Planemo()   Motion in a Plane with Constant Acceleration   2-17-08

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This is a generalization of my program, Projctle(), to include acceleration due to forces other than gravity. For example, it can be used for a charged particle moving in a uniform electric field.

The values of any 7 of the 11 quantities { a_x, a_y, x_o, y_o, v_o, α, x, y, v, θ, t } must be entered, then the program solves for the remaining 4 unknown quantities from the list. The number of unknowns must always be 4. One restriction is that no more than one unknown angle can be found, that is, either α or θ must be given. The initial time is assumed to be t_o=0. Only solutions with t>0 are given. Values for α and θ must be from $-180°$ to $180°$.

If you almost always use x_o=0, y_o=0, you may want to edit the program, changing the first couple of lines after Lbl f21, from " x_o" → x_o and " y_o" → y_o to "0" → x_o and "0" → y_o. Or if you use it mainly for projectile motion, you may want to change " *ax*" → *ax* and " *ay*" → *ay* to "0" → *ax* and "–9.81" → *ay*. If so, you can also save a few keystrokes each time you run the program by editing the first dialog box, moving the Request lines for x_o and y_o (and *ax* and *ay*) to the bottom, after the Request for α. If you need to fill in a value or treat one of them as a variable, you can fill it in along with the other data.

Copyto_h(), by Samuel Stearley, is used to copy the solutions to the home screen so they can be more easily used in further calculations.

For projectiles in a resistive medium, see Projdrag().

Place Planemo() and Copyto_h() in the same folder, then run Planemo().

Ex 1: A projectile is launched from (0, 10 m) with a speed of 40 m/s at an angle of 30° above horizontal. It lands at (x, 25 m). a) Find the coordinates of the landing point and the time of flight. b) Find the maximum altitude reached.

$a_x = 0 \quad a_y = -9.81 \quad x_o = 0 \quad y_o = 10 \quad v_o = 40 \quad \alpha = 30 \quad y = 25$

Sol #1:

$t = 3.087 \quad x = 106.9 \quad v_x = 34.64 \quad v_y = -10.28 \quad v = [\ 36.13\angle -16.53\ ]$

Sol #2:

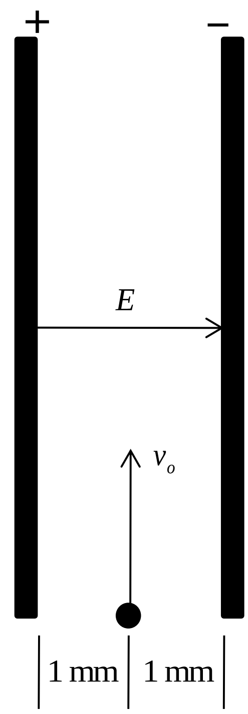
$t = 0.9907 \quad x = 34.32 \quad v_x = 34.64 \quad v_y = 10.28 \quad v = [\ 36.13\angle 16.53\ ]$

Edit previous result to find maximum altitude:

$a_x = 0 \quad a_y = -9.81 \quad x_o = 0 \quad y_o = 10 \quad v_o = 40 \quad \alpha = 30 \quad \theta = 0$

Sol : $t = 2.039 \quad v = 34.64 \quad x = 70.62 \quad y = 30.39$

Ex 2. An electron enters a uniform electric field E in the region between two charged metal plates. Initially the electron moves with a speed of $v_o = 3\times10^5$ m/s as shown. The electron hits the positive plate 3.2 mm from the bottom edge. Determine the electric field E.



$a_x = \frac{qE}{m} = -\frac{(1.6\times10^{-19})e}{(9.1\times10^{-31})}$ $\quad a_y = 0 \quad x_o = 0 \quad y_o = 0$

$v_o = 3\times10^5 \quad \alpha = 90 \quad x = -0.001 \quad y = 0.0032$

Sol. $\quad t = 1.067\times10^{-8} \quad e = 99.98$

$v_x = -1.875\times10^5 \quad v_y = 3\times10^5 \quad v = [3.538\times10^5 \angle 122.0]$

Ex 3: At t=0, a particle is at position $\vec{r} = (10\hat{\mathbf{i}} - 4\hat{\mathbf{j}})$ m moving with velocity $\vec{v} = (4\hat{\mathbf{i}} + \hat{\mathbf{j}})$ m/s. 20 seconds later, its velocity is $\vec{v} = (20\hat{\mathbf{i}} - 5\hat{\mathbf{j}})$ m/s.

a) Find the x and y components of its acceleration.
b) Find its position and velocity at $t = 25$ s.

a) $x_o = 10 \quad y_o = -4 \quad v_o = \sqrt{(4^2 + 1^2)} \quad \alpha = \tan^{-1}(1/4) \quad v = \sqrt{(20^2 + 5^2)}$

$\theta = -\tan^{-1}(5/20) \quad t = 20$ s

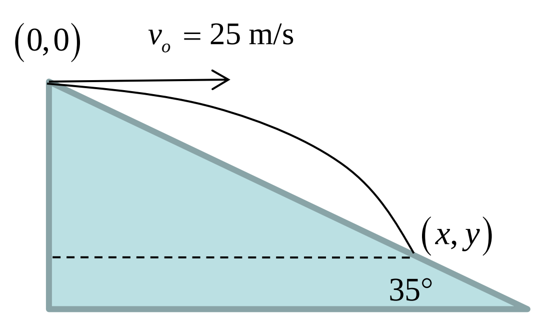
Sol : $x = 250. \quad y = -44. \quad a_x = 0.8 \quad a_y = -0.3 \quad a = [.8544\angle -20.56]$

b) Edit previous result:

$a_x = 0.8 \quad a_y = -0.3 \quad x_o = 10 \quad y_o = -4 \quad v_o = 4.123 \quad \alpha = 14.04 \quad t = 25$

Sol : $x = 360. \quad y = -72.75 \quad v_x = 24. \quad v_y = -6.5 \quad v = [24.86\angle -15.15]$

Ex 4: A projectile is launched horizontally at 25 m/s above a surface inclined at 35° below horizontal. Find the coordinates of the landing point.



$a_x = 0 \quad a_y = -9.81 \quad x_o = 0 \quad y_o = 0 \quad v_o = 25$

$\alpha = 0 \quad y = -x * \tan(35)$

Sol: $\quad t = 3.569 \quad x = 89.22 \quad v_x = 25. \quad v_y = -35.01 \quad v = [43.02\angle -54.47]$

Then: $\quad y = -(89.22) * \tan(35) = -62.47$