Newton's Third Law

By

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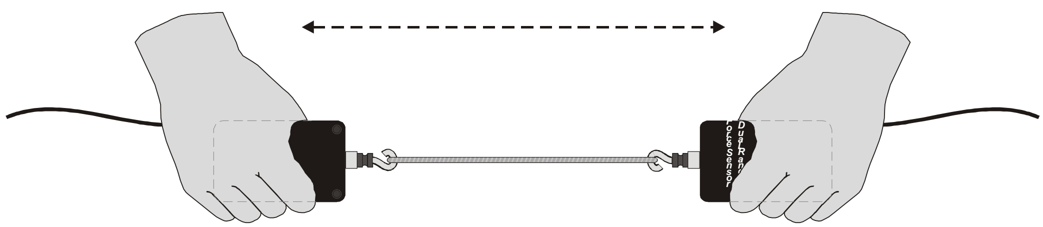
Introduction

Newton's three laws of motion are some of the most important physical concepts in mechanics. Unlike the first two of Newton's laws that deal with a single body, the third law deals with the interaction between 2 bodies two bodies interacting. For example what happens if you pull on your partner's hand? To study this interaction we will use two force sensors as you push or pull them. The result will be displayed on LoggerPro software and this will be a simple example of the application of Newton's third law.



Background

In this lab we will explore Newton's third law which states: "To every action there is an equal and opposite reaction." Where action is the applied force and reaction is the resultant force.

Objective:

- Calibrate two Force Sensors.
- Observe the directional relationship between force pairs.
- Observe the time variation of force pairs.
- Explain Newton's third law in simple language.

Equipment List

-PC computer
-Vernier Data Lab Pro
-LaggerPro software
-Two Vernier Force sensors
-String or rope
-rubber band

Experimental Procedure:
Part 1, acquiring data

1. Connect two force sensors to the LoggerPro Channels 1 and 2. Make sure that the range on the Force sensor is set to 50N
2. Open file named NewtonsThirdLaw on your desktop.
3. The force sensor can only measure force along one direction. If you try to apply force along any other direction the reading will not be meaningful.
4. In this experiment you will be comparing the readings of the two sensors. So we have to make sure that both sensors have the same measurement. In other words we have to calibrate them. To calibrate the sensor place it vertically with hook pointing down. Wait until the reading stabilizes, you can see the readings just above the data tables to the right of icon resembling LabPro. Now hit Zero button to the left of green start button. If you want to check the sensor take 500g mass and hang it on it, the reading should be about 4.9 N. One more thing one of the sensors should read negative value due to the Third Law definition. Right click on one of the sensors and click Reverse.
5. Now connect the two force sensors with a string or a rope provided. Click Collect button. Tug on your partners force sensor with your force sensor. Also make your partner tug on your sensor. What do you see on the graph?
6. What would happen if you used the rubber band instead of the string? Would some of the force get "used up" in stretching the band? Sketch a prediction graph, and repeat Steps 8-9 using the rubber band instead of the string.

Analysis/Questions:

1. Examine the two data runs. What can you conclude about the two forces (your pull on your partner and your partner's pull on you)? How are the magnitudes related? How are the signs related?

2. How does the rubber band change the results—or does it change them at all?

3. While you and your partner are pulling on each other's Force Sensors, do your Force Sensors have the same positive direction? What impact does your answer have on the analysis of the force pair?

4. Is there any way to pull on your partner's Force Sensor without your partner's Force Sensor pulling back? Try it.

5. Reread the statement of the third law given at the beginning of this activity. The phrase *equal and opposite* must be interpreted carefully, since for two vectors to be equal ($\vec{\mathbf{A}} = \vec{\mathbf{B}}$) and opposite ($\vec{\mathbf{A}} = -\vec{\mathbf{B}}$) then we must have $\vec{\mathbf{A}} = \vec{\mathbf{B}} = 0$; that is, both forces are always zero. What is really meant by *equal and opposite*? Restate Newton's third law in your own words, not using the words "action," "reaction," or "equal and opposite."

6. Re-evaluate your answer to the bug-windshield question.

References

[1] Paule G. Hewitt, Conceptual Physics. Prentice Hall, Upper Saddle River, NJ, (2002).
[2] K. Appel, J. Gastineau, C. Bakken, D. Vernier, Physics with Computers. Vernier Software & Technology, Beaverton, Oregon, 3rd Ed., (2003).