Name(s): _____ _____

_____ _____

Date: _____ Course/Section: _____

Grade: _____

Mass of the Earth

Part 1: The Angular Size of the Earth

Examine the image on the lab website. The image of the Earth was taken from the Moon on Aug 23, 1966 by Lunar Orbiter 1. Use the scale given in the image to estimate the radius of the Earth. Show your work.

Part 2: Measuring Gravity

You will determine the force of gravity at the surface of the Earth using the pendulum by swinging it and making measurements of the time. The relationship in use is

$$L = \frac{g}{4\pi^2} T^2$$

where L is the length of the string, g is gravity, and T is the period. The units are mks.

Tips for making good measurements:

- Do not offset the mass by more than 5° from its center, as the equation is only valid for small amplitudes.
- When displacing the mass, try to release it in such a way that the direction of movement is in one direction, e.g., avoid a swirling pendulum.
- Measure the time is takes to complete 30 periods. You can always divide the time by the number of swings to find an estimate of the time per period.
- Have two people record the time. The difference between the two measurements will give you a rough estimate of the systematic error of the experiment.

You will make measurements for 4 different lengths of string. Complete four trials for each length, having two people simultaneously measure the time. Fill in your data on the table below.

Trial	T per 30 periods (s)	T per 30 period (s)
Length =		
1		
2		
3		
4		
Length =		
1		
2		
3		
4		

Trial	T per 30 periods (s)	T per 30 periods (s)
Length =		
1		
2		
3		
4		
Length =		
1		
2		
3		
4		

Enter your time data into Excel. Then, enter in or calculate the following:

- Time per period
- Systematic Error on Measurement
- Mean of T (μ)
- Standard Deviation of T
- Standard Deviation of the Mean
- Total Error including systematic and random
- Square of Mean T
- The propagated total error on T^2

Examine your pre lab question answer for number 3 for guidance. Open Logger Pro.

- Enter in your X and Y data.
- Enter in the data from your classmates as well.
- Add a new data column called Error (Data → New Manual Column)
- Enter in your total error on your X data in your new Error column
- Double click the 'X' column and enter in the correct units and the change x axis label. Then, click the error check box and use your Error column. (Options -> Error Bar Calculations → Use Column)
- Double click the 'Y' column and enter in the correct units and change the y axis label.
- Fit a linear model to the data. (Analyze → Linear Fit)
- Turn on uncertainties in the fit by double clicking the fit box and checking Show Uncertainty.
- You will be expected to turn in a printed copy of you excel spread sheet and the Logger Pro Graph.
- Email yourself a copy of the Excel sheet for future reference and use (Analysis Questions)

1. Record the slope of the line, the y-intercept, and the associated error.

2. Determine g in the appropriate units and the error. Show your work.

Determining the Mass of the Earth

1. From Part 2, assume the error on your measurement of θ is 5.2 arcminutes. Use your answer from the Pre Lab to propagate this error forward to the measurement of the radius of the Earth. Show all your work.

2. Calculate the mass of the Earth using your answer in Part 2, question 2. Use your answer from the Pre Lab Question 2 to propagate the errors of g and R (Part 1) onto M. Show all your work.

Analysis Questions

1. Why can you neglect m, the mass of the pendulum?

2. What kinds of errors dominate your estimate of g, i.e., systematic or random? How could you minimize this error in a future experiment?

3. What is standard deviation and standard deviation of the mean? Explain qualitatively and with equations.

4. Look up the accepted mass of the Earth and compare your value to it by reporting your observed value in units of mass of the Earth. Compare your answer to the accepted value.

5. What is the 5σ error of your answer? Does it agree with the accepted value? If not, how many σ away is your answer from the accepted value?

6. Think about every aspect of this experiment. What other assumptions did you make along the way that contributed to your accuracy and precision? List as many as you can think of.