Gravity Lab

This lab evaluates several key physics-based concepts essential to astronomy and cosmology, including:

1. Quantitative methodology, the Scientific Method (Galileo)

2. Application of fundamental laws of physics (Newton)

3. Sir Isaac Newton's breakthrough in explaining astronomical phenomena with a mathematical model based on physics principles vis-à-vis Kepler's explanation(s) which were derived from empirical observations.

Specifically, you will apply Newton's Version of Kepler's Third Law to calculate the period of the Moon's orbit.

Formulas used in this lab:

Velocity:

$$V = \frac{D}{T}$$

Acceleration:

$$a = \frac{V_f - V_i}{T}$$

(In this case $a = a_g$ = gravity)

Simplified ("Idealized") version of Newton's Law of Gravity:

$$F_g = \frac{GM}{r^2} \qquad (F_g = a_g)$$

Mass of Primary (Earth in this case) using variant of simplified version of Newton's Law of Gravity:

$$m = \frac{F_g r^2}{G}$$

Kepler's Third Law:

$$p^2 = a^3$$

NOTE:
a = radius of orbit in AU,
p = time of orbit Earth Years

Newton's version of Kepler's Third Law:

$$p^2 = \frac{4\pi^2 a^3}{GM}$$

therefore, $p = \sqrt{\frac{4\pi^2 a^3}{GM}}$

NOTE:
a = radius of orbit in meters
p = time of orbit in seconds)

Preliminary Data/Instructions:

- Mean radius of Earth at equator: 6378 Km
- Mean radius of Moon's orbit: 384,000 Km
- Numeric value of Universal Gravitational Constant: 6.672×10^{-11}
- Remember, you cannot use kilometers, hours, days in Newton's formulas – you must use standard units: meters, seconds, kilograms!
- 1 hour = 3600 sec, 1 day = 24 hours
- **USE SCIENTIFIC NOTATION!**

Lab Procedure:

1. Using a pendulum determine the acceleration of gravity on the surface of the Earth

Analysis 1:

1. Determine the average velocity of each event using the formula for velocity. Use measured distance(s) in meters for D, duration for T
2. Calculate the average acceleration of gravity by using the acceleration formula; use the average velocity of the earlier Event for V_i, the later Event for V_f, and elapsed time (not duration) for T.
3. Use procedure in Step 2 to compare E_2 with E_1, E_3 with E_2, and E_3 with E_1.
4. Average the results from Step 3. This is your measured/calculated average acceleration of gravity (a_g) at sea level.

Analysis 2:

1. Calculate the mass of Earth using the preliminary data and your measurement of a_g using the variant of simplified version of Newton's law of Gravity.
2. IMPORTANT: Use your measured/calculated a_g for the value of F_g

Analysis 3:

1. Calculate the period of the Lunar orbit (in seconds) using Newton's Version of Kepler's Third Law
2. Use values from Preliminary Data and your calculations from Analysis 2
3. Convert result to "days"
4. **USE SCIENTIFIC NOTATION!**

ANALYSIS 2 WORKSHEET

Required data:

1. Calculated a_{avg} : _____

2. Radius of Earth (in meters) _____

3. Numerical value of G: _____

Calculations:

ANSWER:

ANALYSIS 3 WORKSHEET

Required Data:

1. Earth Mass as calculated in Analysis 2 _____

2. Numerical value of G _____

3. Radius of Lunar orbit in meters _____

ANSWER (IN DAYS):