The Determination of G

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April 3, 2013

Outline of Presentation

Be prepared...

History and motivation.

Experimental procedure.

Systematic Errors.

Random Errors.

Final results.

Questions.

Lessons learned.

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Henry Cavendish 1731-1810

Cambridge drop out.

Used the torsion pendulum to try determine the density of the Earth.

The literature value for G is $6.67 \times 10^{-11} m^3 kg^{-1} s^2$

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Two Methods

Why?

End Deflection

Uses equation

Acceleration.

Uses Gradient

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How it works.

$$G = \frac{\pi^2 \Delta S b^2 d}{T^2 m_2 L} \ \mathrm{m^3 kg^{-1} s^{-2}}$$

That's pretty much as exciting as it gets.

Well almost.... Here's my result

$6.56(16) \times 10^{-11}\ \mathrm{m^3 kg^{-1} s^{-2}}$!!!

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Acceleration

How it works.

$G = \frac{a_0 b^2}{2m_2}\ \mathrm{m^3kg^{-1}s^{-2}}$

Where:

$a_0 = \frac{L}{d} =$ gradient of linear fit

$\frac{a_o L}{d}$ is the slope of linear graph

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Acceleration Downsides

Reproducibility is questionable

Not Enough data points.

Hard to swing it the same way, every time.

a_o is the slope of linear graph.

Acceleration Upsides

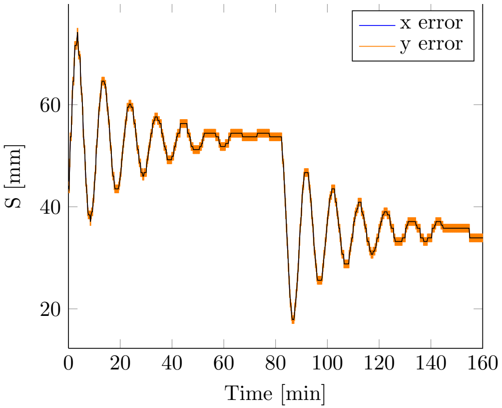
Damping and Crashing

Does not matter too much about damping.

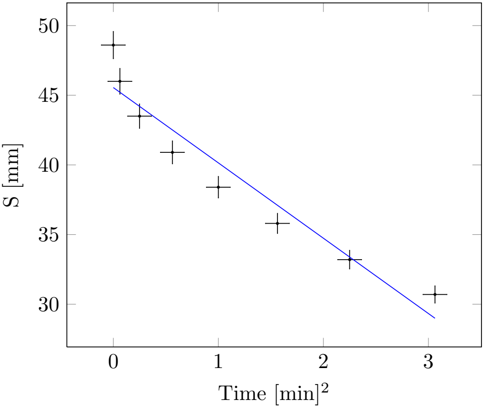
Don't need to wait too long to get results.

With different software you can record more time steps.

Main Result



Acceleration

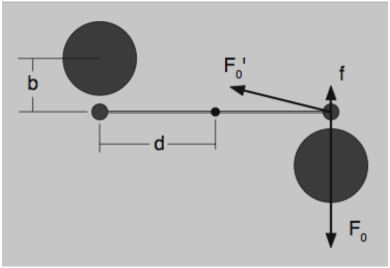


Systematic Errors

Influence of the large lead balls

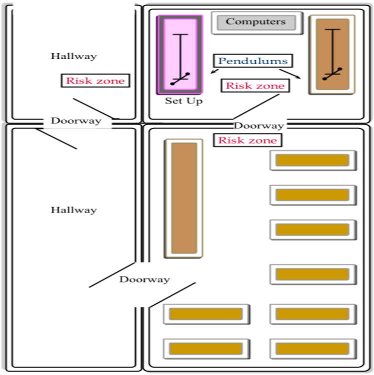
Want:

$$\tau_g = 2F_0 d = \frac{2Gm_1 m_2}{b^2}$$



Random Errors

High risk zones



Analysis

The Acceleration was analysed using my java program

The graphs with pgfplots

End deflection was analysed using CASSY Lab for ΔS

Maple for the algebra

Random Errors

Additional Forces Due to.

Atmospheric pressure.

Radiation pressure.

Magnetic field of earth.

Banging the swing doors.

People moving around in the room.

Error on G

$$\sigma_G = \sqrt{\left(\frac{\partial^2 G}{\partial a^2}\Delta a\right)^2 + \left(\frac{\partial^2 G}{\partial b^2}\Delta b\right)^2}$$

For b, d, m_{1rf}, T ΔS and L

Conclusions

This experiment can also be improved...

If the measurements are more exact

If the room is isolated from external noises and temperature/humidity controlled.

More time steps are recorded.

Questions?