Subject Code	PHY 1	**Physics 1**
Module Code	5.0	**Newton's Laws of Motion**
Lesson Code	5.2	**Activity: Newton's Laws of Motion**
Time Frame		60 minutes

Components	**Tasks**	**TA[1] (min)**	**ATA[2] (min)**
Target	By the end of this activity, the student should be able to: ● compare the time required to accelerate objects of different mass ● relate the net force acting on an object to its mass and acceleration	1	
Hook	We have always been observing motion in our everyday lives. It could be a car as you go to school or just a person doing a mundane task. But sometimes it's hard for us to imagine and connect the knowledge we have about motion to what we usually encounter. How fun would it be to see the values of physical quantities overhead of some objects or persons as we see them on the street as shown in Figure 1. We would immediately know which one is moving faster or which one is accelerating. This would help us better understand the world around us.  ***Figure 1.*** *Track and Field event during Pisay Ugnayan 2019. Retrieved from https://web.facebook.com/Philippine.Science.High.School.System/photos/* Good thing we have computer simulations that help us visualize a variety of physical phenomena. Simulations help us connect the physical world with the Physics we learn in school.	2	

[1] Time allocation suggested by the teacher.
[2] Actual time allocation spent by the student (for information purposes only).

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In this activity we will explore how an applied force influences the motion of an object. We will make use of a simulation toolkit, "**Phet Interactive Simulations**" developed by the research institution University of Colorado Boulder. PHET, or Physics Education Technology, started as a simulation toolkit for Physics but has expanded to many disciplines including Math, Biology, Chemistry and Earth Science.

Currently, Phet has 158 interactive simulations. One of these interactive simulation toolkits is named, "**Forces and Motion: Basics**". Four(4) variations of experiments are included in this simulation but we will only be using the **Motion** simulation variation.

The learning environment of this simulation is shown in Figure 2, with its corresponding elements.

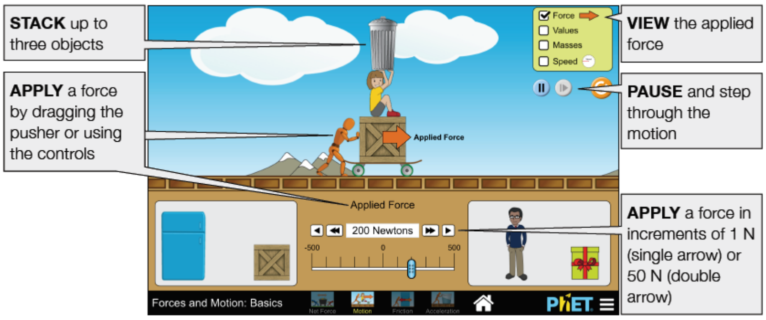

Figure 2. *Phet Forces and Motion:Basics learning environment. Retrieved from: https://phet.colorado.edu/sims/html/forces-and-motion-basics/latest/forces-and-motion-basics_en.html*

Using this toolkit we will be able to explore the relationship between force and acceleration for objects of different mass.

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Navigate

Before we start, we need to prepare the following materials.

Materials Needed:

1. Smart Phone
2. Stopwatch
3. Pen and paper

Procedure:

1. There are 2 ways to access the simulation. The Android app version can be downloaded for free at the Google play store, "**Phet Interactive Simulations**". The Windows version of the simulation, "**Forces and Motion: Basics**",

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can be accessed in the official site of Phet through this link: https://phet.colorado.edu/sims/html/forces-and-motion-basics/latest/forces-and-motion-basics_en.html.

2. There are 4 different variations of simulation under "Forces and Motion: Basics". We will be using the variation **"Motion"**, as shown in Figure 3, for this activity.

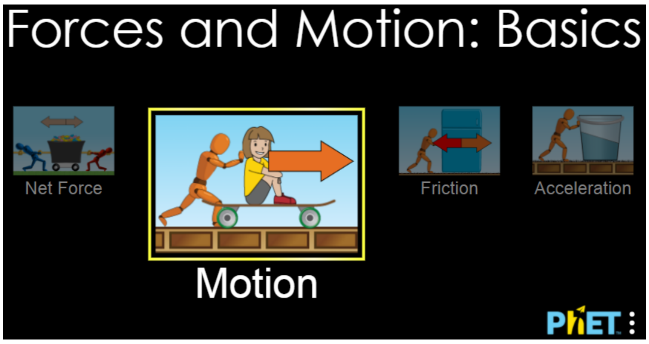

Figure 3. *Forces and Motion: Basics simulation toolkit from Phet.*

After selecting the Motion Simulation, the interface will open as shown in Figure 4 below. Note that friction is ignored in this simulation.

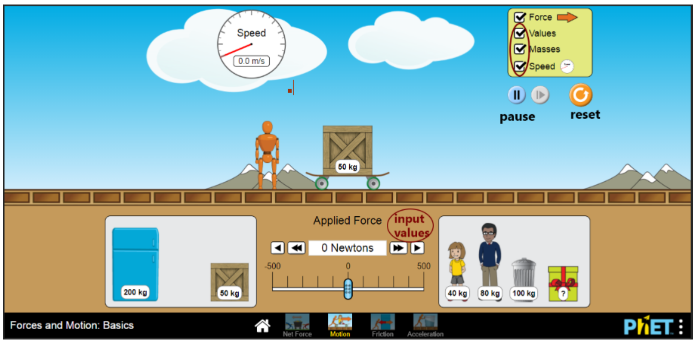

Figure 4. *Labelled parts of the Motion variation of Forces and Motion: Basics simulation toolkit from Phet.*

Part 1. Varying Applied Force

3. Press the reset button before starting the experiment to set the simulation into its default setting. Press the pause button so that the simulation will not start automatically while setting up the experiment.

4. Check the checkbox for values, masses and speed, located at the upper right portion of the screen, to see the respective real-time values during the simulation.

5. Use the default 50 kg box in the simulation for this experiment. Set the applied force to 10 N. Use the arrow to increase or decrease the applied force.

6. Using your stopwatch, record the time for the speed of the box to reach a velocity of $\vec{v} = 5\, m/s$. Start your stopwatch as you press the play button on the simulation toolkit. Record the time in Table 1.

7. Calculate the average acceleration using the formula, $\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$ in which we started at $\vec{v}_0 = 0$ at $t_0 = 0$. Record your calculations in Table1.

8. Pause the experiment again. Set the applied force to zero and then press play to continue the simulation. Take note of your observation.

Table 1. Data Record for Varying Applied Force Experiment.

Trial	Mass	Applied Force	Time to reach $\vec{v} = 5m/s$	Average Acceleration $\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$
1	50 kg	10 N		
2		20 N		
3		30 N		
4		40 N		
5		50 N		

9. Repeat Procedure 3 to 8 for different values of applied force, 20 N, 30 N, 40 N and 50 N. Record your results in Table 1.

Questions and Calculations:
Part 1:

1. As you increase the applied force, what happens to the time it takes for the box's velocity to reach 5 m/s? Is this change linear or not? Why do you think so?

2. By how much factor does the acceleration of the 50 kg mass increase if you increase the applied force from 10 N to 50 N? What does this tell you about the relationship between acceleration and force?

3. What happens to the box when you remove the applied force acting on it? Why?

4. Graph the acceleration vs applied force for all 5 trials. Calculate the slope of your graph. What do you think this slope represents?

5. If you reduce the applied force on an object by 1/4, what do you think will happen to the acceleration of that object?

Part 2. Varying Mass

1. Press the reset button before starting the experiment to set the simulation into its default setting. Press the pause button so that the simulation will not start automatically while setting up the experiment.

2. Check the checkbox for values, masses and speed, located at the upper right portion of the screen, to see the respective real-time values during the simulation.

3. Set the applied force to 50 N. Drag and drop another 50 kg mass on the skateboard so that there is a total of 100 kg.

4. Using your stopwatch, record the time for the speed of the box to reach a velocity of $\vec{v} = 5m/s$. Start your stopwatch as you press the play button on the simulation toolkit. Record the time in table 1.

5. Calculate the average acceleration using the formula, $\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$ in which we started at $\vec{v}_0 = 0$ at $t_0 = 0$
Record your calculations in table1.

6. Repeat step 1-6 for the other masses, 150 kg, 200 kg, 250 kg and the unknown mass. For the 50 kg, you may use your data from Part 1.

Table 2. Data Record for Varying Mass Force Experiment.

Trial	Mass	Applied Force	Time to reach $\vec{v} = 5m/s$	Average Acceleration $\vec{a} = \frac{\Delta\vec{v}}{\Delta t}$
1	50 kg	50 N		
2	100 kg			
3	150 kg			
4	200 kg			
5	250 kg			
6	Unknown mass			

Questions and Calculations:
Part 2:

1. Compare the acceleration of the 100 kg mass and the 250 kg mass which are both subject to the same amount of force (50 N)? By how much factor do they vary?

2. Graph the acceleration vs mass (trials 1-5). Calculate the slope of your graph. What do you think this slope represents?

3. If you increase the applied force on the 250 kg object from 50 N to 200 N, by how much factor will the acceleration of the object increase?

4. Calculate the mass of the gift box (unknown mass).

Knot 	**Conclusion:** Write your conclusion on what you have learned from this activity. Discuss the relationship among mass, force, and acceleration and how these factors affect each other.	3	

References:

1. Young, Hugh D. and Freedman, Roger A. (2012). *University Physics with Modern Physics 13th ed*. United States of America: Pearson Education, Inc.
2. Cutnell, John D. and Johnson, Kenneth W. (2012). *Physics 9th ed*. United States of America: John Wiley & Sons, Inc.
3. Podolefsky, Noah, and Reid, Sam. Forces and Motion: Basics. Retrieved from *https://phet.colorado.edu/en/simulation/forces-and-motion-basics*
4. Newton's Law: Force Interactive. Retrieved from *https://www.physicsclassroom.com/Physics-Interactives/Newtons-Laws/Force/Force-Exercise-1*

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