Exp 0: On Falling Bodies
PHYS 37100

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Abstract

What happens when objects fall? In this experiment we investigate the physics of point masses under the influence of a uniform gravitational field.

1 Introduction

The force of gravity between two objects, m_1 and m_2 is given by:

$$F_G = G\frac{m_1 m_2}{R^2} \tag{1}$$

where G is the Universal Gravitational Constant, m_1 and m_2 are the two masses, and R is the distance between the two masses. In the case of a point-like mass near the surface of the Earth, this equation becomes:

$$F_G = G\frac{m_E m}{R_E^2} \tag{2}$$

where m_E is the mass of the Earth (5.972×10^{24} kg), m is the point mass and R_E is the (average) radius of the Earth (6.371×10^6 m)

In the absence of drag forces, we can assume this is the only force acting on the mass as it falls, thus with Newton's 2$^{\text{nd}}$ Law, we can write:

$$\Sigma F = G\frac{m_E m}{R_E^2} = ma \tag{3}$$

where a is the acceleration of the mass.

Solving for a using the values quoted above leads to:

$$a = G\frac{m_E}{R_E} = 9.8 \text{ m/s}^2 \tag{4}$$

Thus, we can say that any mass in this situation should accelerate towards the Earth at a rate of $g = 9.8$ m/s^2.

2 The Physics

We can calculate the velocity at a time t by using:

$$v(t) = gt \tag{5}$$

Integrating this result to obtain the position:

$$y = g\int_0^t t\,dt = \frac{1}{2}gt^2 \tag{6}$$

As we see in figure 1, the velocity is a linear line while the position is a parabolic curve, as expected[1].

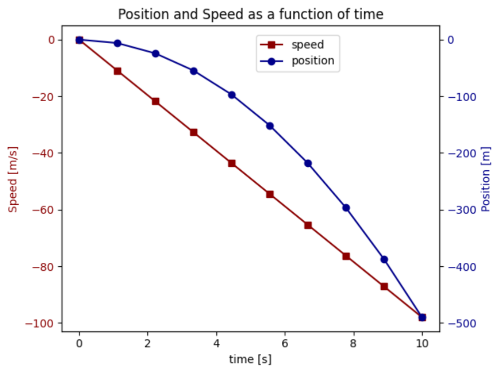

Figure 1: A plot of a ball falling with constant acceleration

3 Code/Data

The code that was used to generate some example data. (note the listings package in the preamble)

```
import numpy as np

time = np.linspace(0, 10, 10)
a = 9.8
speed = a*time
position = 0.5*a*np.square(time)
```

Not included here is the plot commands, because they are boring and not very relavent. But the entire script is available at this Colab Notebook.

We can present some of our data in a table form if that's helpful too.

Time [s]	Speed [m/s]	Position [m]
0	0	0
1	9.8	4.9
2	19.6	19.6
3	29.4	44.1

We don't need to reproduce our entire data set here, but the rest can be found at our online repository.

4 Other things

You can include links like this one here. (note the **hyperref** package in the preamble)

The 371 Course Page: Course Page.

Or make smaller, wrapped figures using the **wrapfig** package. In general images can be a little tricky to get just right. You can adjust the size by playing with the width control.

For a more thorough guide, see this help page.

Figure 2: An early experimenter. This figure is in the Public Domain.

References

[1] Newton, Isaac *Principia - The mathematical principles of natural philosophy.*, 1687.