

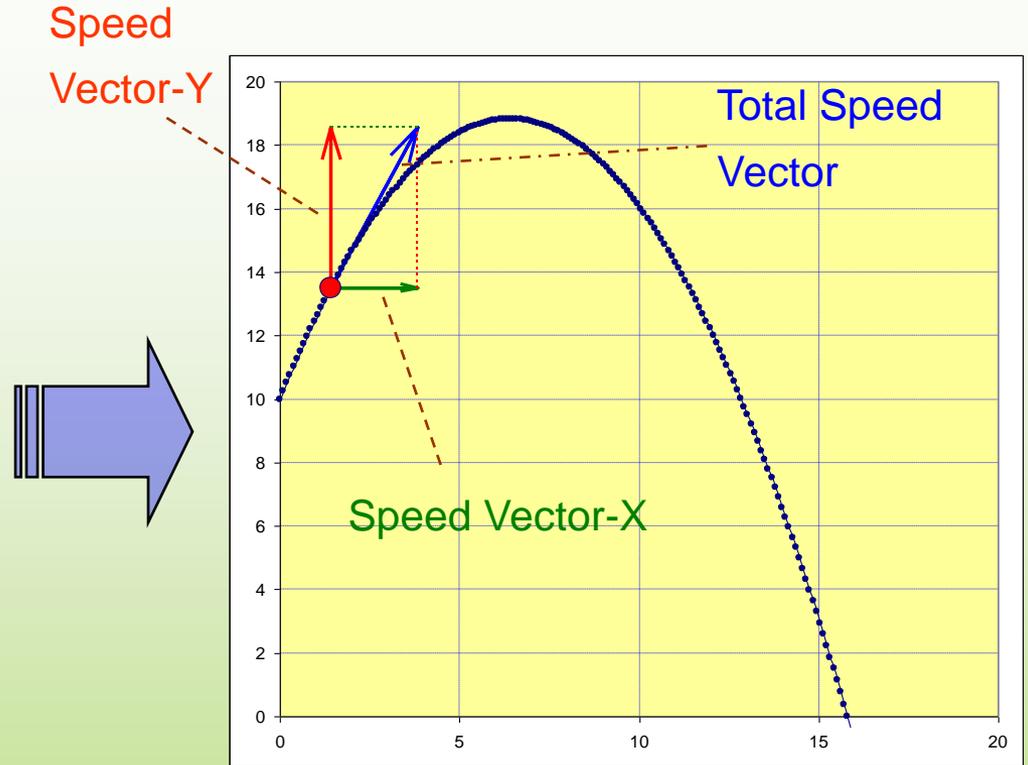
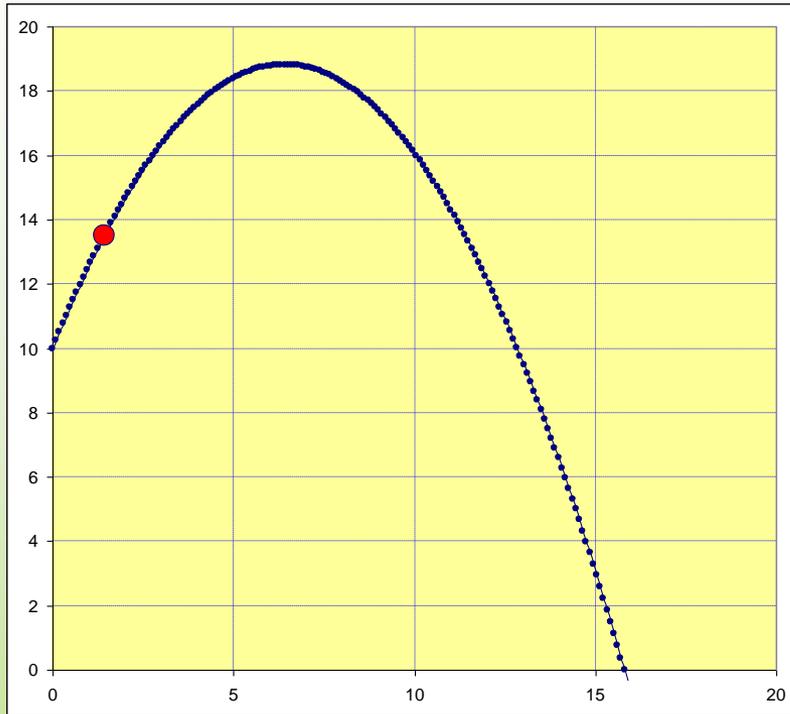
Projectile Motion Tutorial #3

- adding speed vector animation



[Adding speed vector animation:](#)

Now that we have a simple animated projectile motion (left chart) let's try to add the three instantaneous speed vectors associated with the projectile (right chart). These speed vectors are: the horizontal speed, vertical speed and the total speed vector.



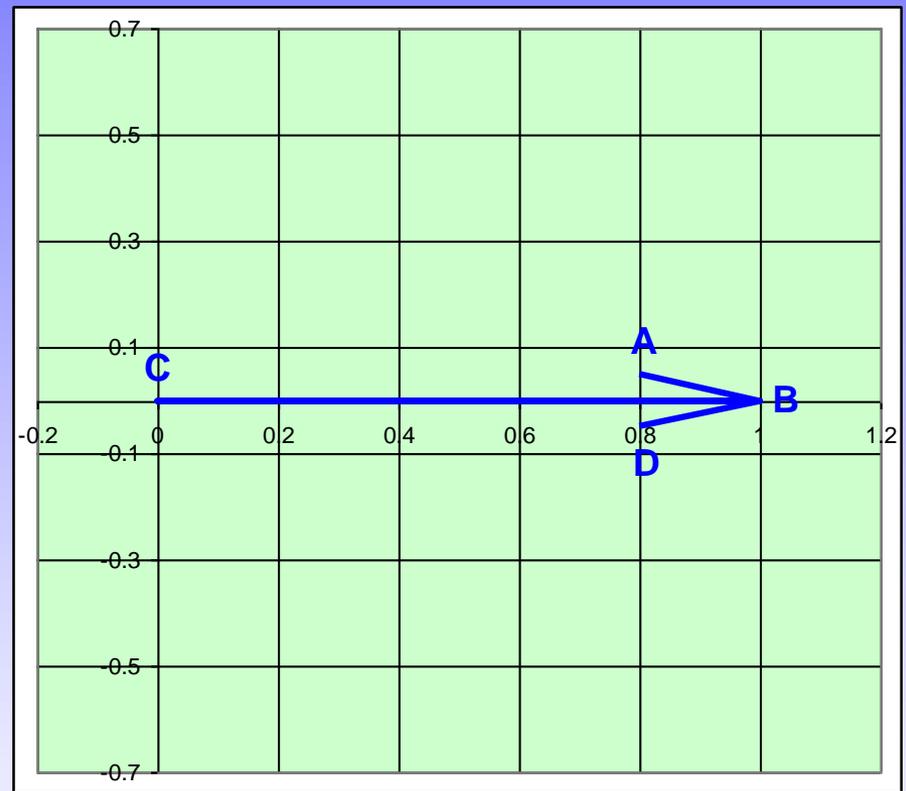
Starting with this plain vanilla model let's add speed vectors to the projectile

Creating a horizontal vector:

Let's plot the data in the table below on a 2D scatter chart. You can adjust the numbers to get a different shape arrow at the end of the stick.

A => B => C => B => D

A	0.8	0.05
B	1	0
C	0	0
B	1	0
D	0.8	-0.05



We will use three tables like this for the three speed vectors with the following transformations:

- We need to have a global scale factor for the user to adjust to his preference
- In addition to the global scaling operation mentioned above, each of the three vectors will be individually scaled by the three speed components (horizontal, vertical and total)
- All three vectors need to be translated from the origin to the projectile coordinates
- The vertical speed component needs to be rotated by +90 degrees
- The total speed component has to be rotated by $\text{arctangent}(v_{\text{vertical}} / v_{\text{horizontal}})$

Let's create an area in the worksheet with the following variables :

Current coordinates: these are calculated from two consecutive slices of the trajectory table. The position of the slices is selected by the "Index" which is dynamically generated by the "Fire" macro and is found in cell B20. We could have use exact formulas to calculate speed but this approach is also valid for future models which use numerical methods to derive the position of the projectile.

Scaling Factor	0.5	
Current_x	Current_y	
1.436485	13.50526	
Speed_x	Speed_y	
4.788282	10.1146	
Speed_vector_general		
A	0.8	0.05
B	1	0
C	0	0
B	1	0
D	0.8	-0.05

Global scaling factor: it is just a constant adjustable by user depending of how large he wants the vectors to look

Current coordinates: these are a slice of the trajectory table. The position of the slice is selected by the "Index" which is dynamically generated by the "Fire" macro and is found in cell B20

Cell F36: "OFFSET(C26,B20,0)"

Cell G36: "OFFSET(D26,B20,0)"

Cell F39: "=(OFFSET(C27,B20,0)-OFFSET(C26,B20,0))/B16"

Cell G36: "=(OFFSET(D27,B20,0)-OFFSET(D26,B20,0))/B16"

This is how the speed components were estimated (Δt is the time step)

$$v_x = \frac{x_{next} - x_{current}}{\Delta t}$$
$$v_y = \frac{y_{next} - y_{current}}{\Delta t}$$

Speed Vector-X is calculated by taking the **Speed Vector General** coordinates, multiplying them by the **general scaling factor** and by the **Speed_x** and shifting them by the **current coordinates**

Speed Vector-Y is calculated by taking the **Speed Vector General** coordinates, multiplying them by the **general scaling factor** and by the **Speed_y**, rotating everything by 90° and then shifting them by the **current coordinates**

Total Speed Vector is calculated by taking the “Speed Vector General” coordinates and multiplying them by the general scaling factor and by the total speed (we use Pythagoras to estimate it from **Speed_x** and **Speed_y**), rotating everything by arctangent(**Speed_x/Speed_y**) and then shifting them by the **current coordinates**

Aux_line_vert is generated from the tip of the **Total Speed Vector** and the tip of **Speed Vector-X**

Aux_line_horiz is generated from the tip of the **Total Speed Vector** and the tip of **Speed Vector-Y**

	E	F	G	H
32				
33		Scaling Factor	0.5	
34				
35		Current_x	Current_y	
36		1.436485	13.50526	
37				
38		Speed_x	Speed_y	
39		4.788282	10.1146	
40				
41		Speed_vector_general		
42		0.8	0.05	
43	B	1	0	
44	C	0	0	
45	B	1	0	
46	D	0.8	-0.05	
47				
48		Speed Vector-X		
49		Scale	2.394141	
50		Angle	0	
51		3.351797	13.62497	
52		3.830626	13.50526	
53		1.436485	13.50526	
54		3.830626	13.50526	
55		3.351797	13.38555	
56				
57		Speed Vector-Y		
58		Scale	5.057298	
59		Angle	1.570796	
60		1.18362	17.5511	
61		1.436485	18.56256	
62		1.436485	13.50526	
63		1.436485	18.56256	
64		1.68935	17.5511	
65				
66		Total Speed Vector		
67		Scale	5.595371	
68		Angle	1.128652	
69		3.098932	17.6708	
70		3.830626	18.56256	
71		1.436485	13.50526	
72		3.830626	18.56256	
73		3.604662	17.43139	
74				
75		Aux_line_vert		
76		3.830626	13.50526	
77		3.830626	18.56256	
78				
79		Aux_line_horiz		
80		1.436485	18.56256	
81		3.830626	18.56256	

All these five groups of data must be added to the chart as independent series so that we can give them different colors and styles.

The image shows two instances of the 'Source Data' task pane in Excel. The left pane shows the 'Trajectory' series selected in the 'Series' list. The right pane shows five series selected: 'Speed_x', 'Speed_y', 'Speed_total', 'Aux_line_vertical', and 'Aux_line_horizontal'. Both panes include 'Data Range' and 'Series' tabs, and 'Add' and 'Remove' buttons.

