COMPUTATIONAL PHYSICS WITH SPREADSHEET – I

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Introduction

In classroom teaching, students are often shown graphs of relations derived which they themselves never generate using calculator as it becomes cumbersome and time consuming. This leaves a gap in their understanding of visualising mathematical dependence from the mathematical formula. The spreadsheet becomes an efficient means of generating data from the known mathematical relation. In this article we discuss three examples viz. δ v/s i curve for prism, trajectory of a projectile, exponential growth and decay and addition of simple harmonic oscillations.

Angle of Deviation in Prism

Consider the deviation of a ray through a prism as a function of the angle of incidence.

For prism of refracting angle we have following relations:

$$\mu = \frac{\text{Sin i}}{\text{Sin } r_1} = \frac{\text{Sin e}}{\text{Sin } r_2}$$

$\delta = i + e - A$ and $A = r_1 + r_2$

We may take independent variable i (angle of incidence) in column A and then calculate, r_1, r_2, e and δ in the columns from B to E.

A2 contains increment in angle i, B2 contains angle of prism A, C2 contains the refractive index of material of the prism.

So if the angle is in cell A5, the formulae for other angles become–

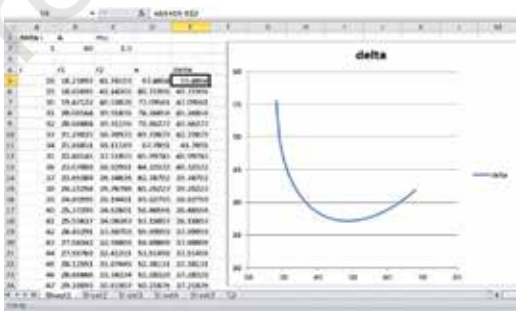
B5→=degrees (asin(sin (radians(a5))/C$2))

C5→=B$2-B5

D5→= degrees (asin(c$2 * sin (radians (C5))))

E5→=A5+D5-B$2

We get following calculations and plot for μ = 1.5 and A = 60°



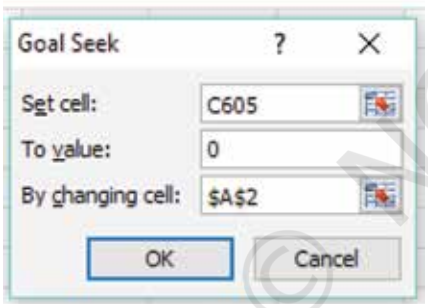
Projectile Motion

A body is projected with velocity u at an angle θ.

The equation for x displacement is
x = ucos(θ)t.

The equation for y displacement is $y = u\sin(\theta)t + \frac{1}{2} gt2$.

Since the excel calculations are done for a particular number of data points and graph plotted for the same, it becomes tricky to decide how many iterations to do for the projectile to land again on the ground. This can be found from trial and error. However there is a way to overcome this problem by using the 'goal seek' tool from what-if-analysis tool pack. Let us say we have used 600 data points for t. But it is not guaranteed that for the given value of u and theta, the projectile will ground again at 600th data point. So we click on Data → What-if-analysis → Goal Seek. A dialogue box opens:



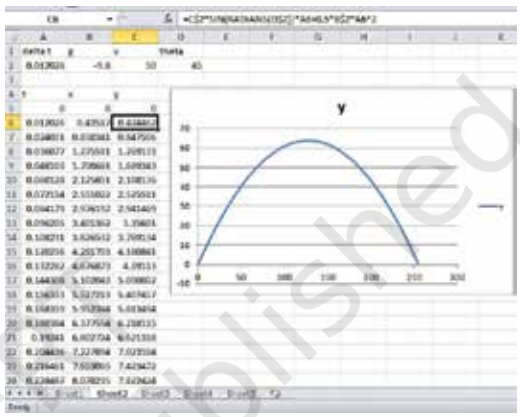
In 'Set cell': Type the address of the last cell of iteration for y value.

In 'To value': Type 0. (As the projectile grounds again, y coordinate is 0).

In 'By changing cell': Type the address of the delta t (incremental value of t). The address is provided by locking the cell. E.g., here it is A2, instead of just A2.

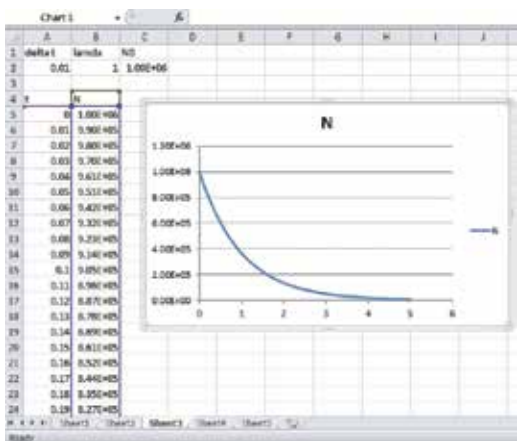
After putting the values, press the Ok button and the excel calculates what value of delta t will make the projectile land on ground in 600th t value. The corresponding value of x gives the range of the projectile.

As the speed and angle of projectile is changed, we have to do this process every time.



Radioactivity

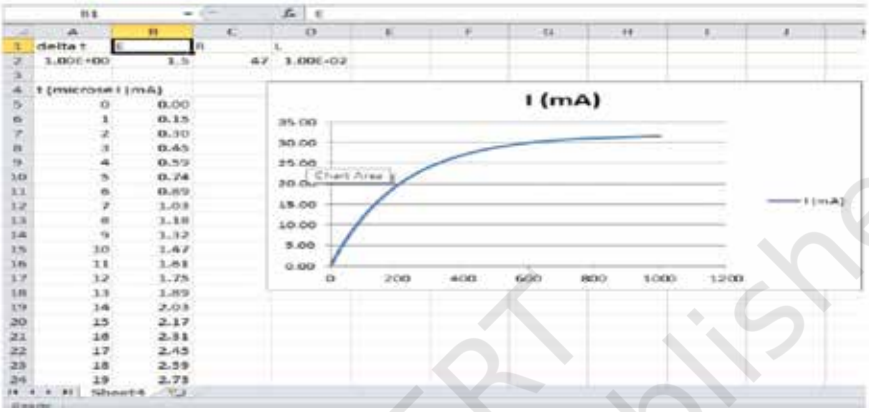
The number of radioactive atoms remained after time t is given by $N(t) = N_0 e^{-\lambda t}$. Where N0 is the number of atoms in the beginning and λ is the disintegration constant.



Growth of current in Inductor

The value of current in an LR circuit connected to a battery of E.M.F. E and resistor R is given by $i = \frac{E}{R}\left(1 - e^{\frac{-t}{(L/R)}}\right)$

We can observe by changing the value of L or R, how current grows faster or slower.



References

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Halliday, Resnick and Walker. 2005. Fundamentals of Physics 6th Ed., John Wiley & Sons.

Jain. M. K., S. R. K. Iyengar and R. K. Jain. 2010. *Numerical Methods for Scientific and Engineering Cλ*