Sir Isaac Newton (1642-1727) is probably one of the most remarkable men in the history of science. He graduated from Cambridge University in England at the age of 23. Records indicate that although he was a good student, he was not outstanding. He had intended to stay on after graduation but the University closed down for two years due to the plague. Newton returned home and during these two years he worked out the law of universal gravitation, explained the motion of the solar system, developed the laws of motion, invented the calculus, invented the reflecting telescope, and proposed a theory of light and color. When the University reopened he was made a professor at the age of 26. He lived to the ripe old age of 85, but never again approached the productivity achieved during the two years Cambridge closed down.

Here is a list of concepts that you will need to include in your observations and explanations:

**MASS, WEIGHT, INERTIA, SPEED, ACCELERATION, FORCE, DIRECTION, FRICTION.**

**STATION #1: MASS VS WEIGHT**
The mass of an object is the amount of matter in the object and can be measured by comparing the mass of an unknown object with the mass of a known object. This is exactly the principle used when measuring the mass of an object on a triple-beam balance. The standard unit of mass is the gram. The weight of an object is a downward force. Standing on a bathroom scale measures your downward force exerted on the scale which is dependent upon your mass (the quantity of you) and the downward pull of the Earth’s gravity on your mass. The standard unit of force is the Newton (approximately 100 g or 0.1 kg—about the mass of an average apple.). Thus, your weight is measured in Newtons!

- Stand on the bathroom scale and record your mass in kilograms. ________________

The average acceleration of all objects toward the earth is the same, approximately 9.80 m/s/s. Using Newton’s Second Law of Motion, Force (N) = mass (kg) x acceleration (9.80 m/s/s), calculate your downward force onto the scale.

**STATION #2: AIR FRICTION**
An object falling through air encounters an upward force due to the air pushing in the opposite direction of the moving object. This is air friction. Friction always acts in the direction opposite in which the object is moving. The greater the mass of the falling object, the greater the force it exerts in a downward direction. If the force of the object is greater than the upward force of the air, the object will accelerate (speed up) on its way down. If the object’s downward force is equal to the upward force of the air, then the object will fall with a constant velocity (terminal velocity) and an acceleration of zero.

Drop the piece of paper and the metal disk side-by-side to see which one hits the floor first. Repeat, but place the piece of paper on top of the metal disk so it rides "piggy-back" on the disk. Make sure that the disk is horizontal. How do you account for your results?
With the paper provided construct a paper helicopter as you did in the laboratory on Speed & Acceleration. Take an identical piece of paper and roll it into a tight ball. Drop them simultaneously side-by-side. What are you observations?

Since they are identical in mass, which has the greater downward force? The helicopter, the paper ball, or are their downward forces equal?

Provide an explanation why there is a difference in their rates of fall?

**STATION #3: ACTION / REACTION**
A force acting in one direction encounters a force equal and opposite in direction. Adjust the postal scales to read zero. Hold the scales in front of you and press the right hand scale against the left hand scale. Read the weight (force) on each scale.

Repeat, but this time press the left hand scale against the one on the right. Note the force on each. Try increasing the force on the right hand scale. How did the left hand scale react. Describe your results and provide an explanation.

**STATION #4: IT'S HAMMER TIME**
Common sense tells you that it is not a good idea to pound on the palm of your hand with a hammer. Newton says its OK, if you place a massive object (2 kg) between your palm and the hammer. Repeat the same experiment with the less massive object (0.5 kg mass).

Prepare a statement that describes the mass in your hand and the force applied by the hammer required to accelerate it.
**STATION #5: CELEBRITY BOWLING WITH ISAAC NEWTON**
Inertia is a measure of mass. Inertia is the resistance of an object to change its motion (increase or decrease its speed, or change its direction.) Place one of the bowling balls in front of the mallet. Pull the mallet back and allow it to strike the ball when you release it. Observe the motion of the ball. Repeat the procedure, but now use the other bowling ball. How do their accelerations compare?

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Prepare a statement that describes the relationship between the masses of the bowling balls and their velocities when a constant force is applied to them by the mallet.

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**STATION #6: SPRING INTO ACTION / REACTION**
Compress the spring in one of the carts and place it in contact with the other cart. Release the spring and observe the accelerations of the two carts. Compare the acceleration of each of the carts? Repeat, except this time double the mass of one of the carts by placing a brick on it (the mass of the brick is equal to the mass of the cart.) Compare their accelerations.

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Although the force of the spring was the same in both cases, how do you account for the resulting acceleration of the carts in each case? Explain in terms of Newton's Laws.

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**STATION #7: SPUDS IN MOTION**
Push the knife about an inch into the potato. Holding the potato upright with the knife, bring the handle of the knife down sharply onto the table. Explain your observations.

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Your reasoning for behavior of the potato on the knife is exactly why you should wear seat belts in your car. Why?
Station #8: A Penny for Your Thoughts

Place the card on top of the glass and place the penny on top of the card directly over the glass. Give the card a quick flick with your finger. Did the penny drop into the glass? Provide an explanation for your observations.

Replace the card with a piece of sandpaper so that the rough side is in contact with the penny. Try to flick the sandpaper out from under the penny. Why are the results different this time?

You may have witnessed (or tried) to pull a tablecloth out from under a table of dinnerware. Would you have better luck completing this demonstration with heavy china or with paper plates and cups? Why?

Station #9: Physics in the Toy Store

A. Wind up the surfer-dude and place him in the water. What is the action/reaction pair of forces responsible for making him move through the water?

B. Place the shaft of the helicopter between your palms and quickly slide your hands apart to rotate the helicopter. Identify the action/reaction forces that cause it to fly.