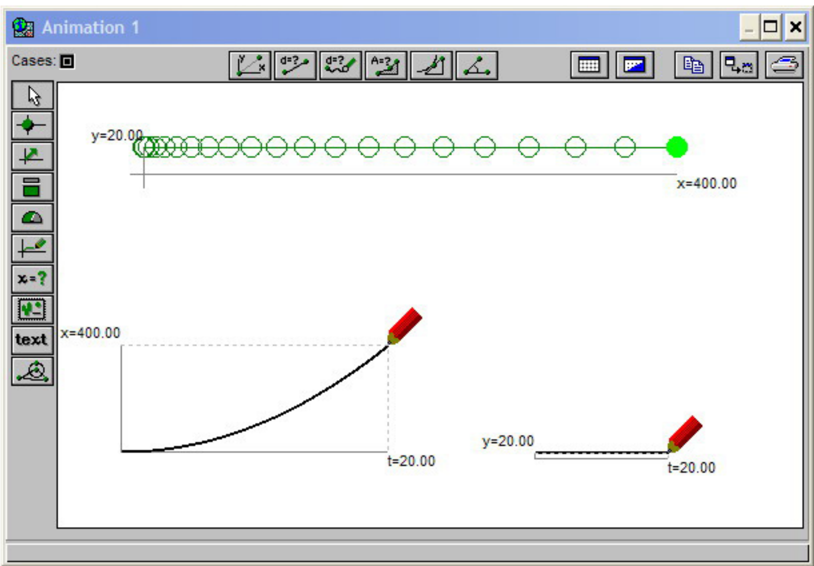
Exploring position-time graphs with quadratic functions (II)

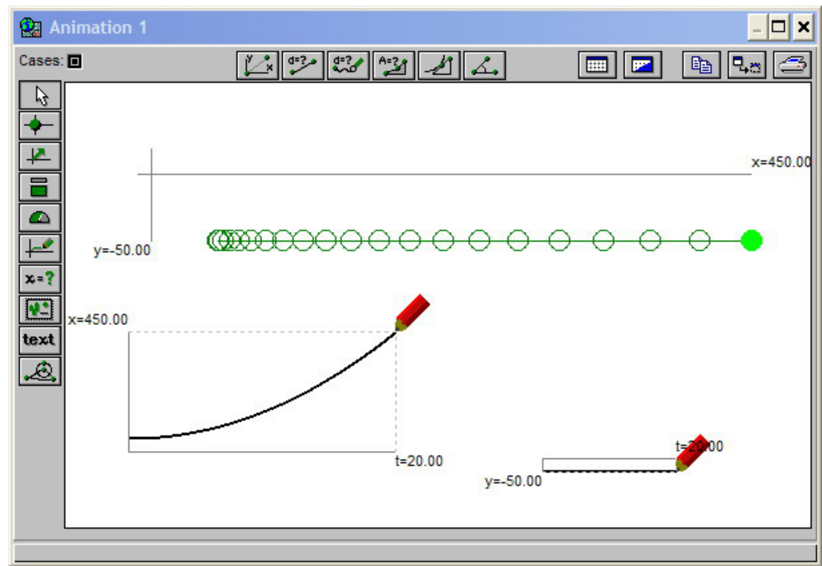
1. Change the model in order to obtain the following trajectories and graphs.

2. Analyse the functions, the trajectories and the graphs.





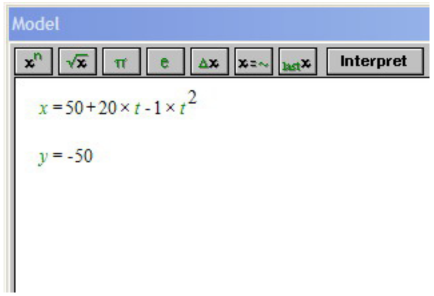


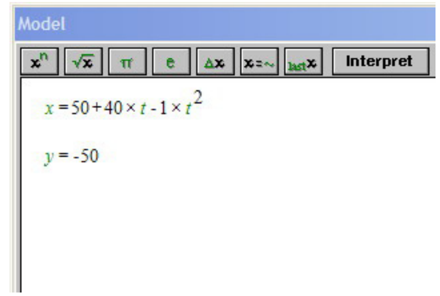


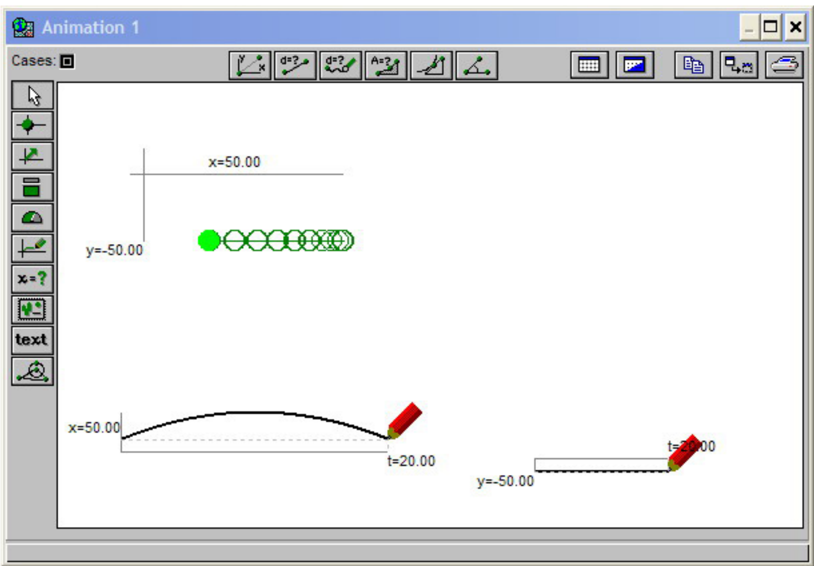
Exploring position-time graphs with quadratic functions (III)

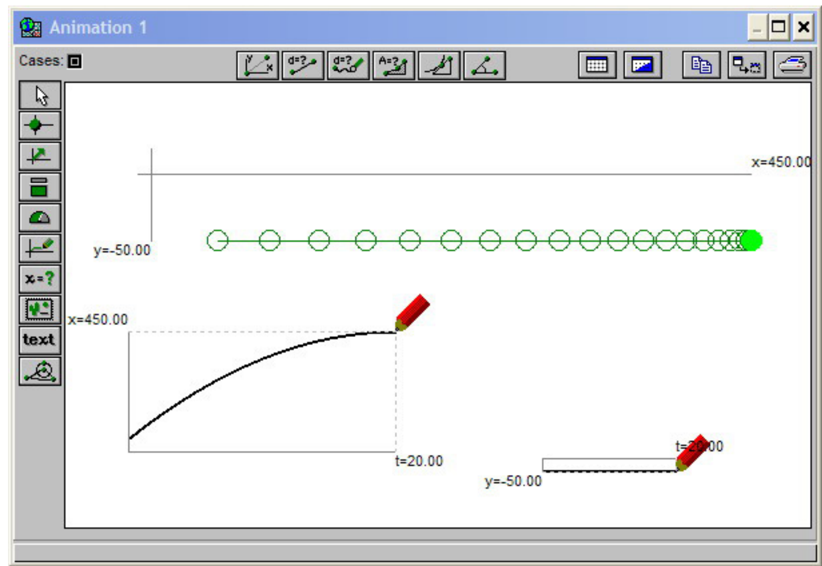
1. Change the model in order to obtain the following trajectories and graphs.

2. Analyse the functions, the trajectories and the graphs.







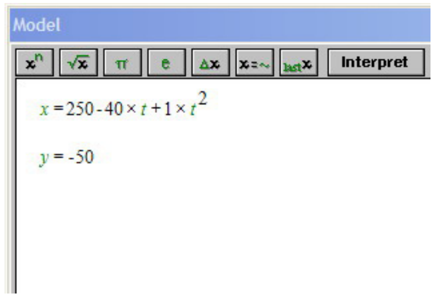


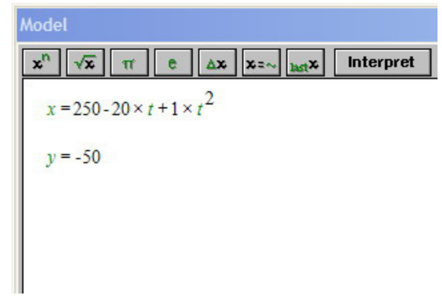
☐ OK ☐ I need to do this again... ☐ I need tutor support

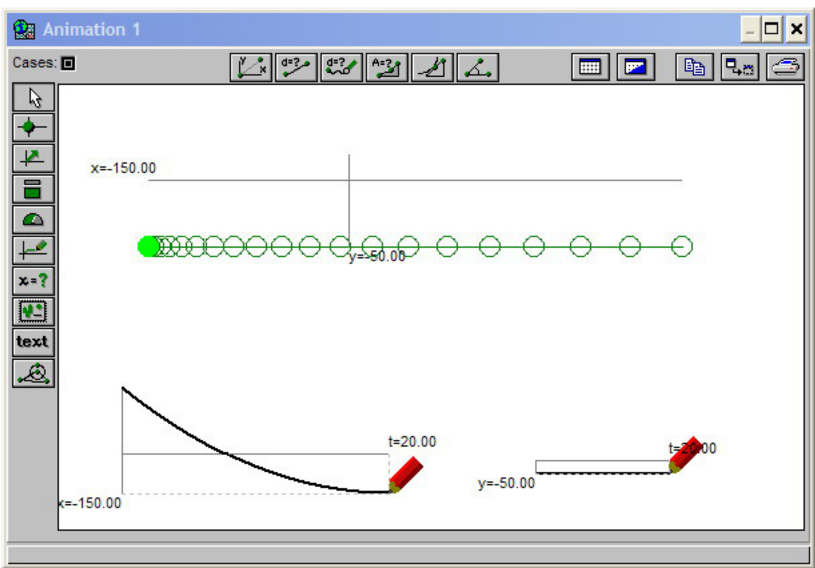
Exploring position-time graphs with quadratic functions (IV)

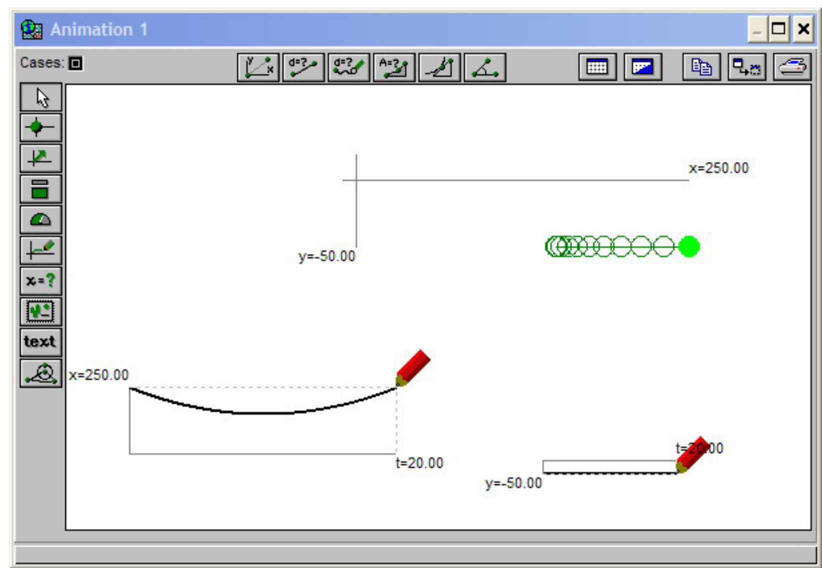
1. Change the model in order to obtain the following trajectories and graphs.

2. Analyse the functions, the trajectories and the graphs.





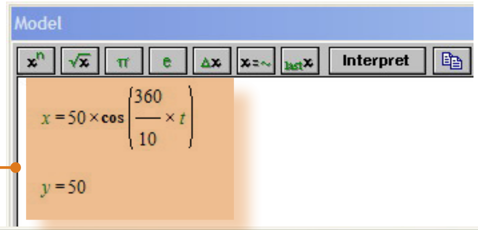




☐ OK ☐ I need to do this again... ☐ I need tutor support

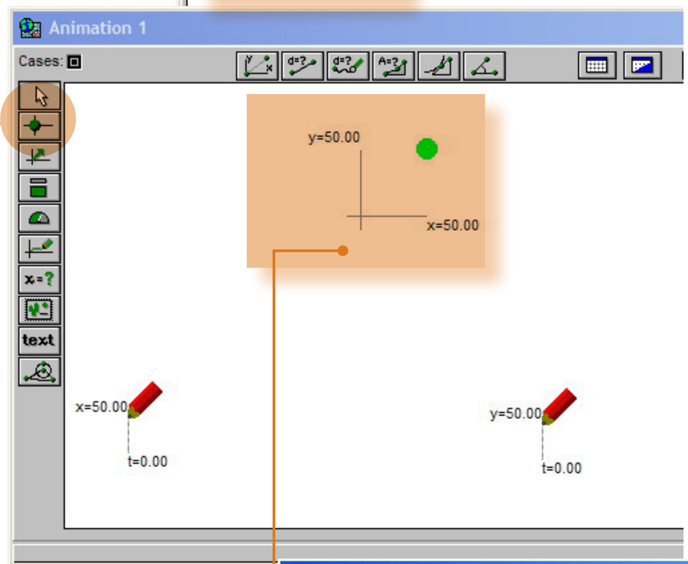
Exploring position-time graphs with sinusoidal functions (I)

1. Run Modellus or create a New Model (menu File / New).



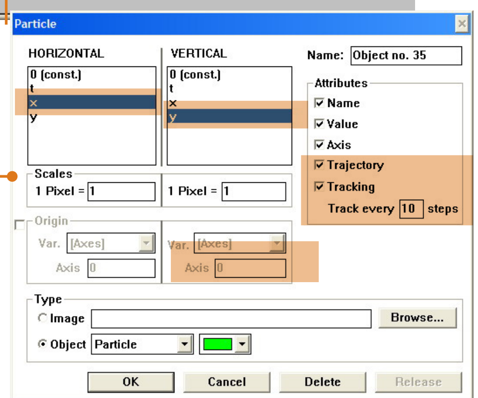
2. Write the following functions on the Model Window.

3. Press the Interpret button on the Model Window.



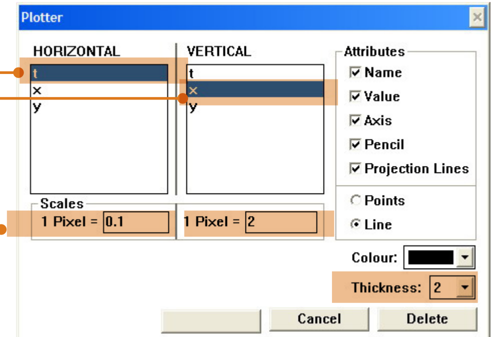
4. Create a particle on the Animation Window using the Create Particle button.

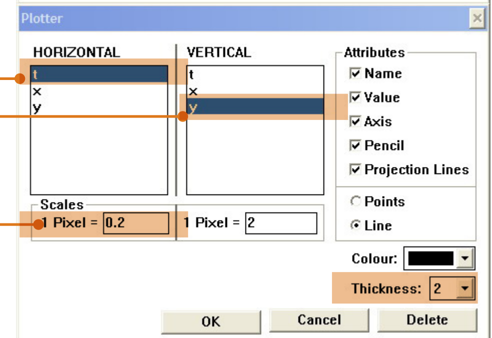
5. Give the following properties to the particle:



6. Create two graphs on the Animation Window using the Create New Plotter button.

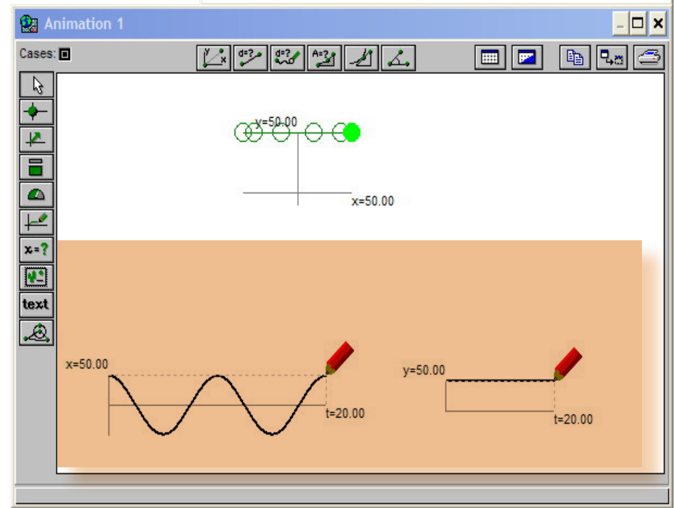
7. Give the following properties to the plotters:





8. Run the Model using the Start Button.

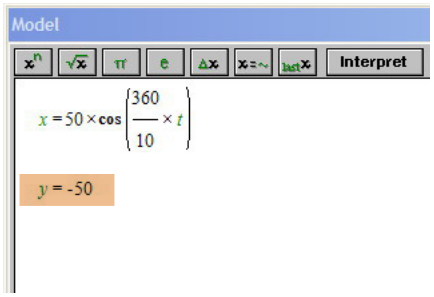
9. Analyse the trajectory and the graphs. Do the graphs make sense? Explain your reasoning.

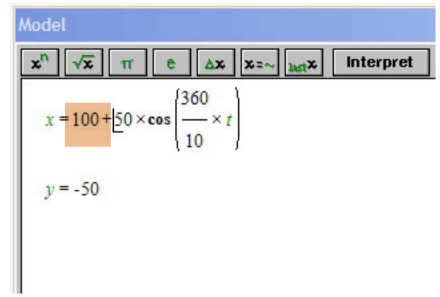


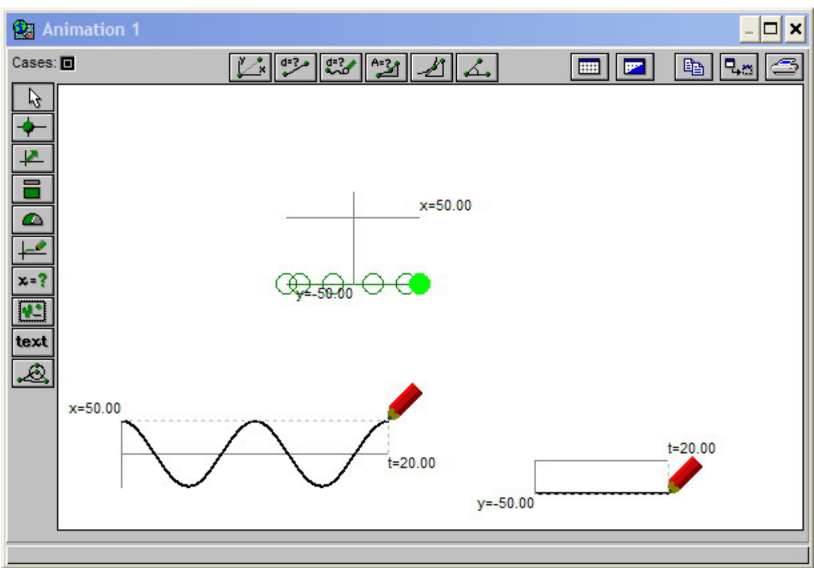
Exploring position-time graphs with sinusoidal functions (II)

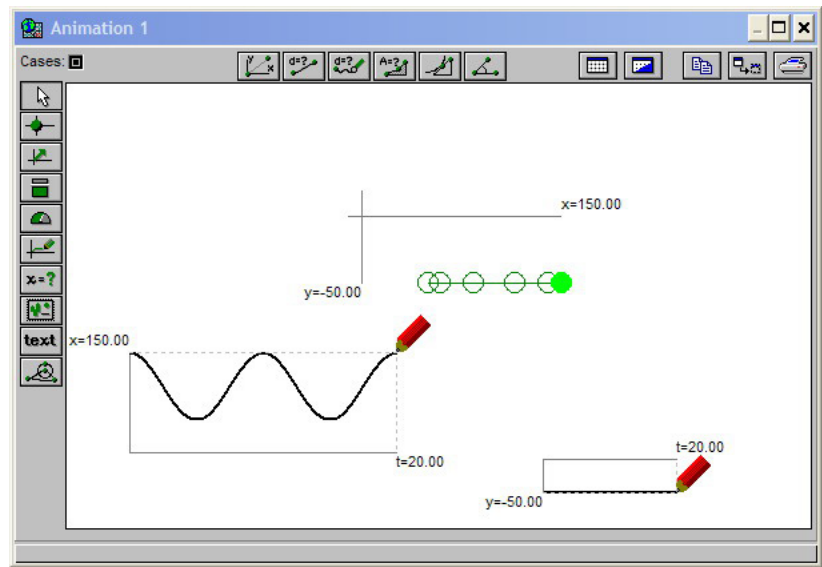
1. Change the model in order to obtain the following trajectories and graphs.

2. Analyse the functions, the trajectories and the graphs.





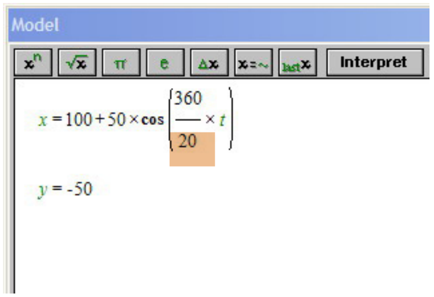


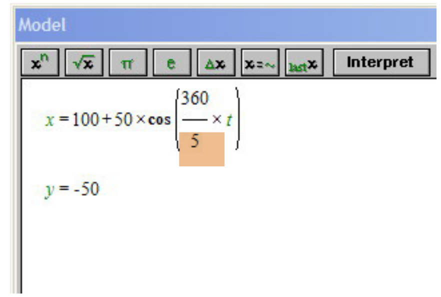


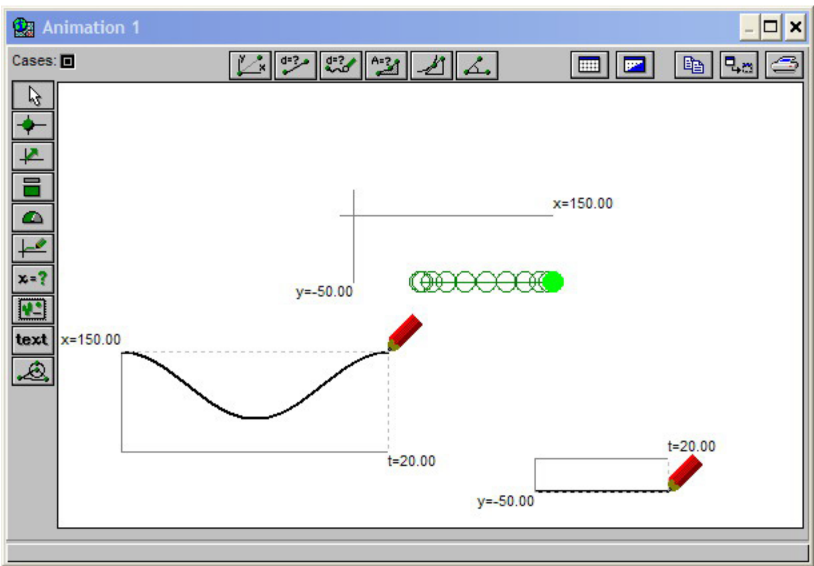
Exploring position-time graphs with sinusoidal functions (III)

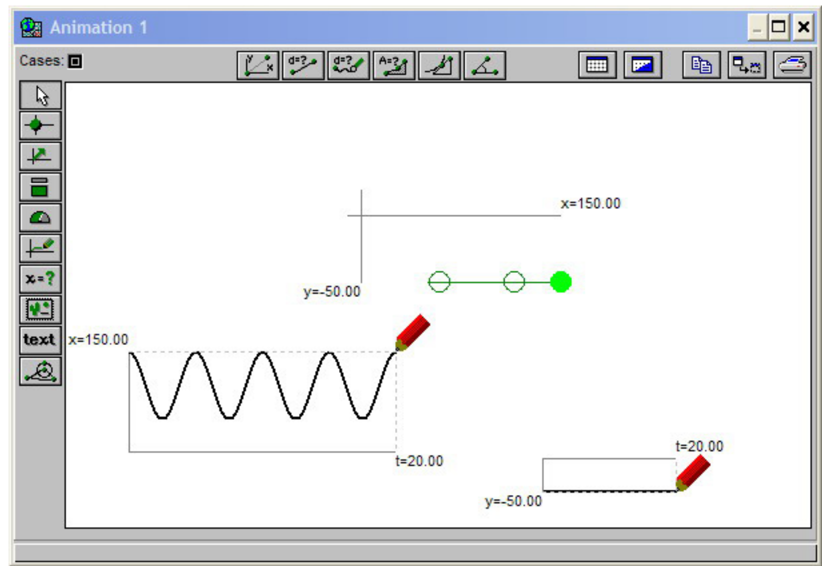
1. Change the model in order to obtain the following trajectories and graphs.

2. Analyse the functions, the trajectories and the graphs.





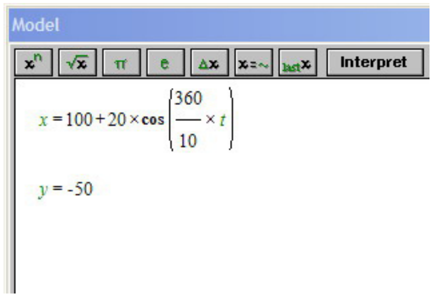


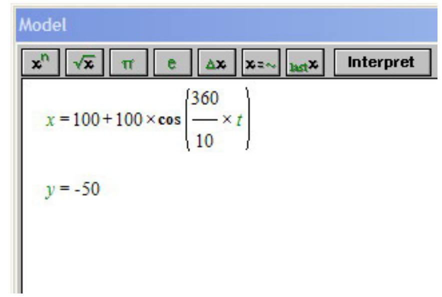


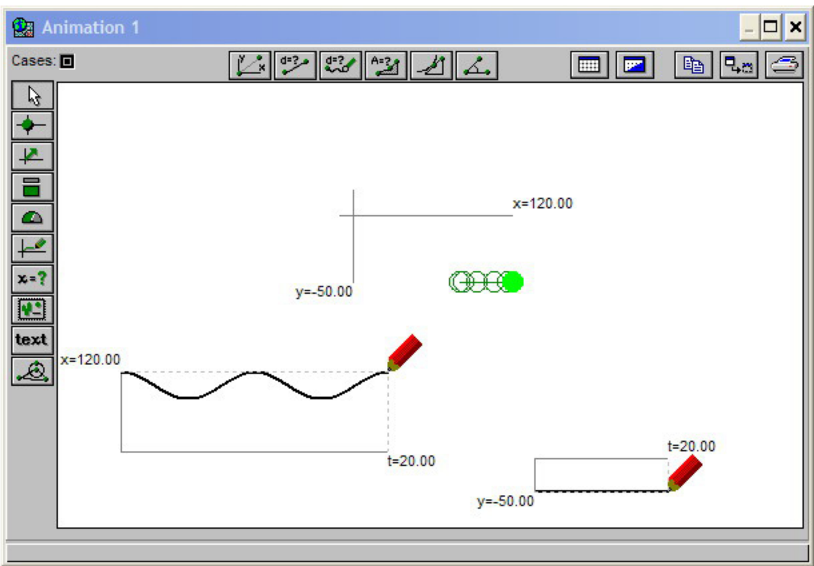
Exploring position-time graphs with sinusoidal functions (IV)

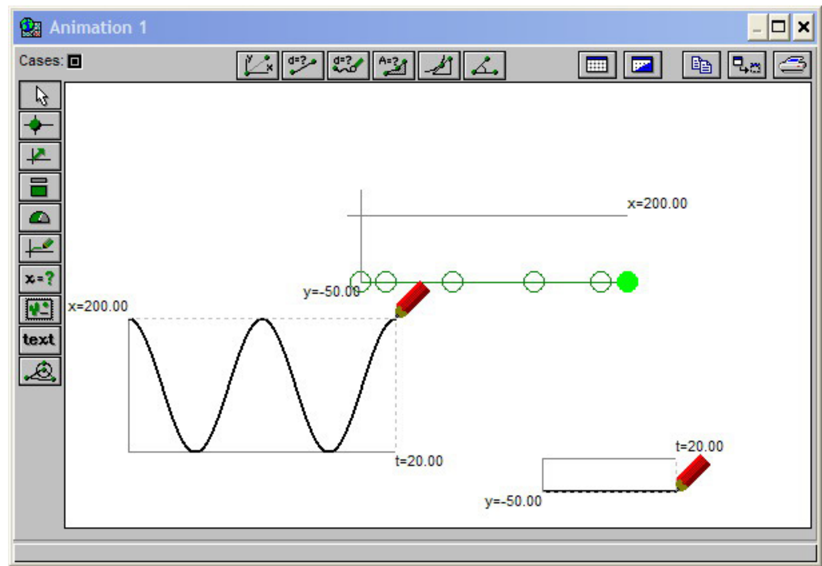
1. Change the model in order to obtain the following trajectories and graphs.

2. Analyse the functions, the trajectories and the graphs.



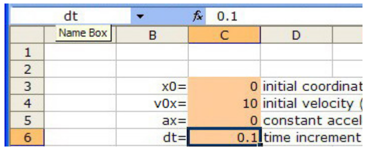






Using Excel to explore position-time graphs (I)

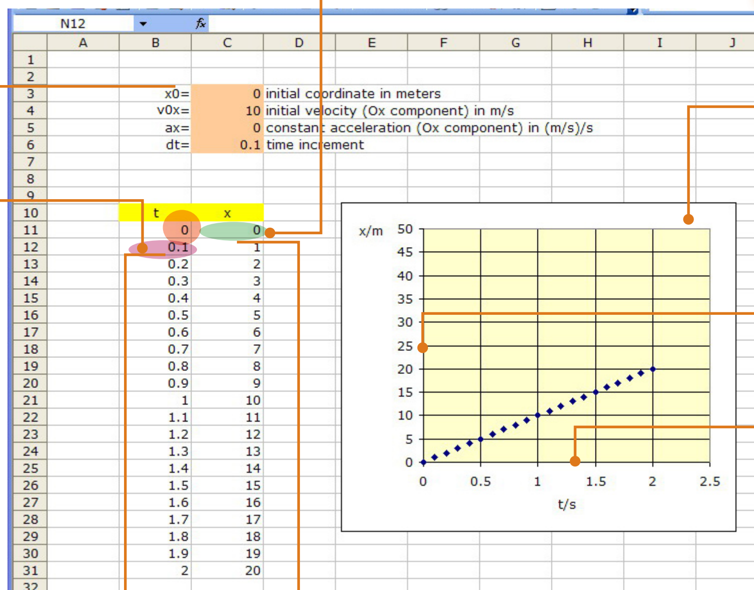
TIPS: *To define a name on a cell, such as dt for cell C6, place the cursor on the cell and write dt (the name) on the name box. Define also cells C3 and C4 as x0 and y0, the initial values of the coordinates.*



=x0+v0x*B11+(1/2)*ax*B11^2

Function used:

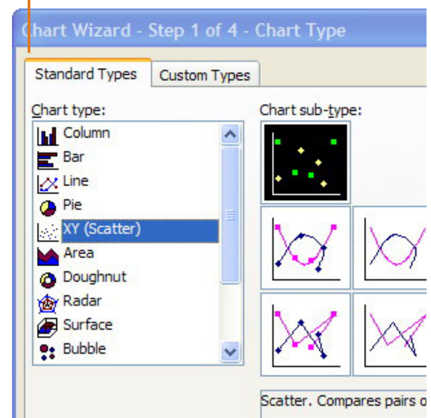
$$x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$$

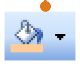


=B11+dt

Time t has a step of dt, defined on cell C2.

This is a scatter graph: one numerical variable versus another numerical variable (y versus x, in this case)

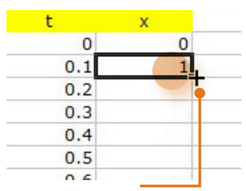




TIP: *Paint the cells that are independent from other cells and are used to give values to independent variables or parameters.*

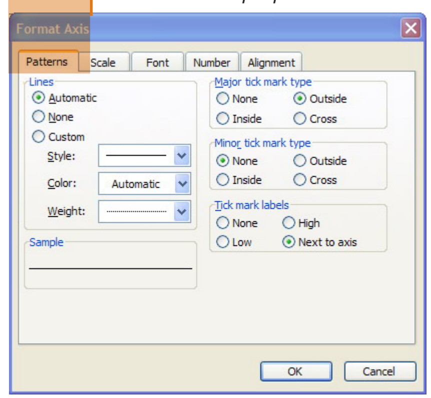
copy this cell down...

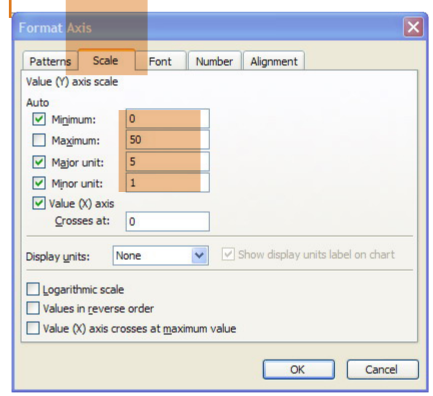
copy this cell down...



TIP: *to copy a cell down, place the mouse on the right down side of the cell and drag it*

TIP: *click on each axis to define its properties*



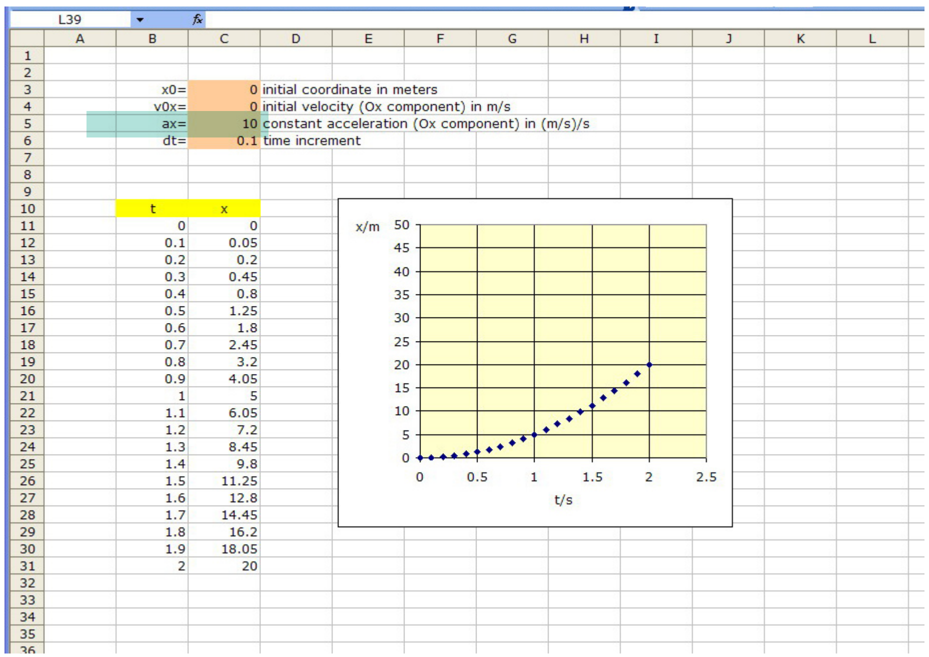


 ☐ OK ☐ I need to do this again... ☐ I need tutor support

Using Excel to explore position-time graphs (II)

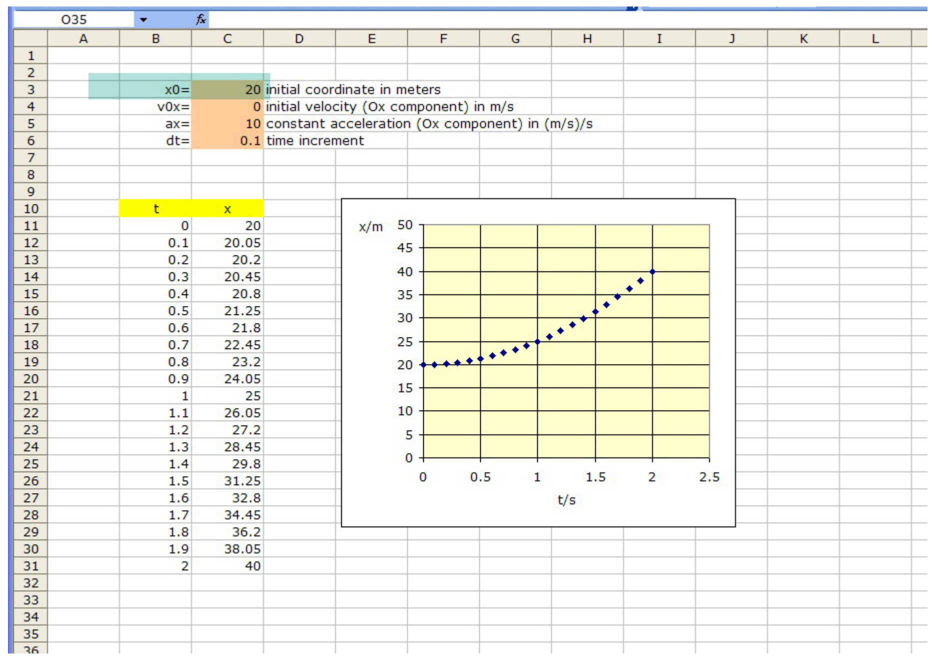
1. Change the model in order to obtain the following graphs.

2. Analyse the functions, the trajectories and the graphs.



x0=	0	initial coordinate in meters
v0x=	0	initial velocity (Ox component) in m/s
ax=	10	constant acceleration (Ox component) in (m/s)/s
dt=	0.1	time increment

t	x
0	0
0.1	0.05
0.2	0.2
0.3	0.45
0.4	0.8
0.5	1.25
0.6	1.8
0.7	2.45
0.8	3.2
0.9	4.05
1	5
1.1	6.05
1.2	7.2
1.3	8.45
1.4	9.8
1.5	11.25
1.6	12.8
1.7	14.45
1.8	16.2
1.9	18.05
2	20



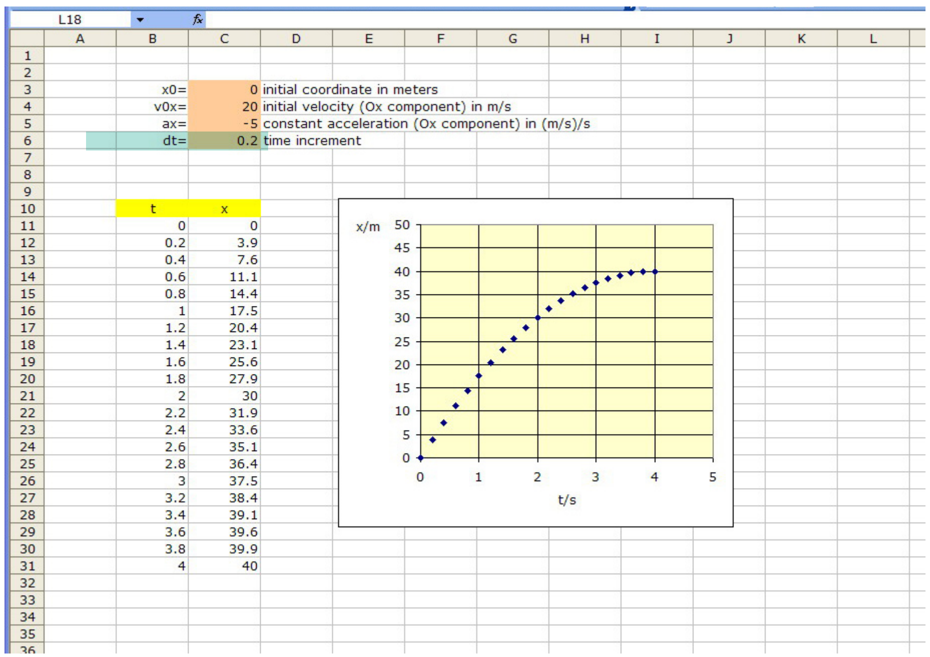
x0=	20	initial coordinate in meters
v0x=	0	initial velocity (Ox component) in m/s
ax=	10	constant acceleration (Ox component) in (m/s)/s
dt=	0.1	time increment

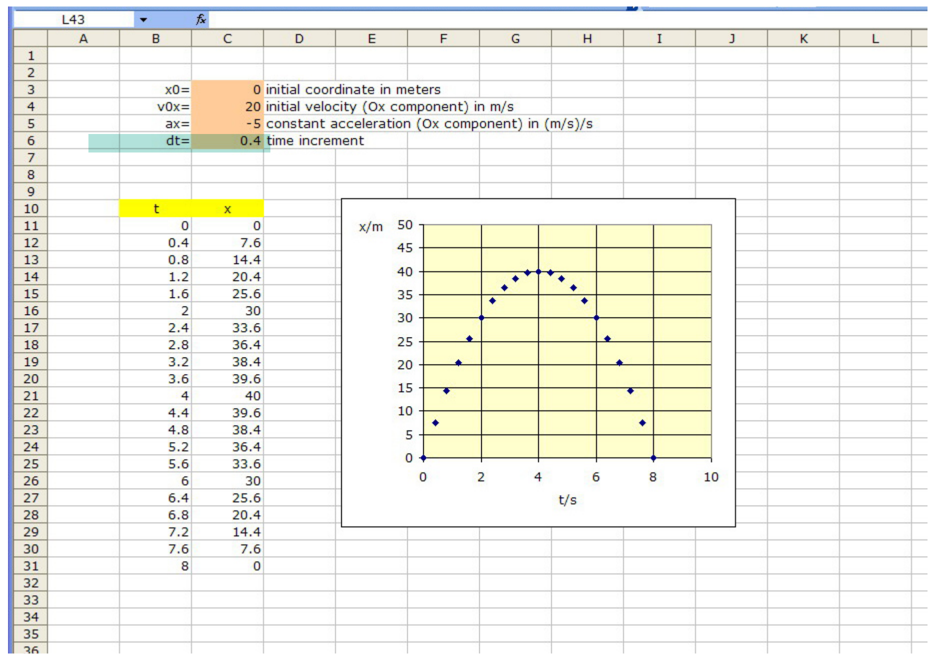
t	x
0	20
0.1	20.05
0.2	20.2
0.3	20.45
0.4	20.8
0.5	21.25
0.6	21.8
0.7	22.45
0.8	23.2
0.9	24.05
1	25
1.1	26.05
1.2	27.2
1.3	28.45
1.4	29.8
1.5	31.25
1.6	32.8
1.7	34.45
1.8	36.2
1.9	38.05
2	40

Using Excel to explore position-time graphs (III)

1. Change the model in order to obtain the following graphs.

2. Analyse the functions, the trajectories and the graphs.





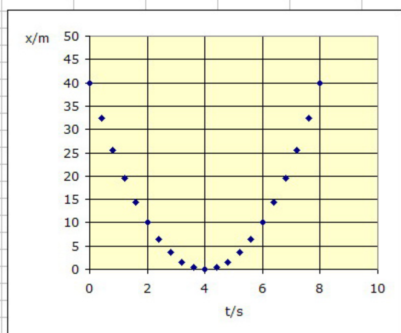
Using Excel to explore position-time graphs (IV)

1. Change the model in order to obtain the following graphs.

2. Analyse the functions, the trajectories and the graphs.

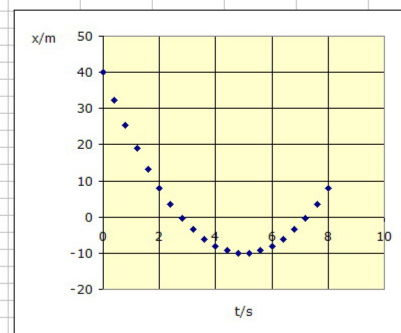
x0=	40 initial coordinate in meters
v0x=	-20 initial velocity (Ox component) in m/s
ax=	5 constant acceleration (Ox component) in (m/s)/s
dt=	0.4 time increment

t	x
0	40
0.4	32.4
0.8	25.6
1.2	19.6
1.6	14.4
2	10
2.4	6.4
2.8	3.6
3.2	1.6
3.6	0.4
4	0
4.4	0.4
4.8	1.6
5.2	3.6
5.6	6.4
6	10
6.4	14.4
6.8	19.6
7.2	25.6
7.6	32.4
8	40



x0=	40 initial coordinate in meters
v0x=	-20 initial velocity (Ox component) in m/s
ax=	4 constant acceleration (Ox component) in (m/s)/s
dt=	0.4 time increment

t	x
0	40
0.4	32.32
0.8	25.28
1.2	18.88
1.6	13.12
2	8
2.4	3.52
2.8	-0.32
3.2	-3.52
3.6	-6.08
4	-8
4.4	-9.28
4.8	-9.92
5.2	-9.92
5.6	-9.28
6	-8
6.4	-6.08
6.8	-3.52
7.2	-0.32
7.6	3.52
8	8



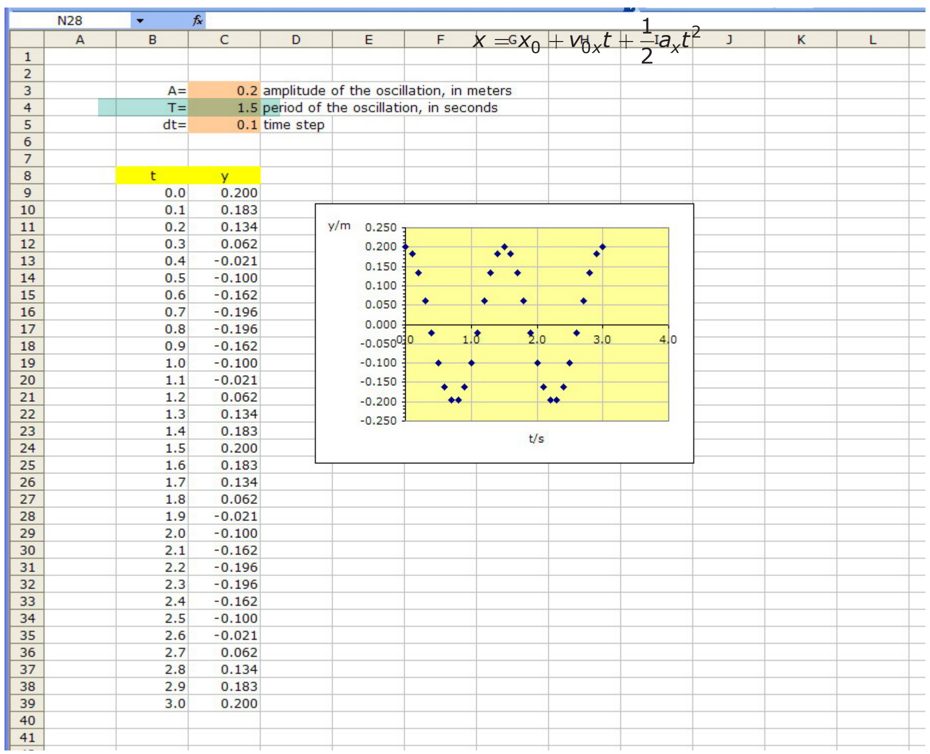
☐ OK ☐ I need to do this again... ☐ I need tutor support

Using Excel to explore position-time graphs (V)

1. Create the graph of a sinusoidal function that describes the coordinate of a vertical oscillator, as explained below.

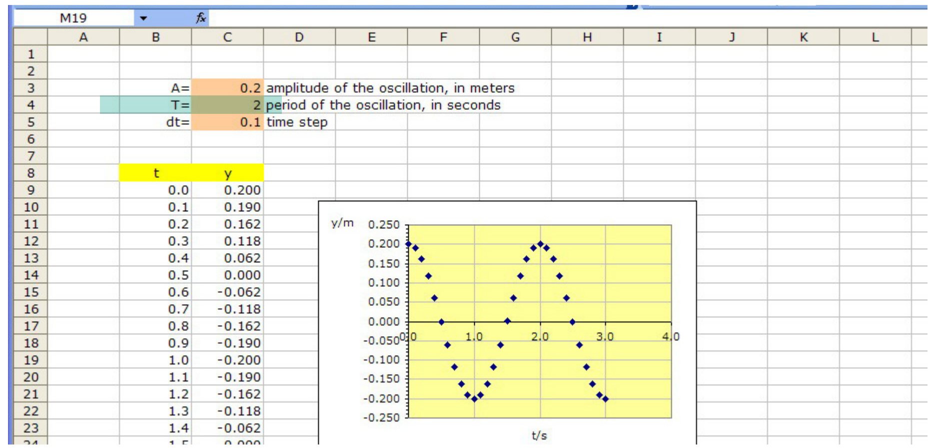
$$y = A\cos\left(\frac{2\pi}{T}t\right)$$

2. Analyse how changing the values of the parameters amplitude *A* and period *T* affects the graphs.



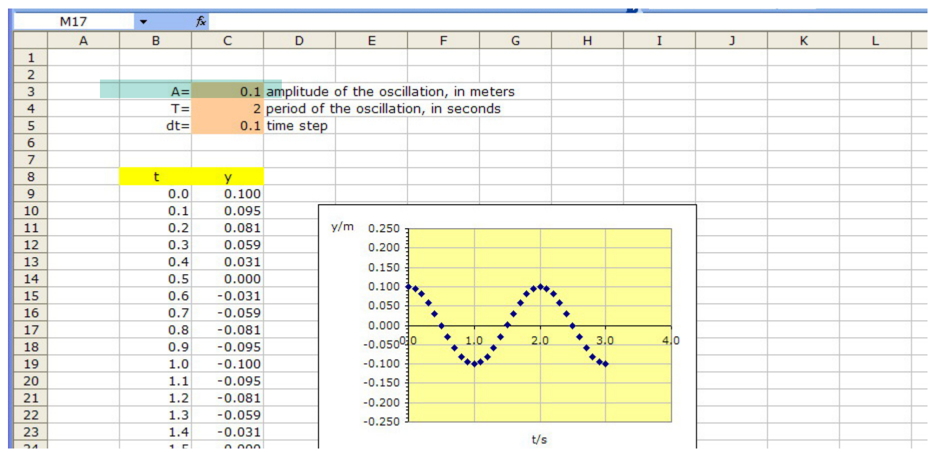
A=	0.2 amplitude of the oscillation, in meters
T=	1.5 period of the oscillation, in seconds
dt=	0.1 time step

t	y
0.0	0.200
0.1	0.183
0.2	0.134
0.3	0.062
0.4	-0.021
0.5	-0.100
0.6	-0.162
0.7	-0.196
0.8	-0.196
0.9	-0.162
1.0	-0.100
1.1	-0.021
1.2	0.062
1.3	0.134
1.4	0.183
1.5	0.200
1.6	0.183
1.7	0.134
1.8	0.062
1.9	-0.021
2.0	-0.100
2.1	-0.162
2.2	-0.196
2.3	-0.196
2.4	-0.162
2.5	-0.100
2.6	-0.021
2.7	0.062
2.8	0.134
2.9	0.183
3.0	0.200



A=	0.2 amplitude of the oscillation, in meters
T=	2 period of the oscillation, in seconds
dt=	0.1 time step

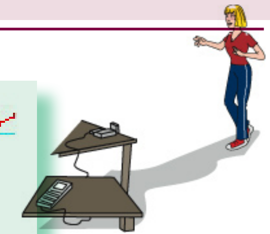
t	y
0.0	0.200
0.1	0.190
0.2	0.162
0.3	0.118
0.4	0.062
0.5	0.000
0.6	-0.062
0.7	-0.118
0.8	-0.162
0.9	-0.190
1.0	-0.200
1.1	-0.190
1.2	-0.162
1.3	-0.118
1.4	-0.062



A=	0.1 amplitude of the oscillation, in meters
T=	2 period of the oscillation, in seconds
dt=	0.1 time step

t	y
0.0	0.100
0.1	0.095
0.2	0.081
0.3	0.059
0.4	0.031
0.5	0.000
0.6	-0.031
0.7	-0.059
0.8	-0.081
0.9	-0.095
1.0	-0.100
1.1	-0.095
1.2	-0.081
1.3	-0.059
1.4	-0.031

Analysing a position-time graph obtained with a motion sensor (I)

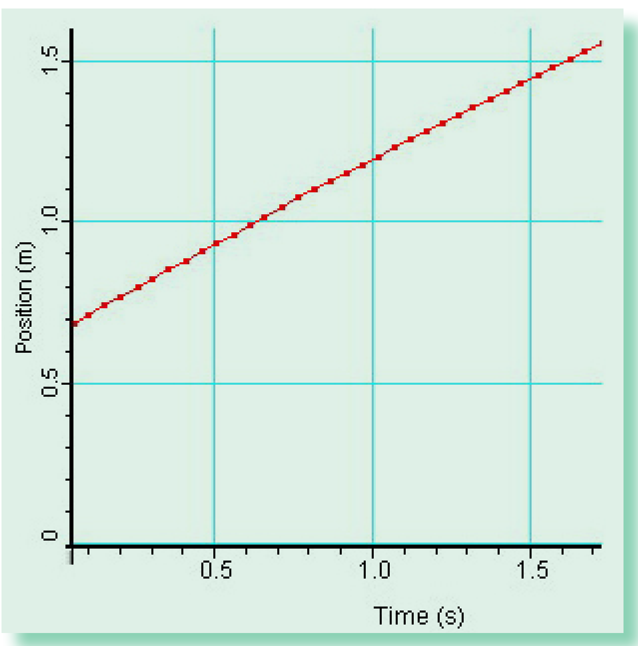


1. A motion sensor can measure distance to a sensor using ultrasound (a sound non-audible by the human hear).

2. The image below shows a graph of the distance to the sensor of a person, as a function of time.

3. At time = 0 s, how far was the person from the motion sensor?

4. At time = 1.5 s, how far was the person from the motion sensor?



5. How long took the person be at 0.5 m from from the motion sensor?

6. How long took the person be at 1.5 m from from the motion sensor?

7. After 1.5 s, what was the distance travelled by the person?

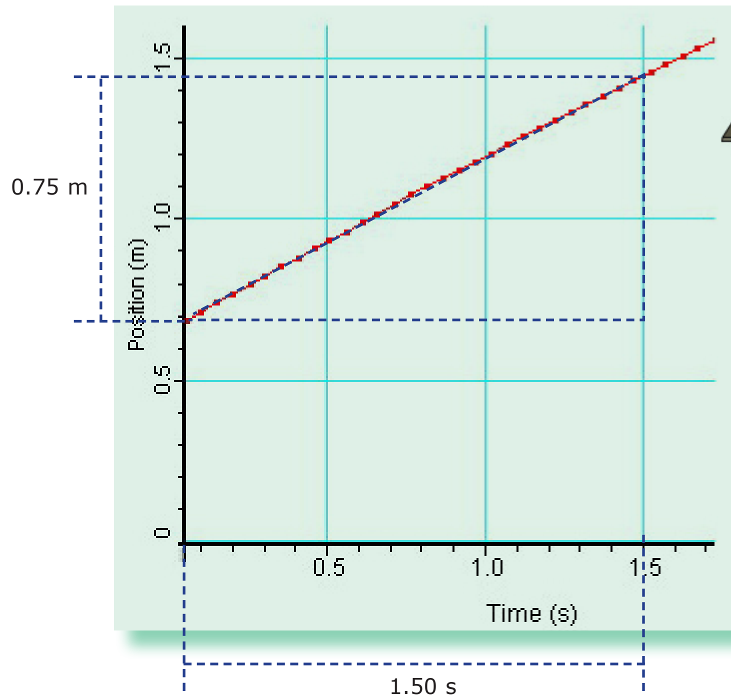
8. The velocity points do the sensor or away from the sensor? Explain you reasoning.

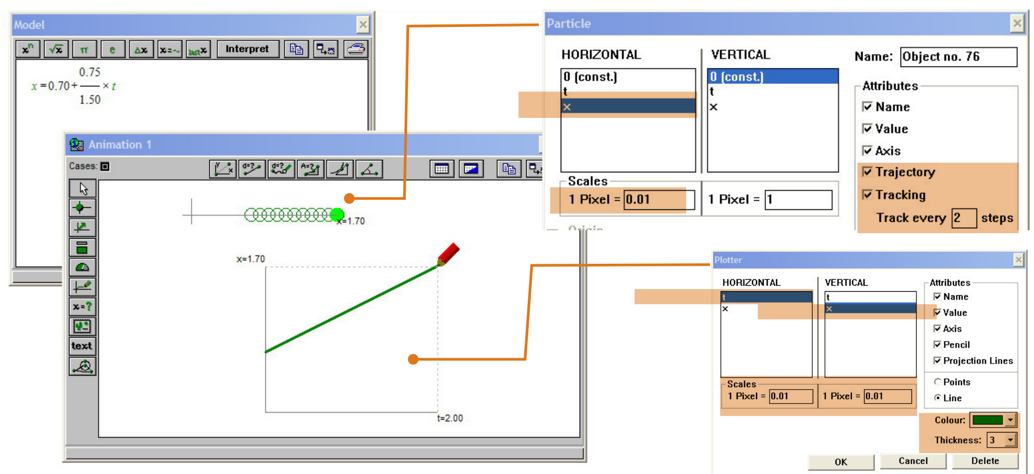
9. The much is the speed of the person?

10. Is this speed constant? Why?

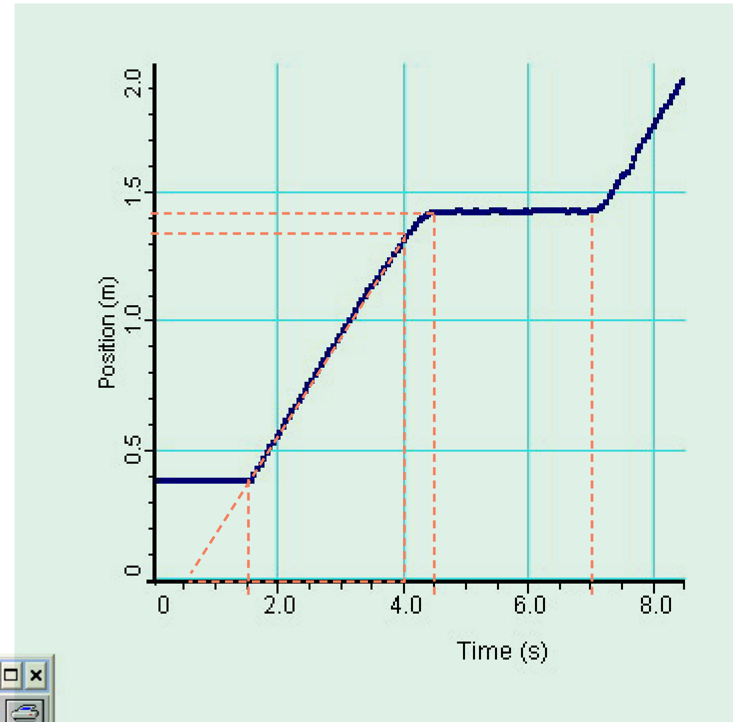
11. Create the Modellus model on the right and analyse it.

12. How different could the model be if the person was approaching the motion sensor?





Analysing a position-time graph obtained with a motion sensor (II)



1. The image on the right shows a graph of the distance to the sensor of a person, as a function of time.

2. At time = 0 s, how far was the person from the motion sensor?

3. At time = 1.0 s, how far was the person from the motion sensor?

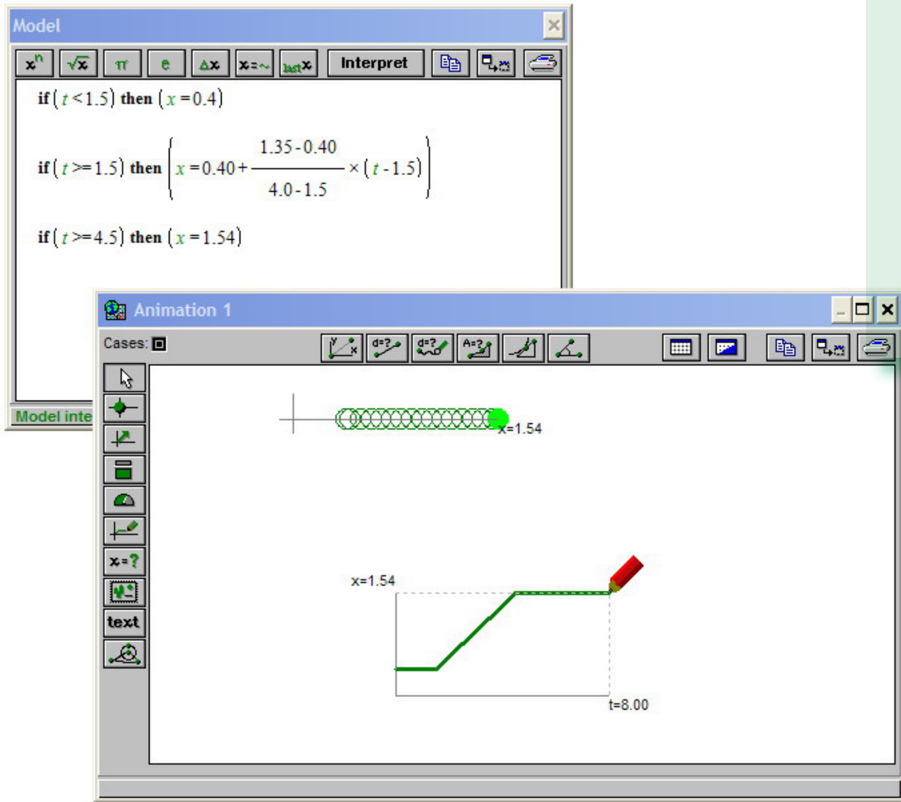
4. How long took the person to start moving? Explain your reasoning.

5. How fast was the person moving at time = 3.0 s? Explain your reasoning.

6. How fast was the person moving at time = 6.0 s? Explain your reasoning.

7. Create the Modellus model on the right and analyse it.

8. How can it be changed in order to make it more comparable with the true motion of the person? Change the model and explore different possibilities...



Analysing a position-time graph obtained with a motion sensor (III)

1. The image on the right shows a graph of the distance to the sensor of a person, as a function of time.

2. At time = 0 s, how far was the person from the motion sensor?

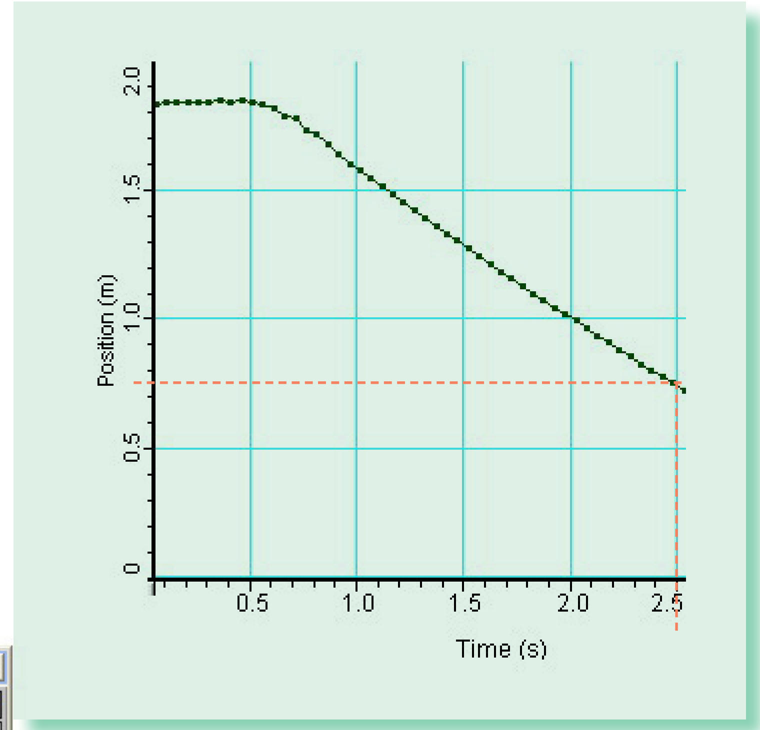
3. At time = 1.0 s, how far was the person from the motion sensor?

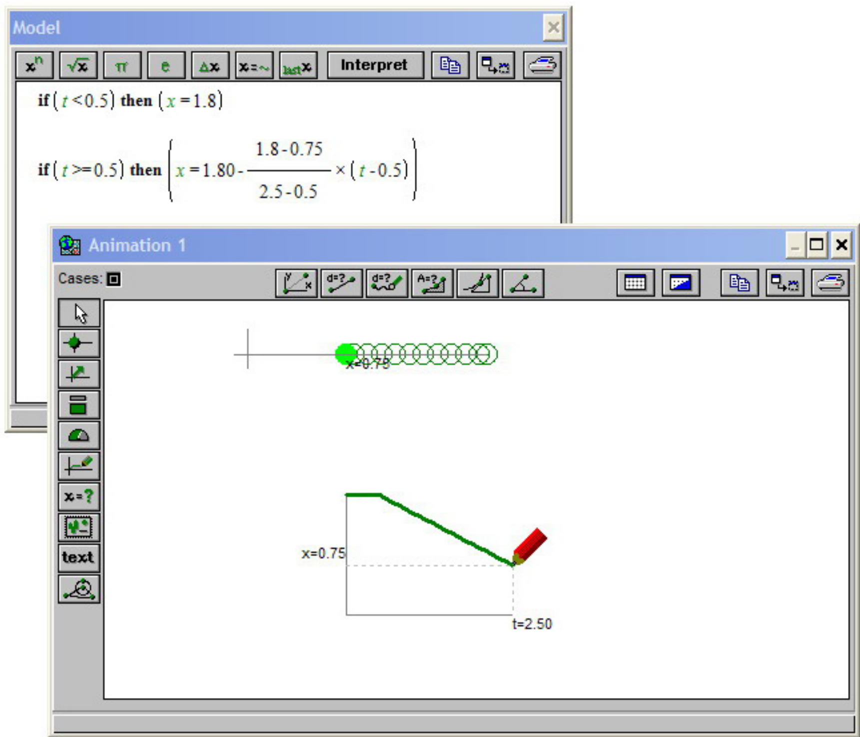
4. How long took the person to start moving? Explain your reasoning.

5. How fast was the person moving at time = 2.0 s? Explain your reasoning.

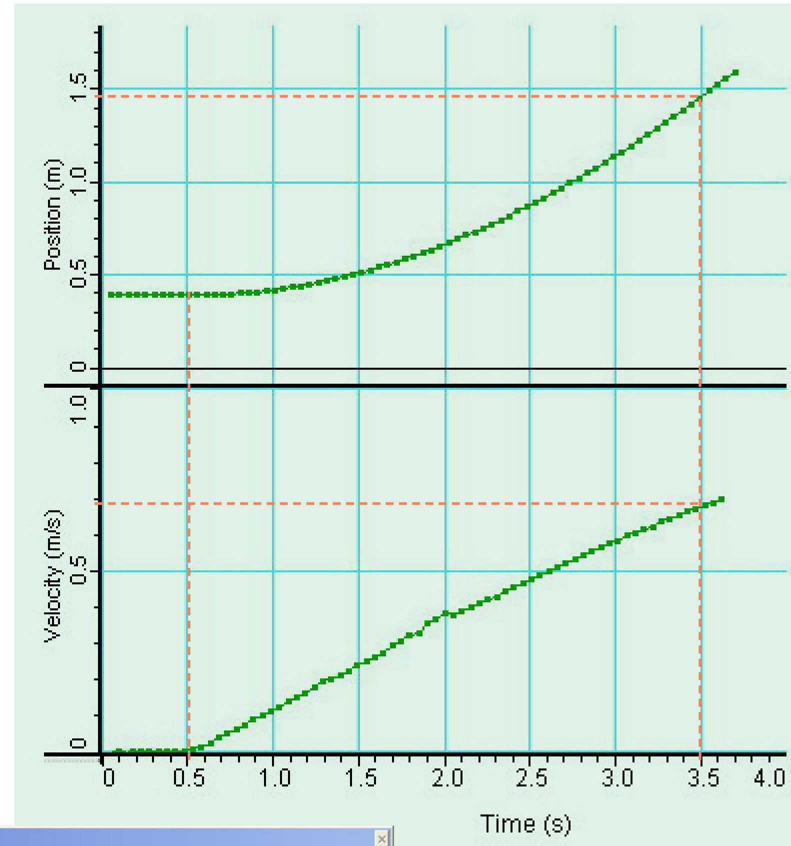
6. Create the Modellus model on the right and analyse it.

7. How can it be changed in order to make a model of a person that moves away from the motion sensor, with the same speed and starting from the same position? Check your ideas changing the model.





Analysing a position-time graph obtained with a motion sensor (IV)



1. The image on the right shows two graphs of a small car (**distance to the sensor** and **scalar component of velocity** as functions of time). The car has a fixed fan that can apply an almost constant force.

2. At time = 0 s, how far was the car from the motion sensor? With what velocity was it moving?

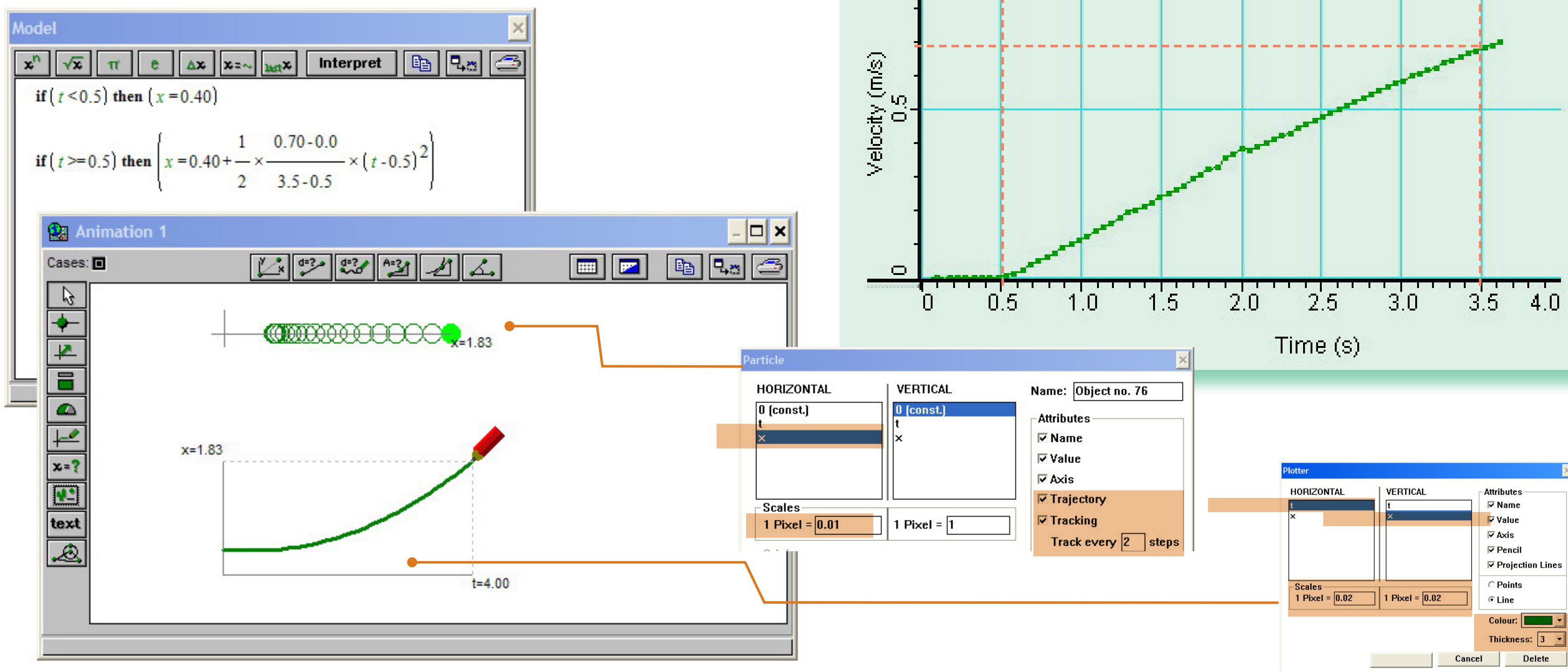
3. At time = 2.5 s, how far was the car from the motion sensor? With what velocity was it moving?

4. How long took the car to start moving? Explain your reasoning.

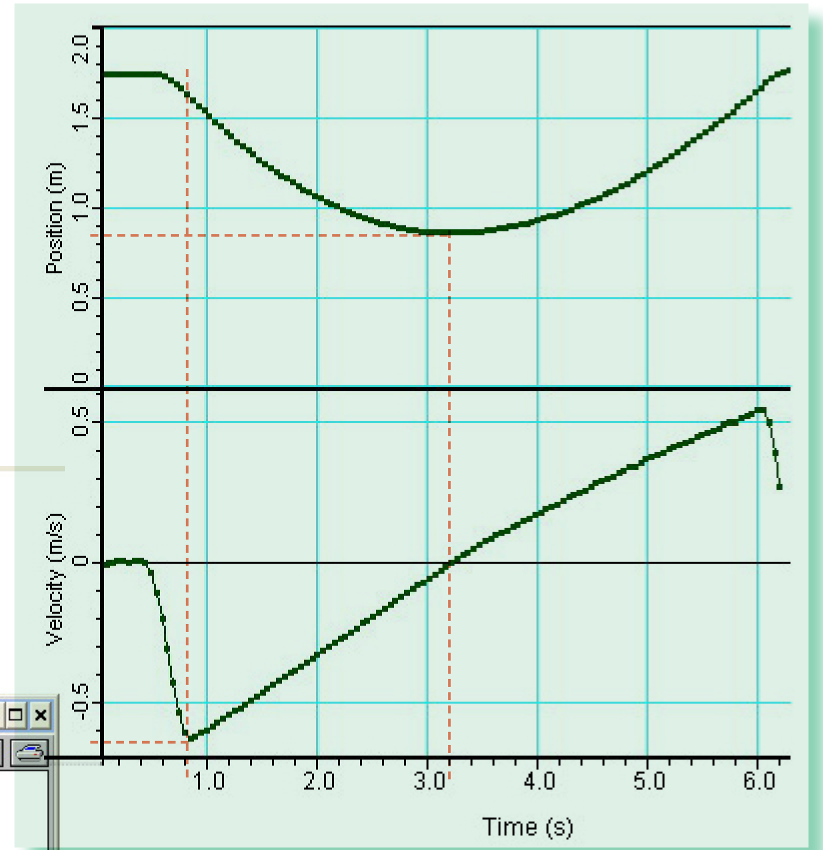
5. How fast was the car moving at time = 2.0 s? Explain your reasoning.

6. How fast was the car accelerating at time = 2.0 s? Explain your reasoning.

7. Create the Modellus model on the right and analyse it.



Analysing a position-time graph obtained with a motion sensor (V)



1. The image on the right shows two graphs of a small car (**distance to the sensor** and **scalar component of velocity** as functions of time). The car has a fixed fan that can apply an almost constant force.

2. At time = 0 s, how far was the car from the motion sensor? With what velocity was it moving?

3. At time = 0.8 s what was the velocity of the car? In what direction was it moving?

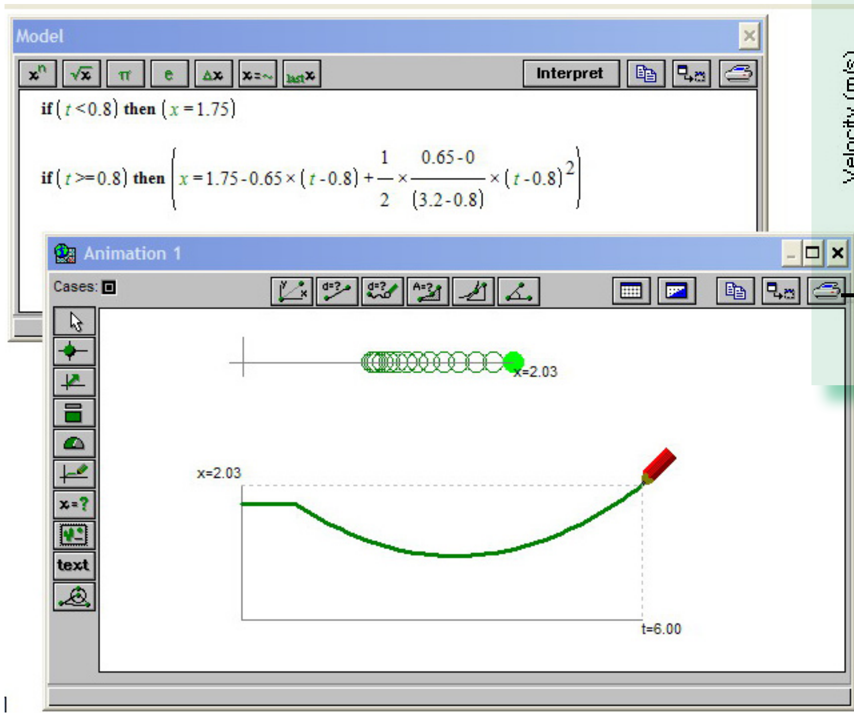
4. After time = 0.8 s the car has an almost constant acceleration. Check that (0.65-0)/(3.2-0.8) = 0.271 meters per second per second is a reasonable value for its acceleration.

5. Between 0.8 s and 3.2 s the scalar component of the velocity of the car is approaching zero but after 3.2 s is increasing...

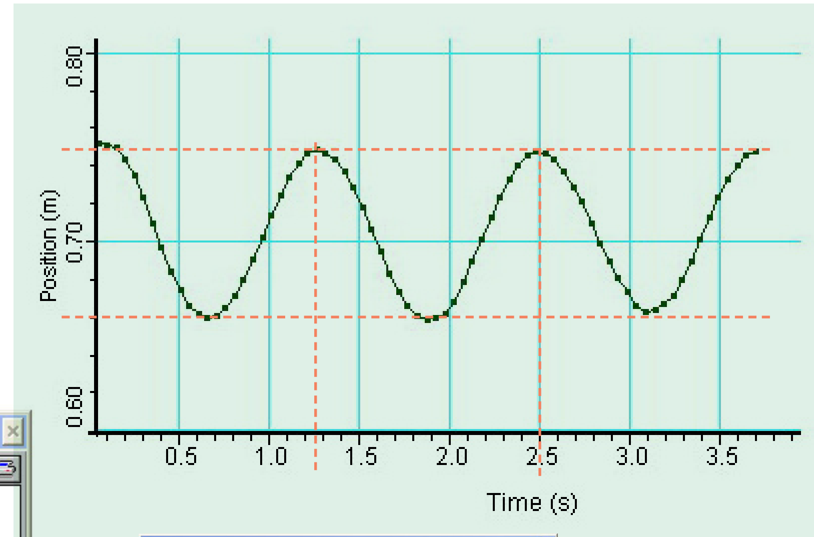
6. How fast was the car moving at time = 2.0 s? Explain your reasoning.

7. How fast was the car accelerating at time = 2.0 s? Explain your reasoning.

8. Create the Modellus model on the right and analyse it.



Analysing a position-time graph obtained with a motion sensor (VI)



1. The image on the right shows the graph of the distance to the sensor of a small object oscillating vertically in a spring, as a function of time.

2. How long is the period T of the oscillator? Explain your reasoning.

3. The amplitude A of the oscillation is (0.75-0.66)/2 = 0.045 m. Explain why this is a reasonable value for the amplitude.

4. The distance to the sensor can be described by any of the sinusoidal functions on the model below, using angular frequency in degrees per second. Explore these functions changing the parameters A and T.

5. To use angular frequency in radians per second it is necessary to select Radians on the Options... button on the Control bar and change 360 on the functions to 6.28 (2π).