NEWTON'S THIRD LAW OF MOTION AND MOTION ITSELF

Essential Question: *What it the relation between Newton's Third Law of motion and how vehicles are able to move?*

RET Laboratory Assignment:
LED Based Sensor System. ENG/Biomedical Engineering and CAS/Physics & Biology: Biological Neuroengineering Laboratory, Boston University, Boston, MA. Summer 2011.

We created a box for the training and testing of the mice in order to later on observe the neurons in the brain when performing activities. This box went through a design process to best suit the mice as well as purpose of the box. The box is specifically designed to test the special abilities of the mice with respect to observing lights that are symmetric on a wall at different distances apart. This project will allow for more information in mapping the neurons in the brain to later help in identifying issues in the brain. With the mapping of the neurons the lab will be able to try and control neuron firing and observe the results to search for medical applications for brain issues in the future.

RET Teacher:	Jessica Leach
School:	Marshfield High School
Town/District:	Marshfield, MA (Marshfield Public Schools)
Subject(s) Taught:	Physical Sciences, Physics, Honors
Subjects Covered:	Physics
Grades Appropriate:	9-12
Lesson Duration:	1 Week (students should be given at least 1 week between being given this lesson and racing the vehicles)

Fundamental Topics: Newton's Third Law of Motion, Interpreting Motion, Friction

Goals/Objectives (Student will):

1. explore Newton's Third Law of motion
2. explore how Newton's Third Law of motion helps us today in moving from location to location
3. investigate different methods on how to use Newton's Third Law of motion to create their own vehicle
4. compare Newton's Third Law of motion to the motions they already know

Background Information:

We use Newton's Laws every day – from traveling to work or school to sitting in a chair – and we can investigate these laws by looking at the world around us. While Newton's first two laws are more intuitive – such as the forces that people feel every day or the motion of a hockey puck – Newton's Third Law is sometimes hard to grasp.

Newton's Third Law – every action has an equal and opposite reaction – completes Newton's Laws of motion. A better way of conveying Newton's Third Law is: "To every action there is always an equal and opposite reaction: or the forces of two bodies on each other are always equal and are directed in opposite directions." What this means is that for every force that is applied there is an equal and opposite force in response. Examples are the friction on our feet which opposes the motion of our feet so we can walk forward (as well as with cars). Friction is a force constantly in action which is used with Newton's Third Law of motion to help everyone travel every day.

Vocabulary and Definitions (including some examples)

Newton's 3rd Law:	$\Sigma F_{a,b} = -\Sigma F_{b,a}$	where $F_{a,b}$ is the forces of B on A and $F_{b,a}$ is the forces of A on B.
Newton's 2nd Law:	$\mathbf{F}=m\mathbf{a}$	where **F**=force, m=mass, **a**=acceleration
Friction:	$\mathbf{F_{fr}}=\mu\mathbf{F_n}$	where μ=coefficient of friction, F_n=normal force

Friction: a force that resists the relative motion of solid surfaces, fluid layers, and materials sliding against each other.

Examples of Friction:

- Static Friction: the friction between two objects that are not moving relative to each other
- Kinetic Friction: when two objects are moving relative to each other and rub together

Misconceptions: (the correct statements)

1. That the action – reaction pair happens simultaneously and not like a series
2. That even though force pairs are equal their consequences are not normally the same.

Links to Massachusetts Physics Frameworks:

1.3 Distinguish between, and solve problems involving, velocity, speed, and constant acceleration.

1.7. Interpret and apply Newton's second law of motion to show how an object's motion will change only when a net force is applied.

1.8. Use a free body force diagram with only co-linear forces to show forces acting on an object, and determine the net force on it.

1.10 Interpret and apply Newton's third law of motion.

Materials Required:

- ❑ Handouts
- ❑ Research materials such as books, access to internet, etc.
- ❑ Students will need to come up with their own for their vehicles at home
- ❑ Make sure to have on hand some meter sticks in case groups want to make measurements

Lesson Procedure

1. Engagement
    a. Have two students volunteer. Then have them stand at the front of the room and with their hands push against each other (make sure that everyone is safe). Then have the students stand/sit on something that has wheels (that is mobile) and have then do the same action again. Have the students then return to their seats.
    b. Have the class take 1-2 minutes and write down what happened as best as they can, including what role forces played in these scenarios.
    c. Then for 1-5 minutes have a brief discussion on what answers the class came up with.
2. Explore*
    a. Students will then be told the challenge for the lesson.
    b. Students should then be put into small groups of 3-4 and allowed to look more into Newton's 3rd Law, friction, and how vehicles propagate.
    c. On their own, each student will make 3 design ideas for their vehicles. These designs will then be brought to the group members for discussion to decide which design is best
3. Experiment**
    a. Students will then build on their own their vehicle to bring to class
    b. In class, these vehicles will be tested in a race to see which can travel the farthest
4. Explanation
    a. After the test the students will be brought together as a whole to discuss the process of designing as well as what physics was involved such as friction.
    b. The teacher will also lead a short discussion on what is involved in Newton's 3rd Law encouraging questions, clarifications, and examples.
5. Closure
    a. Students will be asked to reflect on how successful their designs worked and what changes they would make if it were possible.

*This part can be started in class and if this is a longer term project some of this part can be done at home. Part c should happen at a later time so that the students can come up with design ideas individually and not entirely as a group.
**This should be on a different day at least a week later to allow enough time to build. It is up to how much time is available but how the race is conducted is up to the teacher. It is recommended that each vehicle be given 2-3 tries, that multiple vehicles race at a time, and that the distances be recorded for each vehicle (possibly by a student) to be looked at later.

Assessment Procedures

Students will be assessed on:

- Their teamwork
- Their designs
- How their final vehicle performs
- Classroom participation

Accommodations/Modifications

In classes that need more guidance: there can be a discussion on important points to focus on when

creating a vehicle, possible vehicle designs (as the class as a whole creates) as well as in class time to build the vehicles.

Explorations and Extensions

For a more in depth project:

- Students can test their vehicles on different surfaces and analyze how friction plays a role in the motion of their vehicles
- Students can make Force diagrams and do quantitative problems for the vehicles
- Students can, if not minded, do some collisions and analyze what happens (as a preemption into momentum and conservation of momentum)
- Students can create graphs (distance, velocity, acceleration) for the motion of their vehicles

Lesson Development:

- Explore the basics of Newton's 3rd Law.
- Carry out a race of vehicles.
- Analyze results of the race.
- Discuss what Newton's 3rd Law means and how it is both applied and around us.

Concerns:

The point is to have students thoughtfully and creatively approach this project, however many students will attempt to build vehicles like those that they see around themselves (like cars). The concern is to cause students to be more creative and inventive with this project. Another is the correct understanding of Newton's 3rd Law and how the 'action-reaction' pair is not something that is delayed but simultaneous.

References and Resources:

Problem Based Learning (New England Board of Higher Education): http://www.pblprojects.org
(The worksheets for this project are based off of the tool kit in problem solving from this website)

Physics classroom: http://www.physicsclassroom.com/class/newtlaws/u2l4a.cfm
Offers a description of the law with examples as well as a couple of test questions, links for extension, and has worksheets available

Bill Nye, First aired November 18, 1989 copyright King 5:
http://www.youtube.com/watch?v=NRKmJgIokxg
Demonstrates an experiment of Newton's 3rd Law and then relates the actions of his experiment to conservation of energy and describes the relationship of the variables.

Zona Land by Edward A. Zobel :
http://zonalandeducation.com/mstm/physics/mechanics/forces/newton/newtonLaw3.html
This one has a good animation of the law in action for the students to observe.

NASA rocket propulsion tie in: http://microgravity.grc.nasa.gov/education/rocket/newton3r.html
This is useful in preparing alternate activities for this lesson with more control.