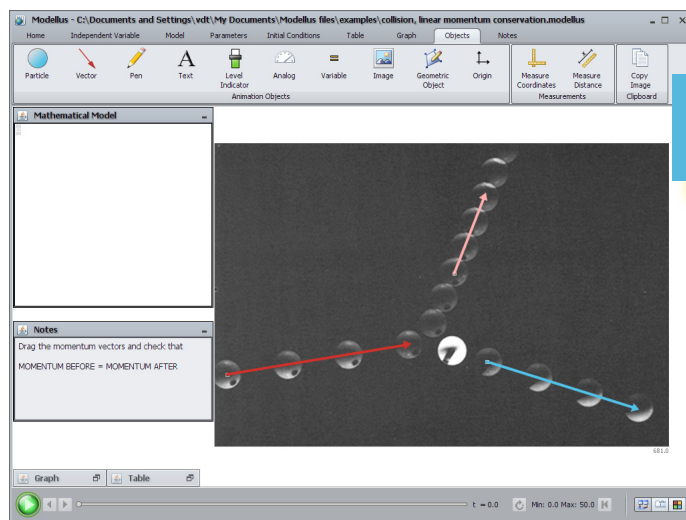
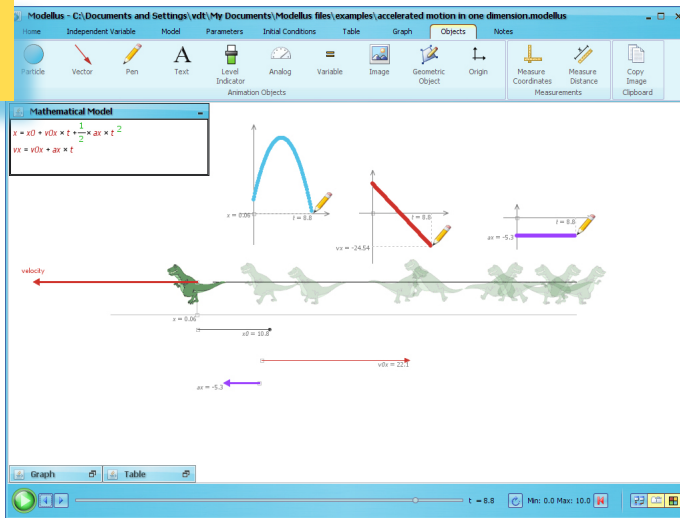


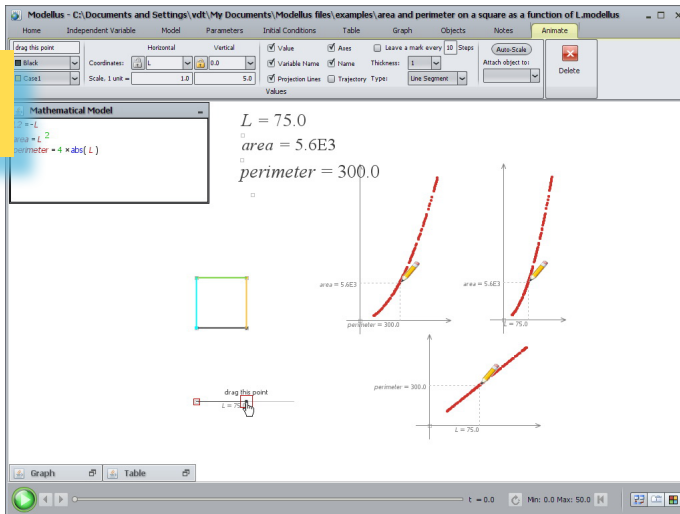


Four examples...

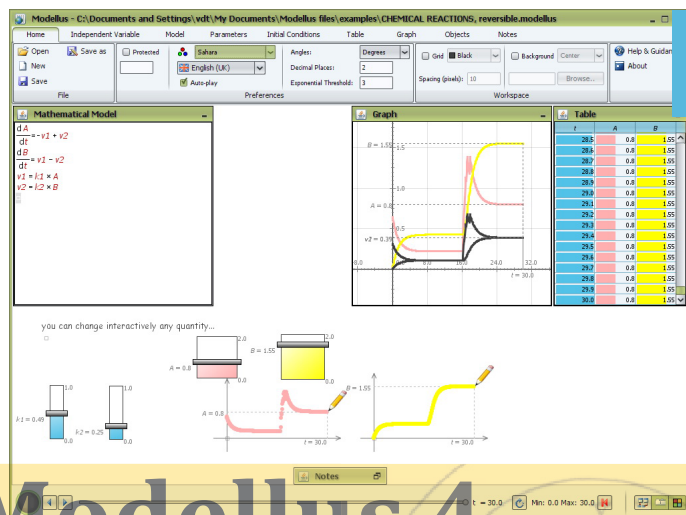
The Dino starts moving to the right with acceleration pointing to the left..
Before starting the motion, it is possible to define the initial position, the initial velocity and the acceleration, dragging the corresponding Vectors.
In the graphs drawn, the second graph represents the derivative of the first and the third graph represents the derivative of the second...



A stroboscopic photo of a collision was placed as a background in the workspace..
Three Vectors were created to measure, in an arbitrary scale, the linear momentum of each object, before and after the collision..
Dragging the Vectors it is easy to check the conservation of the linear momentum...



The side of a square was defined..
The area and the perimeter were calculated..
The square was represented by Geometrical Objects (Segments), which may be linked in succession..
Several Pens were created to represent relations between area and perimeter, etc..



A model was created using a system of ordinary differential equations (which represent the instantaneous rate of change of products and reactants...).
The model assumes plausible reaction velocities..
Several Level Indicators (Bars) and Pens were created to represent parameters and initial values..
Play / Pause executes the model..
Using the mouse it is possible to dynamically change the concentration values and observe how the system behaves when there is a change in the concentration of the chemical species...

Modellus 4

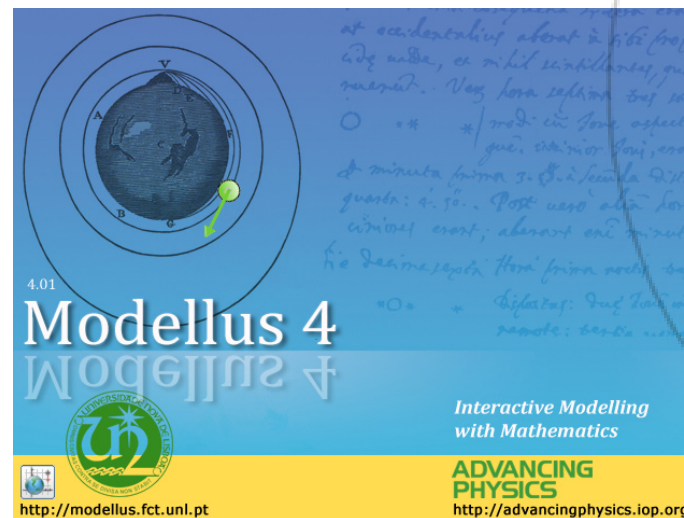
2008

<http://modellus.fct.unl.pt>



Interactive Modelling with Mathematics

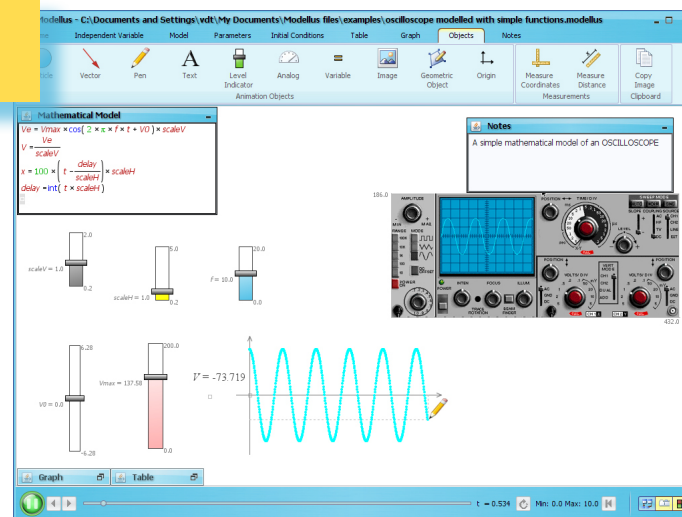
Modellus is designed to **introduce students and teachers in scientific computation**, namely through the analysis and exploration of mathematical models based on functions, iterations and differential equations. For example, it allows the construction and analysis of models illustrating Newton's reasoning when comparing the motion of a projectile and the motion of a satellite.



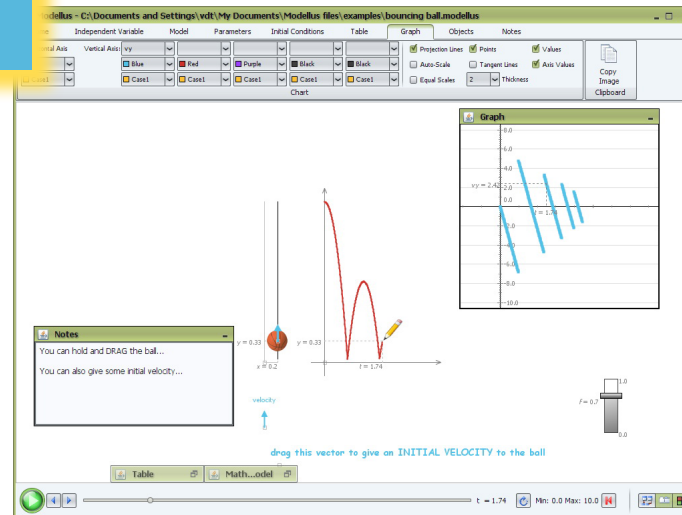
The development of Modellus 4 is being done with generous support from the Portuguese Ministry of Education (DGIDC), the Portuguese Foundation for Science and Technology (FCT), the European Community, the Institute of Physics (UK) and the research unit UIED-FCTUNL.

The Modellus installation program includes many examples and others are regularly added to the web site <http://modellus.fct.unl.pt>.
Besides the Modellus files, the web site also contains several documents for students and teachers from basic learning levels to higher education. These documents are regularly updated.

In the figure, an example that illustrates the use of sinusoidal functions in an oscilloscope. With this model it is possible to analyse the frequency, the amplitude and other aspects of periodic sinusoidal signals.



Model of the motion of a bouncing ball: the vertical trajectory of the ball and several graphs for physical quantities as functions of time may be visualised simultaneously. It is also possible to attribute a certain initial velocity to the ball and to study the ideal case when there is no energy dissipation.



1

How to build a model?

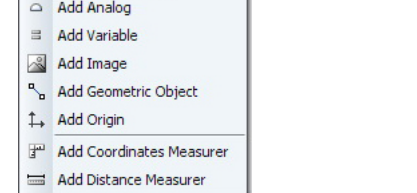
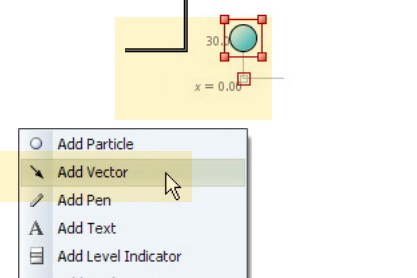
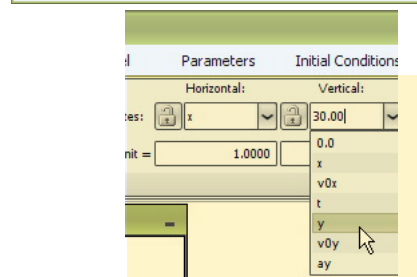
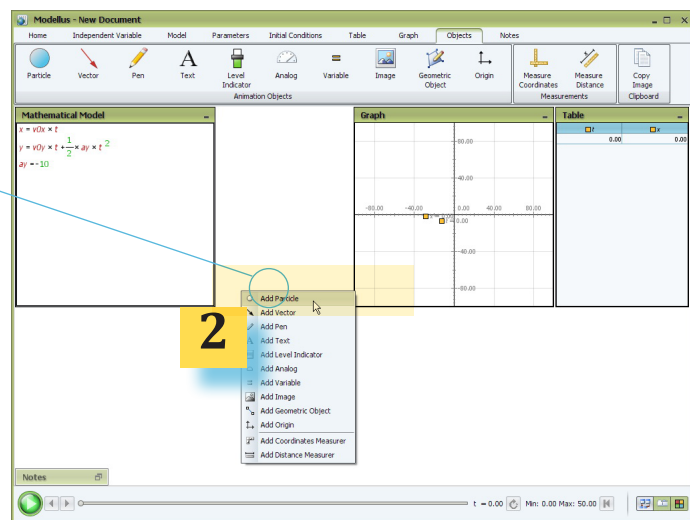
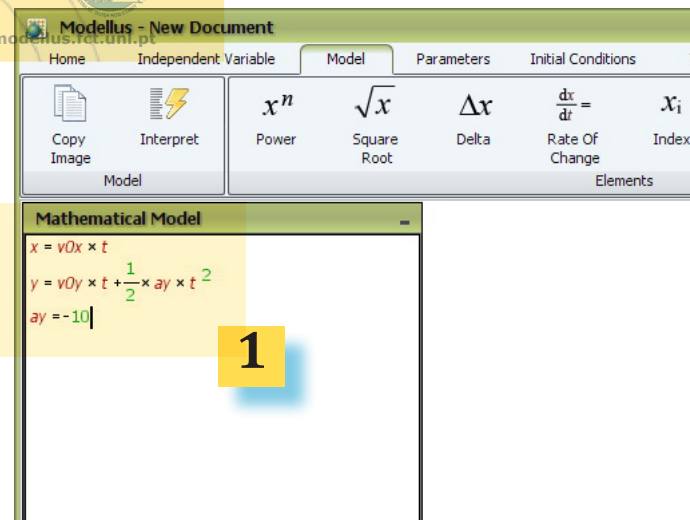
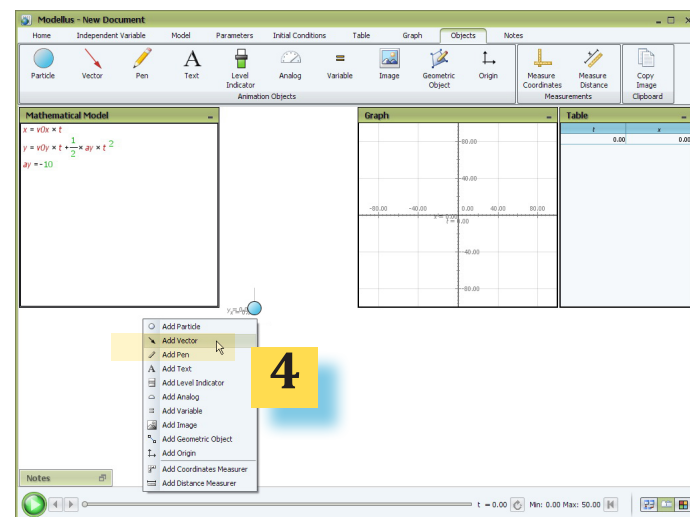
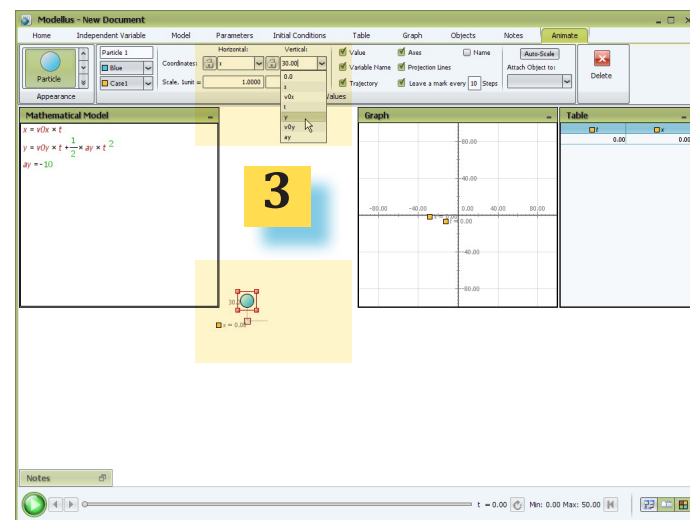
Start by defining the functions that describe one or several properties/quantities of the phenomenon or mathematical object under study...

For example, the equations highlighted in the figure refer to the motion of a projectile when air resistance is negligible.

2

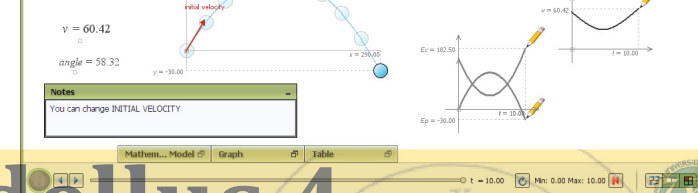
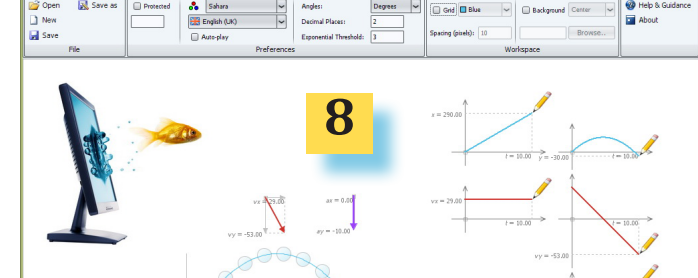
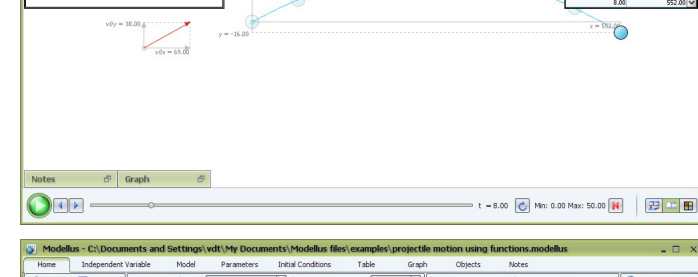
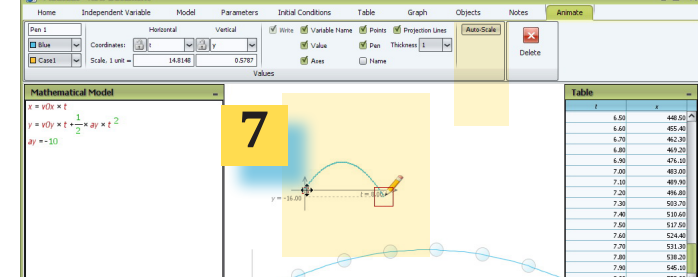
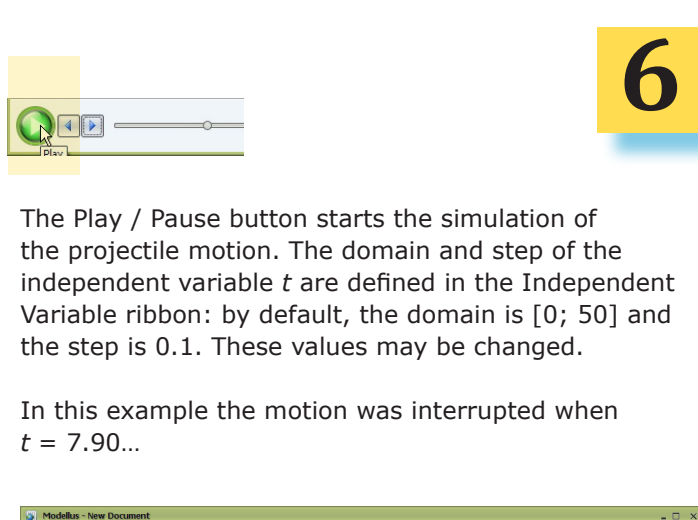
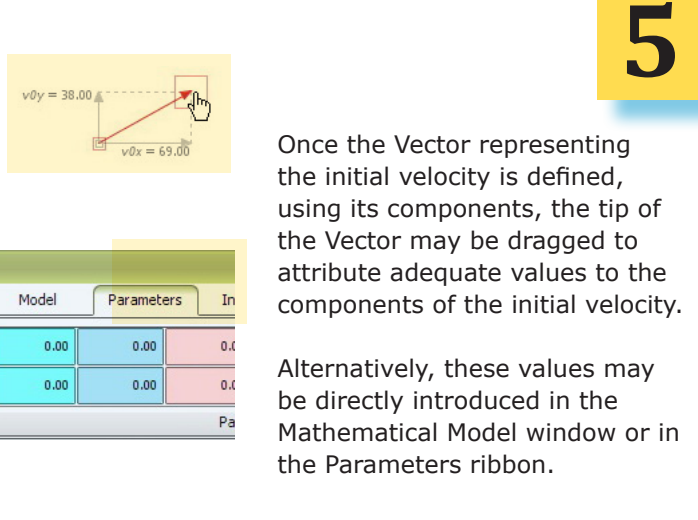
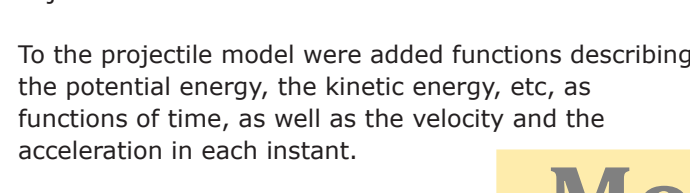
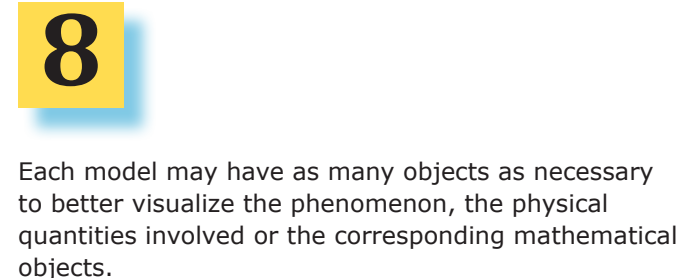
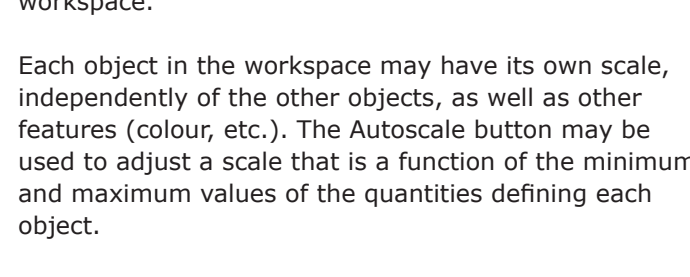
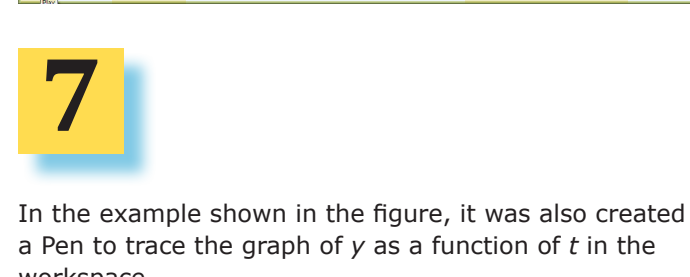
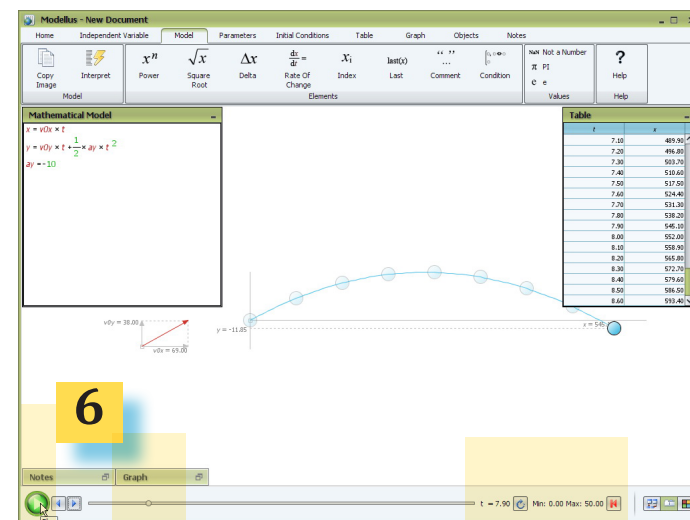
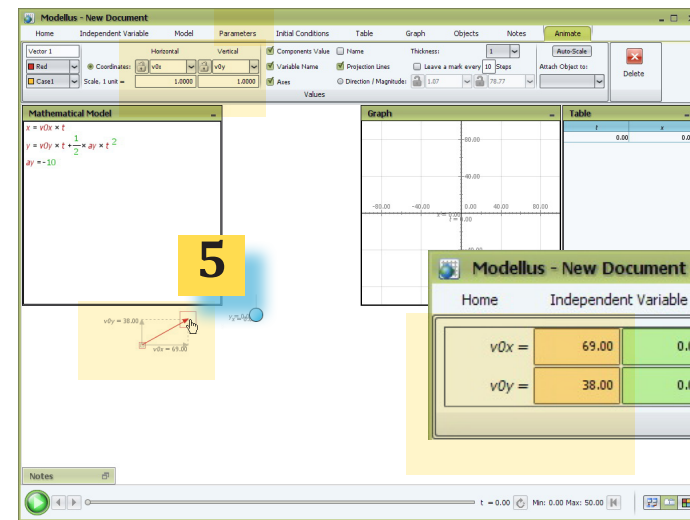
It is possible to create objects in the workspace to represent the variables of the model, either using the icons or the right button of the mouse.

For example, a Particle may be created to represent the projectile.



To each object of the workspace it is possible to assign defining properties. For example, x and y are associated to the Particle as the particle coordinates.

Since in the model the components of the initial velocity are indicated by v_{0x} and v_{0y} , it is possible to represent the initial velocity by a Vector.



Once the Vector representing the initial velocity is defined, using its components, the tip of the Vector may be dragged to attribute adequate values to the components of the initial velocity.

Alternatively, these values may be directly introduced in the Mathematical Model window or in the Parameters ribbon.

The Play / Pause button starts the simulation of the projectile motion. The domain and step of the independent variable t are defined in the Independent Variable ribbon: by default, the domain is $[0; 50]$ and the step is 0.1 . These values may be changed.

In this example the motion was interrupted when $t = 7.90$...