**Newton’s Third Law[[1]](#footnote-1)\***

**Background**

Newton’s 3rd Law is the law of reactions. That is “every force has another force that is equal in magnitude but opposite in direction.” You might know it more colloquially as *“for every action there is an equal and opposite reaction.”* In this lab, we will work with Newton’s 3rd Law to examine these action-reaction pairs (also known as force pairs).

**Part I - Predictions for Two Carts**

For each diagram shown, cars A and B are tied to each other by a string.

* The arrows show the direction in which the cars are being pulled. Which car, if any, do you think is pulling harder on the string? A or B? Or, do you think it depends on other factors? Explain your choice and your reasoning.

|  |  |
| --- | --- |
| A  B |  |
|  |
| A  B |  |
|  |
| A  B |  |
|  |
| A  B |  |
|  |

**Part II - Data Collection and Analysis for Two Carts**

For this experiment, set up a PASCO track. You will need two silver dynamics carts to use as A and B, and you will also need two force sensors so that one can be attached to each car. Attach the force sensor to the top of the car (indicated by an “**S**” on the diagrams) using the long screw provided.

* In the Capstone program, connect two *Economy Force Sensors* to the 850 Interface. Create a single graph with two lines - a *force vs. time* graph for each sensor.
* For each experiment, connect the two dynamics carts with string as shown, press the RECORD and follow the directions for where to pull on the carts. Sketch the graph created, and explain how the forces compare in each case.

|  |  |  |
| --- | --- | --- |
| Experiment | Graph | Compare F |
| A  B  **S**  **S** |  |  |
|  |
| *Pull A and B away from each other* |
| **S**  **S**  A  B |  |  |
|  |
| *Load B with a mass, then pull A and B away from each other* |
| **S**  **S**  A  B |  |  |
|  |
| *Move A and B to the right with a sharp horizontal pull on B* |
| **S**  **S**  A  B |  |  |
|  |
| *Load B with mass, then move A and B to the right with a sharp horizontal pull on B.* |

* What can you conclude about the forces that the cars apply on the string when they are pulling on each other?
* How are the forces affected by the mass of the carts?
* How are the forces affected by the motion of the carts?
* How do your results compare to your original predictions? If you predicted some incorrectly, explain where your reasoning was not consistent.

**Part III - Predictions for Three Carts**

For each diagram shown, cars A and B are still pulling on strings, but there is a third car between them.

* The arrows show the direction in which the cars are being pulled. Which car, if any, do you think is pulling harder on the string? A or B? Or, do you think it depends on other factors? Explain your choice and your reasoning.

|  |  |
| --- | --- |
| A  B |  |
|  |
| A  B |  |
|  |
| A  B |  |
|  |

**Part IV - Data Collection and Analysis for Three Carts**

For this experiment, set up a PASCO track. You will need two silver dynamics carts to use as A and B, and you will also need two force sensors so that one can be attached to each car. Attach the force sensor to the top of the car (indicated by an “**S**” in the diagrams) using the long screw provided.

* For each experiment, connect the two dynamics carts with string as shown, press the RECORD and follow the directions for where to pull on the carts. Sketch the graph that is created, and explain how the forces compare in each case.

|  |  |  |
| --- | --- | --- |
| Experiment | Graph | Compare F |
| **S**  **S**  A  B |  |  |
| *Put the force sensors on A and B and pull A and B away from each other* |
| **S**  **S**  A  B |  |  |
| *Put the force sensors on A and B and pull A and B to the right with a sharp horizontal pull* |
| **S**  **S**  A  B |  |  |
| *Put the force sensors on A and B, so that they are each measuring a different string. Pull on B with a sharp horizontal force* |

* What can you conclude about the forces that the cars apply on the string when they are pulling on each other?
* How are the forces affected by the mass of the carts?
* How are the forces affected by the motion of the carts?
* How do your results compare to your original predictions? If you predicted some incorrectly, explain where your reasoning was not consistent.

**Summary Question**

Summarize your findings. In particular, pay attention to the differences you noticed between cases. Explain what caused the differences.

**Newton’s Third Law**

**Follow Up Question**

Block A with a mass of is sitting next to block B with a mass of on a frictionless surface. An outside force of  pushes on the left side of block A, as shown in the diagram.

B

A

Fpush

1. Draw three Free Body Diagrams (FBDs) below: one for the whole system, one for block A, and one for block B. On each, include the following information:
   1. the direction of every force on the system/object
   2. above your FBD, draw an arrow showing the direction of the acceleration (or, write ).
   3. draw a coordinate system showing the direction where the x-axis and y-axis increase

B

A

B

A

1. Write out Newton’s 2nd Law equations for both directions for all three FBDs on the facing page. This should give you a total of six equations.
2. Use the equations you’ve found to find:
   1. the acceleration of the system, 
   2. the force between the two blocks, that is, the force on block B from block A, 
   3.  Is FAB = FBA? Explain why they should or should not be.
   4. Is FAB the opposite direction to FBA? Explain why or why not this should be.

1. \* Adapted from a *ScienceWorkshop500* lab by PASCO, Inc. [↑](#footnote-ref-1)