Newton's Laws Experiences and Experiments

This lab is exposing you to Newton's laws and some additional science topics (significant figures). We will rotate through each station. You will have about 12-15 minutes at each one. If you finish early please start working on the reflection questions.

The tables in this handout are examples only, please record all data in your notebook.

Station #1: Significant figures

Materials:
Balance 1
Balance 2
Dixie cups
Paper clips
Ruler
Calipers
Object

Rules for Determining significant figures

To determine significant figures for a number:

1. Non-zero digits are always significant
2. Any zeros between two significant digits are significant
3. A final zero or trailing zeros in the decimal portion ONLY are significant
   Example: .500 or .632000 the zeros are significant
   .006 or .000968 the zeros are NOT significant

For addition and subtraction use the following rules:

1. Count the number of significant figures in the decimal portion ONLY of each number in the problem
2. Add or subtract in the normal fashion
3. Your final answer may have no more significant figures **to the right of the decimal** than the LEAST number of significant figures in any number in the problem.

For multiplication and division use the following rule:

1. The LEAST number of significant figures in any number of the problem determines the number of significant figures in the answer. (You are now looking at **the entire number**, not just the decimal portion)
   This means you have to be able to recognize significant figures in order to use this rule
   Example: 5.26 has 3 significant figures
   6.1 has 2 significant figures

Measuring Mass with a Balance

1. Place a dixie cup on balance 1 and zero it by using the “tare” function. Add several paper clips (record how many in your notebooks) and record the mass of those paper clips as given by balance 1. Make sure to record the mass exactly as the balance tells you.

2. Weigh the same number of paper clips as you did in step #1, record the mass of the paper clips as given by balance 2. Make sure to record the mass exactly as the balance tells you.

Example Tables

Balance 1

# of Paper Clips	Mass of Paper Clips

Balance 2

# of Paper Clips	Mass of Paper Clips

Reflection Questions: Please answer in your notebook

1. Define the terms “precise” and “accurate” in terms of scientific data

2. Compare the results from balance 1 with the results from balance 2. Were they similar? Which balance gave you a more precise answer? How do you know?

3. Which balance gave you a more accurate answer? How do you know?

4. If you were using a balance to calculate the mass of a chemicals to use in a reaction which required very precise and accurate masses, which would you use? Why?

Measuring Thickness of an Object

1. Measure the thickness of the supplied object with the ruler. Make sure to record you measurement in mm or cm and to put as many significant figures as you can detect with the ruler in your measurement. Record the measurement in your notebook.
2. Remeasure the thickness of the supplied object with the calipers. Make sure to record you measurement in mm or cm and to put as many significant figures as you can detect with the ruler in your measurement. Record the measurement in your notebook.

Example Tables

Ruler Measurement	

Caliper Measurement	

<u>Reflection Questions: Please answer in your notebook</u>

5. Compare the results from the ruler with the results from the caliper. Were they similar? Which balance gave you a more precise answer? How do you know? Why do you think that is the case?

6. Which of the two measuring tools (ruler or calipers) gave you a more accurate answer? How do you know?

7. You use a laser rangefinder to find the length and height of a wall so that you can buy just the right amount of paint to paint it. You measure the length to be 9.1446310 meters and the height to be 3.048254 meters. What is the area of the wall, make sure to report your results to the proper significant digit.

Station #2: Phet Station

<u>Materials:</u>
Computer (1 for every 2 students)
Link to Phet

This activity makes use of the PHeT: Forces and Motion Basics simulation. The simulation can be found at https://phet.colorado.edu/en/simulation/forces-and-motion-basics

Open the simulation to the Net Force tab and click the Sum of Forces (hereafter known as Net Force) and Values boxes. **Always make sure these are selected**. What is the Net Force on the box? Describe how the box is moving.

Net Force	**Boxes Motion**

Add a single person to one side of the cart. Press ‘Go”. What is the Net Force on the box? Describe how the box is moving (hint: consider any changes in speed you observe as well).

Net Force	**Boxes Motion**

Reset the simulation. Add a single person to one side of the cart. Press “Go”. After ~ 1 second, add the same person of the opposite color to to other side of the cart. How does the Net Force change? Describe the motion of the box.

Net Force	**Boxes Motion**

Reset the simulation. Add a single person to one side of the cart. Press “Go”. After ~ 1 second, add a LARGER person of the opposite color to to other side of the cart. How does the Net Force change? Describe the motion of the box.

Net Force	**Boxes Motion**

1. In your own words, what effect does a Net Force have on the velocity of an object?

Open the Motion tab of the simulation. Make sure all the info boxes are checked **and remain checked for the whole activity**. Choose an object to put on the board. Apply a constant force for exactly five seconds, and then stop the force.

2. How much did the object's *velocity* (speed in a direction) change over how much time? This is your *acceleration*.

3. Repeat the above with the same applied force but a different mass. How much did the new object's velocity change over how much time?

4. Describe the relationship between mass and acceleration with a constant force.

5. What equation would help us calculate acceleration? What equation helps us calculate Force?

6. Explain what you saw in questions 1 and 2 using the language of Newton's first two laws.

#1		#2	

Station #3: Inclined Plane station

Materials:
Plank
Magnetic Cart
Magnetic Tiles
Blocks
Meter Stick
Tape Measure
Phone

Experiment Procedure:

1. Measure your plank and record the measurement in your notebook
2. Use the blocks to raise your plank up to form an inclined plane and secure the bottom of it with duct tape
3. Measure the angle that your plank is at using a protractor and record it in your notebook.
4. Run the cart down the plank with no tiles, record the event with a slow motion video to determine the speed that the cart goes after it leaves the ramp.
5. Run 2 or 3 more trials where you add more tiles to the cart each time, record each trial
6. Process your video data and determine the velocity of the cart in each case, record this in your notebook.

Example table

Trial #	**# of Tiles**	**Velocity**	**Acceleration**	**Force**

Reflection Questions

1. For each trial calculate the acceleration of the cart using kinematic equations and use this value to determine the force driving the cart down the ramp. Record this in your notebook.
2. Draw a diagram and a free body diagram that describes the forces acting on the cart.

3. What happens to the force and acceleration when the mass of the cart increases (more tiles are added)? Using Newton's laws to explain your results.

Station #4: Newton's 2nd Law station

Materials:
Magnetic Cart
Magnetic Tiles
Tennis Ball
String
Ring Stand
Expo Marker
2 Meter Sticks
Phone

Experiment Procedure

1. Place the cart so that the ball rests at the back of the cart when it is in its equilibrium position (hanging straight down).

2. Pull the ball back to a specific height (as measured by the meter stick), record that height, and then let the ball go so that it hits the back of the cart.

3. Record the motion of the cart with a slow motion camera.

4. Repeat the experiment 2 to 3 more times, adding tiles to the cart each time. Record the motion of the cart in each trail and record the number tiles used. Make sure that you are lifting the ball to the same height each time.

5. Take all tiles off the cart and repeat the experiment 2 to 3 more times. Each time raise the ball to different heights. Record the cart's motion with a slow motion camera and record the height the ball was raised to in each trial.

6. Process your data and determine the velocity of the cart after the impact of the ball.

Example Tables
Changing Mass Experiment
Height of Ball_____________

Trail #	**# of Tiles**	**Velocity**	**Acceleration**	**Force**

Changing Height Experiment

Trail #	**Height of Ball**	**Velocity**	**Acceleration**	**Force**

<u>Reflection Questions</u>

1. For each trial calculate the acceleration of the cart using kinematic equations and use this value to determine the force driving the cart down the ramp. Record this in your notebook.

2. Draw a diagram and a free body diagram that describes the forces acting on the cart.

3. What happens to the force and acceleration when the mass of the cart increases (more tiles are added)? Using Newton's laws to explain your results.

4. What happens to the force and acceleration of the cart when the height of the ball is changed? Using Newton's laws to explain your results.

Station #5 Atwood Machine Station

Materials:
Collision Car
Extra Blocks
Pulleys
String
Weight
Phone
Meter stick

Experimental Procedure
1. Make sure the apparatus is set up so that the collision cart is on the track and the string is run from the cart, down through the pulleys and attached to the 2x4 weight with the hook.

2. At this point the collision car should not have any additional weight on it.

3. Pull the collision car back so that it pulls the weight all the way up. Release the cart and video the resulting acceleration. Also time how long it takes for the cart to move to the end of the track.

4. Record data and any observations in your notebook.

5. Add a block to the collision cart and repeat the experiment. Video and time the carts motion and record any observations in your notebook.

6. If there is time repeat the experiment by adding another block. Video and time the carts motion and record any observations in your notebook.

Example Table

Trial #	**# Blocks**	**Time of travel**

Reflection Questions

1. How did the time of travel for the cart change as you increased the number of blocks?

2. Graph the displacement of the cart vs. time and describe what you see. Is the cart accelerating?

3. Draw a free body diagram for the cart and use Newton's laws and kinematics (words and equations if you can) to explain why the cart moves in the way that it does.

4. Challenge: Calculate the mass of the weight.

Station #6: Newton's 3rd Law Station

Materials:
Newton's Cradle
Optional: Phone

**Important note. It is very easy to break a Newton's cradle. Please be gentle with this one. Do not force the masses, simply pull them out from the group gently and then let them fall.

Experimental Procedure

1. In this lab you will be lifting different numbers of masses and releasing them, then observing what happens when they collide with the remaining masses.

2. Start with 1 mass, lift and release and record what happens in your notebook. If you would like record the motion with slow motion video.

3. Next lift two masses and release them and record what happens in your notebook, video the event if you would like.

4. Continue using different numbers and combinations of masses and record your observations in your notebook.

Example Table

Picture of Scenario	Description of Scenario	Observations

Reflection Questions

1. Look over your observations and write what questions you have about the way the newton's cradle behaved. Is there anything that you could do to test those questions? Briefly describe the experiment and if time permits try it.

2. Identify the 3rd law force pairs in each of your trials.

3. Using what you know of Newton's 3 laws try to explain the phenomenon you observed. Use words, equations, force diagrams, and/or pictures (potentially a diagram!) to help you explain it.