**Unit 4 - Activity 4**

**Gravitational Force and Mass Lab**

In this investigation you are asked to measure and determine the relationship between two physical quantities: mass and weight.

We define the weight of an object as the force exerted on that object by the local gravitational field ().

We define mass as a way of counting the ‘particles’ within an object.



#### **Equipment**

* Assorted masses
* Spring scale
* Ring stand

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#### **General Procedure**

You should increase the mass hanging on the spring scale in equal increments so as to get at least ***10 data points***. Record the total mass attached to the spring scale and the total gravitational force as read from the spring scale.

If you are using a scale which has a maximum force reading of 5.00 Newtons, start with a 50.0 g mass hanger for your first data point. Increase the mass by 50.0 g for each trial, until you reach the limit of the scale.

Your data table should have columns for the total mass in kilograms and the total gravitational force in Newtons (to the nearest 0.01 Newton).

|  |  |
| --- | --- |
| **Mass (kg)** | **Force (N)** |
|  |  |
|  |  |
|  |  |

Graph your data. ***Hint:*** The gravitational force depends on the mass. Perform a proper mathematical analysis for your graph (i.e. linearization, analyzing slope, etc…).

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#### **Discussion Questions**

*Write your answers to the following questions on a separate sheet of paper.*

1. Describe and analyze your graph. Write a specific mathematical statement which describes the relationship between mass and gravitational force. What is the slope of your graph? What is the physical significance of this slope?

*Read the article on the following sheet and then answer the following questions.*

1. Explain what would happen to your data if you were to take the same equipment to the moon and perform the experiment?
2. Many unit conversion tables contain the following conversion: 1 kg = 2.2 pounds. Explain what is wrong with this “equation.” Write a statement that includes the terms “1 kg” and “2.2 pounds” that is correct.
3. It is commonplace to find statements on food cans such as “Net Weight: 16 oz. (454g)” Why do most people find this acceptable? Why do “physics types” object to such statements?
4. On the next page is a photo showing two spring scales, each of which has a 500 g object hanging from it. Carefully examine each scale and the scale reading. Are the readings correct for the respective scales? What would each scale read if you were to put the same 500 g object on it on the moon? Is there anything wrong with either scale? Explain.
5. When you go to the doctor’s office you step on a balance, which in the U.S. is typically calibrated in pounds. Is this a correct unit for such a balance? What would happen to the reading on this device if you were to stand on it while on the moon? Is this what the scale should read? How would your answers compare if you were to repeat this situation with a doctor’s balance in Mexico?

## **What are Mass and Weight?[[1]](#footnote-0)**

Which door is harder to open: a one-meter thick aluminum one or an iron one the same size? Easy. The iron door is much harder to open. But *why* is it harder to open? Is it harder to open because it weighs more? No. The weight of the door is being supported by the hinges. You are not trying to lift the door against gravity when you open it. So even though the iron door weighs more, this is not the reason it is harder to open. The iron door is harder to open because it has more mass. The terms *mass* and *weight* are used interchangeably in everyday conversation, but technically they are very different. Mass is a measure of an object's resistance to having its motion changed. The mass of an object depends on the number and kinds of atoms it is composed of. Weight, on the other hand, is the gravitational force with which an object is attracted to the center of the Earth, or any other body, such as the moon. We will use the symbol to describe this gravitational force, or weight.

With the definition of mass in hand, we can return to the doors. An atom of iron has more mass than an atom of aluminum--its nucleus has more protons and neutrons (elementary particles that make up most of the mass of an atom) than does the nucleus of the aluminum atom. So assuming that both doors have the same number of atoms, the iron door logically has greater mass than the aluminum one. That is, it is more resistant to a change in motion, and thus is harder to open.

As you have found in your experiment, the weight of an object (more specifically the gravitational force on the object by the earth) is calculated by multiplying its mass by the strength of the gravitational field in which the object exists. Whereas the mass of an object is constant, its weight varies according to the gravitational field in which the object is placed. To us, weight seems unchanging because the Earth's gravitational field is, for the most part, constant. If we were to ferry an object from Earth to the moon, we would find that its mass, when measured on the moon, was the same as it was on Earth. But its weight would be only one-sixth what it was on Earth, because the strength of the moon's gravitational field is only one-sixth that of Earth. It should not be surprising, then, that a very massive object, if placed in a location with no gravitational field, would be weightless. For example, as a spaceship moves away from the Earth, the gravitational force with which it is attracted to the Earth—therefore its weight—decreases. So, if the ship were to move into interstellar space, far away from the Earth

or another massive body, it could come close to having a weight of zero.

1. (Adapted from an article from Science Digest, February, 1993) [↑](#footnote-ref-0)