Newton's First and Second Laws of Force and Motion
A Short Unit Plan

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SCED 491 Fall 2007
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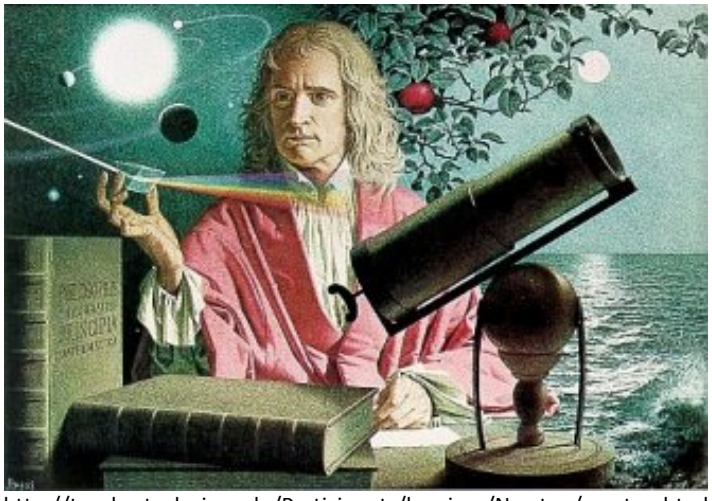

http://teachertech.rice.edu/Participants/louviere/Newton/newton.html

An Introduction to Newton's Laws of Force and Motion
A Short Unit Plan

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Purpose:

In this short unit plan designed for 7th grade physical science students we will examine two of the most basic principles of motion know as **Newton's first law: inertia** and **Newton's second law: Net force acting on an object = (mass of the object)(acceleration of the object).** Using guided inquiry, collaborate idea building, free body diagrams and by demonstration students will model, observe, document and discuss these forces in action to further their understanding of the properties that comprise and influence forces.

Rational:

In 6-8 grades, Project 2061 Benchmarks for science states:

> Most early adolescents have a more immediate interest in nature than in the philosophy of science. They should continue to be engaged in doing science and encouraged to reflect on the science they are engaged in, with the assumption that they will later acquire a more mature reflection on science as a world view.
>
> By this level, student investigations should be more professional than could reasonably be expected in the elementary grades. Students must assess the risks associated with an investigation before being given permission to proceed. Students should now be using computers as scientists use them-namely to collect, store, and retrieve data, to help in data analysis, to prepare tables and graphs, and to write summary reports. Students should have the opportunity to work on investigations in which they can use computers to communicate with students elsewhere who are working on the same problems.
>
> Student investigations ought to constitute a significant part-but only a part-of the total science experience. Systematic learning of science concepts must also have a place in the curriculum, for it is not possible for students to discover all the concepts they need to learn, or to observe all of the phenomena they need to encounter, solely through their own laboratory investigations. And even though the main purpose of student investigations is to help students learn how science works, it is important to back up such experience with selected readings. This level is a good time to introduce stories (true and fictional) of scientists making

discoveries-not just world-famous scientists, but scientists of very different backgrounds, ages, cultures, places, and times.

Students in early adolescence need to see science and science-related careers as a real option for themselves personally.

Goals and Objectives:

Reference to the study of force and motion is made in the state Essential Learning Requirements (EALR's) and the National Science Education Standards (NSES) for grade levels 6-8 In the Force and Motion and physical science sections.

EALR: 1. SYSTEMS: The student knows and applies scientific concepts and principles to understand the properties, structures, and changes in physical, earth/space, and living systems.

Component: 1.3. Changes: Understand how interactions within and among systems cause changes in matter and energy.
Nature of Force - 1.3.1. Understand factors that affect the strength and direction of forces. Observe and describe factors that affect the strength of forces (e.g., an object with a greater mass has a greater gravitational force [weight]; certain types of magnets have greater magnetic forces; a larger muscle can pull with a greater force). Describe how forces acting on an object may balance each other (e.g., the downward force of gravity on an object sitting on a table is balanced by an upward force from the table).

Forces to Explain Motion - 1.3.2. Understand how balanced and unbalanced forces can change the motion of objects. Describe how an unbalanced force changes the speed and/or direction of motion of different objects moving along a straight line, 2nd Law of Motion (e.g., a larger unbalanced force is needed to equally change the motion of more massive objects). Describe how frictional forces act to stop the motion of objects. Investigate and describe the balanced and unbalanced forces acting on an object (e.g., a model car speeding up on a table has both an unbalanced force pulling it forward and a gravitational force pulling it down balanced by the table pushing upward).

EALR: 2. INQUIRY: The student knows and applies the skills, processes, and nature of scientific inquiry.
Component: 2.1. Investigating Systems: Develop the knowledge and skills necessary to do scientific inquiry.

Grade Level Expectation: 2.1.4. Analyze how models are used to investigate objects, events, systems, and processes. Create a model or computer simulation to investigate and predict the behavior of objects, events, systems, or processes (e.g., phases of the

Moon using a solar system model). Explain the advantages and limitations of investigating with a model.

The NSES state:

> **Motions and forces:** The motion of an object can be described by its position, direction of motion, and speed. An object that is not being subjected to a force will continue to move at a constant speed in a straight line. Unbalanced forces will cause changes in the speed or direction of an object's motion.
>
> **Transfer of energy**: Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.

Assessment

Pre-assessment will be used to draw out students preconceptions regarding forces and motion sparking discussion and interest before students participate in demonstrations and labs. It will also be used as a tool to aid the instructor in adjusting the curriculum and differentiate instruction drawn from the responses to the pre-assessment activity and classroom discussion.

Formative assessment: Sample exit slip activity

Demonstration: Laser on Table

Materials Needed: Laser pointer, book, and table

Procedure: Laser shows that the table does indeed flex and exert a force on the book. Guide discussion to elucidate how the table is not just "in the way" of the book but that it is exerting a force on the book.

Safety Issues/Concerns: Review basic safety for labs and demo emphasizing why not to shine a laser someone's eyes.

Have students story board forces exerted on book and table.

Summative assessment: An exam in two parts

First students will answer conceptual questions about Newton's Laws. Students will demonstrate their understanding in short answer applying the concepts of force, motion, rest, inertia, friction, velocity, acceleration and the influence of mass upon a given system. Sketches of forces and explanations of cartoons are to accompany answers. The second half will assess the application of these concepts to real life situations and will utilize free body diagrams and story boards to demonstrate their understanding.

Extension:

Included on the resource page is a link to a physics classroom tutorial and a couple of links to physics WebQuests. These provide background information helpful to both student and educator alike. Students who would like something to review outside of the text or use as a tool to augment in class activities and lecture can access these sites to

deepen their understanding. Students looking for an additional challenge to demonstrate understanding can use these links for just that. During the unit on Newton's Third law and/or that of simple machines I would ultimately like to engage students in the WebQuest activities.

Calendar

70-minute class period

Day 1	**Pre-Assessment**
Instructional Activities	Introduction to forces w/vector review **Discussion:** Forces What are they? How do they work? **Demo**: Laser on Table **HW:** Complete reading and guided notes
Assessment	**Pre-Assessment activity**: Forces **Participation** in discussion **Exit slip:** on demo
Day 2	**Lab: Force and Motion**
Instructional Activities	**Discussion/Lecture:** objects at rest and in motion Address preconceptions from previous day's assessments. Illustrate concepts using Free Body Diagrams. **Lab:** Force and Motion **HW:** Complete take home concept handout
Assessment	**Exit slip**: story board
Day 3	
Instructional Activities	**Finish Lab.** **Demo: "**Hunting Monkeys" **Discussion/Lecture:** motion graphs and inertia **HW:** Complete take home concept handout
Assessment	**Exit slip:** on demo
Day 4	**Lab: Force and Mass**
Instructional Activities	**Demo:** Soda can and Brick **Discussion/Lecture:** opposing forces and real world apps. **Lab:** force and mass **HW:** Prepare for exam
Assessment	Review previous day exit slips. Solicit concerns for the final assessment. Address misunderstanding and misconceptions regarding concepts of Newton's first two laws. Work out ideas during final lab for unit.
Day 5	**Summative-Assessment**
Instructional Activities	**Final Thoughts:** -Forces and motion -Force and mass **Demo:** Students in roller chairs *Preview of Newton's third law after final assessment
Assessment	**Final Assessment**

Physics: Forces and Motion Unit

Day 1: Forces
Objectives: Have students explore what forces are and when and where they occur. Draw out preconceptions and demonstrate how forces act upon objects. Learn to utilize free body diagrams (FBDs)

Materials	Assessment
□ 30 Copies of Pre-assessment □ 30 Copies of Exit slips □ 30 Copies of guided notes □ Spring □ Laser Pointer	Participation in classroom discussion Pre-assessment force probe Exit Slip

Time	Teacher's Notes	Students Role
7 min	Welcome students back and take attendance. Explain to students that they will be taking a pre-assessment for the up coming unit on force. This will allow them to record their initial ideas about force and will help me prepare for future class discussions.	*Get seated and get pencil and science notebook out.*
20 min	Administer probe and monitor class and provide support.	Maintain testing environment.
10 min	Slam book on table to end probe and ask students to describe the forces acting on the book with partner and then with class. Generate discussion to dial into common themes and develop ideas regarding forces.	Participate in discussion. Take notes in science notebook (encourage sketching).
10 min	Guide discussion and introduce to students the idea that all objects can exert a force. Repeat demo with the book using a spring and discuss the relationship between the book and the spring when compared to that of the book and the table.	Participate in discussion. Take notes in science notebook.
5 min	Do the final demo with a table and laser showing that the table does indeed flex and exert a force on the book.	Participate in discussion.
10 min	Go over a FBD of the book on the table. Explain that the length of the arrow is proportional to the strength of the force.	Include in science notebook.
8min	Give them their exit slip instructions to draw a FBD of all the forces acting on a student sitting on their chair and explain why they included each force they have drawn. Assign reading and remind students to pick up a guided notes sheet on their way out.	Complete exit slip and turn in before leaving class.

Name: _____

Pre-assessment Force Probe

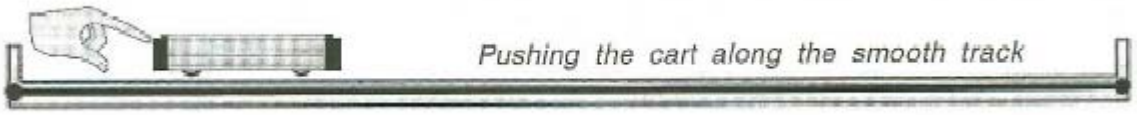
1) To the best of your ability define the concept of a **Force.** What is it? How is it exerted? And any other information you want to include. Draw pictures to help explain your ideas.

2) To the best of your ability define the concept of a **speed**. What is it? Any other information you want to include. Draw pictures to help explain your ideas.

3) To the best of your ability define the concept of a **velocity**. What is it? How is it different from speed? And any other information you want to include.
Draw pictures to help explain your ideas.

4) To the best of your ability define the concept of **inertia**. What is it? How is it exerted? And any other information you want to include.
Draw pictures to help explain your ideas.

Imagine the following situation:
Examine the diagram as it will be used to answer the following questions.



5) What do you have to do to make the cart move at a **constant** speed? Assume negligible friction.

a) Give it a push from behind and immediately let go.
b) Maintain a constant push.
c) Continually increase the strength of the push.
d) Continually decrease the strength of the push.
e) Something else.

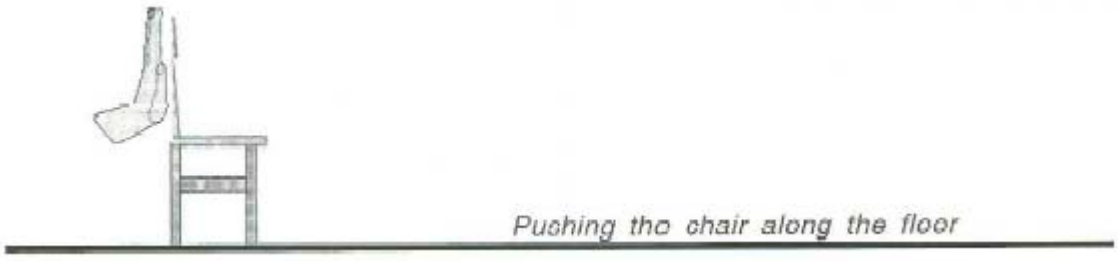
In the space below **explain** your choice.
Draw pictures to help explain your ideas.

6) Instead of maintaining a constant speed you now want to **continuously increase** the cart's speed. What do you have to do to make this happen?

a) Give it a push from behind and immediately let go.
b) Maintain a constant push.
c) Continually increase the strength of the push.
d) Continually decrease the strength of the push.
e) Something else.

In the space below **explain** your choice.
Draw pictures to help explain your ideas.

Imagine the following situation:
Examine the diagram as it will be used to answer the following questions.



7) What do you have to do to make the chair move at a **constant** speed?

a) Give it a push from behind and immediately let go.
b) Maintain a constant push.
c) Continually increase the strength of the push.
d) Continually decrease the strength of the push.
e) Something else, you describe it.

In the space below **explain** your choice.
Draw pictures to help explain your ideas.

8) Instead of maintain a constant speed you now want to **continuously increase** the chairs speed. What do you have to do to make this happen?

a) Give it a push from behind and immediately let go.
b) Maintain a constant push.
c) Continually increase the strength of the push.
d) Continually decrease the strength of the push.
e) Something else, you describe it.

In the space below **explain** your choice.
Draw pictures to help explain your ideas.

9) If **A** and **B** are two objects with masses of 100 kg and 75 kg respectively, then

a) Both will have the same inertia
b) **B** will have more inertia
c) **A** will have more inertia
d) Both will have less inertia

In the space below **explain** your choice.
Draw pictures to help explain your ideas.

10) If **A** and **B** are two objects with masses 100 kg and 75 kg respectively, then

a) Both will have the same inertia
b) **B** will have more inertia
c) **A** will have more inertia
d) Both will have less inertia

In the space below **explain** your choice.
Draw pictures to help explain your ideas.

Exit Slip: Laser Demo

A) Describe what happened during the demo. Draw pictures to help explain your ideas.

B) Can you think of another everyday example where this might occur?

C) List three places that forces might be acting (even if you can't see them).

Guided notes (Day 1 Reading)

What is a force?

What is the unit used to measure force?

What are some common forces?

How do we represent forces?

What are some examples of forces given by the book?

How are forces exerted?

If an object is at rest does it have forces acting on it?

Questions and Notes

Physics: Forces and Motion Unit

Day 2: Newton's First - Objects at Rest
Objectives: Learn about objects at rest and in motion through lab inquiry. **Pre conceptions addressed:** Only animate objects can exert a force. Thus, if an object is at rest on a table, no forces are acting upon it. Force is a property of an object. An object has force and when it runs out of force it stops moving. A force is needed to keep an object moving with a constant speed.

Materials	Assessment
☐ 30 copies of concept handout ☐ 30 copies of Forces and Motion ☐ Have computers up and running well before beginning of lab. ☐ Tape	Participation in Lab and Discussion Lab worksheet Concept handout

Time	Teacher Notes	Students
5 min	Welcome the students into the class and take attendance. Hand back force probe.	Review force probe. Prepare to ask questions regarding returned probe.
15 min	Review force probe. Allow for questions and brief discussion, address common ideas and prepare students for activity. Link ideas from previous lecture and discussion to lab.	Participate in discussion, annotate probe, attach probe to science notebook
40 min	Review lab procedures and expectations. Get students started on lab: Forces and Motion	Go to lab stations. Work on lab.
5 min	Have students clean up from lab and pick up a concept handout.	Clean up. Prepare for closing activity.
5 min	Concept handout due next class period.	Pick up handout.

F&M Activity II-D1

How Can You Keep an Object at Rest?

Name:

Group:

Class Period:

If you have ever watched a game of tug-of-war, you have seen the rag that marks the center of the pull rope move back and forth. Sometimes, however, the rag will stand still. What is happening? How can there be no movement with both teams pulling?

Materials: spring scale

- In this cycle we will study forces and the effects they have on the motion of objects. We will begin, however, by considering the conditions necessary to keep an object at rest.

- There are different ways of defining what a force is, but one common definition is that a force is a push or a pull. Spring scales and bathroom scales are two devices that are commonly used to measure the strength of forces.

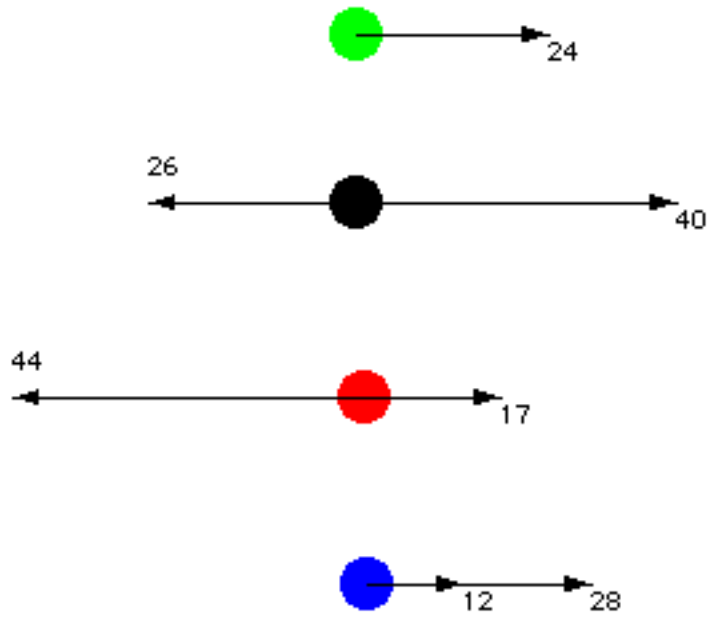
- Hold a spring scale by the closed loop end and pull on the hook end. Pull with different strengths. Note that the scale measures force in units called Newton's or N for short. (Another unit of force, used in the United States, is the pound. Bathroom scales typically measure force in pounds.)

- We can represent forces by drawing **force arrows**. A force arrow is used as a convenient way to represent the strength and direction of the force (push or pull) that one object exerts on another object. The arrow head points in the **direction** of the force, and the length of the arrow is proportional to the **strength** of the force. We always try to draw the arrow so that part of it is actually touching the object on which the force is exerted. We also label the arrow, indicating which other object is exerting the force on the given object. For example, if you pulled on the spring scale with a force of 4 N, and then pulled with a force of 8 N, you might represent that as follows.

- Suppose several people are pushing simultaneously on an object sitting on a smooth table. They all push either to the left or to the right, but with different strengths. Despite all these pushes, you observe that the object remains at rest. What can you say, if anything, about the relationship between all these pushes?

- Below is a picture of four different objects represented by colored disks. Each object has one or two forces acting on it. Each of the forces is represented by an arrow, and the number alongside the head of each arrow represents the strength of that force. So, for example, a single force of strength 24 N is pulling the top (green) object to the right. Two forces are acting on the black object: one of strength 40 N is pulling to the right, and simultaneously another one of strength 26 N is pulling to the left. For the red object, a 17 N force is pulling to the right and a 44 N force is pulling it to the left. Finally, for the blue object, a 12 N force is pulling it to the right, and a 28 N force is also pulling it to the right at the same time.

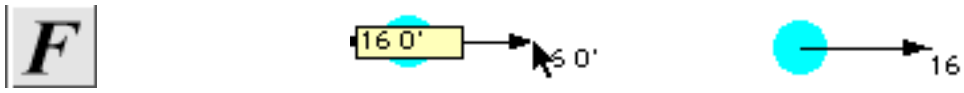
Imagine you wanted to guarantee that each of these four objects would remain motionless (at rest). **Predict** the direction and strength of the additional force you would have to apply, if any, to each of these four objects so the combination of your new force plus the ones already exerted would result in the object remaining at rest. Represent your predictions by drawing the appropriate arrow on each of the four objects, and label its strength, including units.



How did you decide what should be the direction and strength of the forces you chose?

- To **test** your predictions you will use the Simulator. When you first open the simulator, turn it ON and watch the objects move. Then turn the simulator off and rewind it. After that, return to this document for additional instructions. To get to the simulator, click here: Act II-D1 Sim.

- In order to see if your predicted forces are okay you will add the force to each object and then run the simulator to see if the objects remain motionless or move. To add a force to an object you first click on the Force button below the set-up window. (See left picture below.) Then click on the object of choice and drag out the force arrow. As you do this, a small window appears over the object showing the strength and direction of the arrow. (See middle picture, where the strength is 16 N and the direction is 0 degrees.) Let go of the arrow when you have the appropriate strength and direction. (See picture below to the right.) If you want to change your arrow, first click on the pointer arrow, then click on the force arrow you drew and drag it to the desired length and direction.



Do this for all the objects, using your predicted forces, then turn on the simulator. If the objects remain motionless, you have been successful in your predictions. If one or more of the objects begin moving, change the forces. Take a snapshot of objects when you are successful and paste it below.

- Now that you have used the simulator to check your idea, write (or perhaps re-write) a general statement (criterion) that tells how the strengths and directions of the forces acting on an object must be related if the object at rest is to remain at rest.

- Two or more forces that, when acting simultaneously on an object, meet your criterion stated above, are said to be "**balanced**." If the criterion is not met, the forces acting on the object are said to be "**unbalanced**."

- **Imagine** two students, Marcia and Mark, are discussing what they expect would happen when several different forces are acting simultaneously on an object.

Marcia: "The strongest force is all that counts. It dominates the others. When several forces act on an object, the object will be influenced only by the strongest force."

Mark: "No, you cannot ignore the other forces. They all have an influence. What you have to do is simply add the strengths of all the individual forces to come up with the total force."

Do you agree with Marcia, with Mark, with both, or with neither? **Explain** your reasoning.

- Check your response to the previous question with at least one other group. Was the other group's thinking similar to yours, or different (and if so, how)?

- Open your **Cycle II Idea Journal**. Add or modify statements under the following ideas: **Object at Rest Idea**; **Combining Forces Idea**. Add additional ideas as you see fit.

Physics Concept Handout (Newton's first)

What are the **three** parts to **Newton's first law**?

What is the **difference** between **velocity** and **speed**?

Is a **force** required to keep an object in motion? Is a **force** required for an object to accelerate?

You feel the effects of inertia every day.
Can you think of a relationship between **inertia** and seatbelts?

What physical property(ies) does **inertia** depend on?

So if **Newton's 1st Law** says an object in motion will stay in motion, why do so many objects (like a rolling ball) slow down and come to a rest?

If objects in motion are slowing down, according to **Newton's first law**, what must be acting on it?

Physics: Forces and Motion Unit

Day 3: Objects in Motion
Objectives: Learn about objects at rest and in motion. Utilize free body diagrams (FBDs). **Pre conceptions addressed:** The only "natural" motion is for an object to be at rest. A force is needed to keep an object moving with a constant speed. If an object is at rest, no forces are acting on the object.

Materials	Assessment
Shooting Monkey Apparatus Have computers up and running well before beginning of lab. 30 copies of concept handout	Participation in classroom discussion Whiteboard FBD's activity Exit slip Concept handout

Time	Teacher Notes	Students
5min	Welcome the students into the class and take attendance.	Prepare to complete lab. Get science notebook.
15 min	Finish lab on Force and motion.	Work on lab.
5 min	Have students clean up from lab and prepare for "shooting monkeys" activity.	Clean up. Prepare science notebook for activity and note taking.
10 min	Start discussion on "shooting monkeys". Have students offer ideas and illicit solutions to problems posed, probe conceptual understanding of forces.	Participate in discussion. Take notes in notebook.
5 min	Have students work independently to come up with a hypothesis. Students will record their hypothesis in their notebook so that they can refer to it later.	Work individually on hypothesis and maintain a quiet working environment.
10 min	Do the "shooting monkey" demo. Have students share their hypothesis. Go over the FBD of the bullet and the monkey to show students the physics of the problems.	Participate in discussion. Take notes using FBD's
15 min	Transition into lecture about objects at rest and how we can find the forces acting on any object. Use a multi-system example. Get students involved by having them use FBD's' to answer problems on the white board. Pass out exit slip allowing the last five minutes to fill out exit slip.	Participate in discussion. Take notes using FBD's.
5 min	Exit slip due at end of class. Concept handout due next class period.	Turn in exit slip. Pick up concept handout.

Exit Slip: Hunting Monkeys

Draw a story board of all the forces that were acting on the monkey and the bullet.

Physics Concept Handout (Object at Rest)

List two different ways an object can be at **rest** (from a force's viewpoint).

What is the difference, if there is, between an object moving at a **constant speed** and an object **at rest** (again from a force's viewpoint)?

Is a **force** required to keep an object in **motion**?

If an object has 5 Newtons of force pulling it to the right, and 4 Newtons pulling the object to the left:

A) Will the object move?

B) If it moves in what direction?

C) Would it be **accelerating**? Or be moving at a **constant speed**?

Physic: Forces and Motion Unit

Day 4: Newton's Second (F=ma)
Objectives: Learn about opposing forces and real world applications. Learn about force and mass. Be able to utilize free body diagrams (FBDs) **Preconceptions addressed:** Large objects exert a greater force than small objects. Velocity is another word for speed. An object's speed and velocity are always the same. Acceleration always means that an object is speeding up. Acceleration is always in a straight line. Acceleration always occurs in the same direction as an object is moving.

Materials	Assessment
30 copies of Objects at Rest soda can and two lead bricks	Participation in classroom discussion Whiteboard FBD's activity Exit slip

Time	Teacher Notes	Student
5 min	Welcome the students into class and hand back the marked exit slips. Have them prepare for lab.	Grab marked slips and have a seat. Get science notebook and prepare for lab on force and motion.
15 min	Demo: soda can and lead bricks Start discussion on the soda can and two lead bricks demo. Have students offer ideas and solutions to the problems, probing conceptual understanding of forces. Use white boards to illicit ideas and illustrate examples of inertia.	Participate in discussion. Take notes
40 min	Review lab procedures and expectations. Get students started on lab: Force and Mass	Work at lab station. Do activities 1-5
5 min	Have students clean up from lab and pick up a concept handout.	Clean up. Prepare for closing activity.
5 min	Give them their exit slip and concept handout. Exit slip due on their way out concept handout due next class period.	Complete exit slip; grab handout.

F&M Activity II–D5

What Effects do Force and Mass Have on Motion?

Name:

Group:

Class Period:

When shopping for groceries, you start out with an empty cart but it slowly fills up as you get more and more food. Does the weight of the cart affect its motion? Do you need to change how you push a full cart to get the same motion as with an empty cart?

Materials: 2 carts, 2 or 3 fan units, track, wooden holder to mount fan units, heavy blocks

Part I: Exploring the effects of unbalanced force and mass on motion

In previous activities you have seen that an object has an acceleration when there is an unbalanced force acting on it. In the first part of this activity we want you to do some of your own experiments with the fan units and carts. Your task is to use your observations to propose an idea for **how the acceleration of an object is affected by the strength of the unbalanced force acting on it, and it's mass**. (We will use the term "mass" to refer to the amount of stuff contained in an object. It is related to the "weight" of the object.)

If you want, you can use a second or third fan unit with the cart **(but no more than three)** to make forces with more strength. When using two or three fan units, however, you need to stack one cart on top of another, and use the special wooden holder for mounting the fan units.

Remember that to draw a conclusion about how one variable affects another; you must keep all other variables constant. Thus, if you want to see how the force affects the acceleration, you need to keep the mass constant. If you want to see how the amount of mass affects the acceleration, you need to keep the force constant.

(If the MBL equipment is available, you might also wish to carry out part of your experiment with the MBL equipment.)

Describe your experiments and your observations below. Then, **state your summary idea(s) relating acceleration, unbalanced force, and mass**.

Part II: Exploring the effects of mass

1. For the moment, remove the fan units from the carts and put them aside.

2. Give an empty cart a shove to get it moving and feel how much effort is involved. Then,

place the two blocks in the cart, and again give it a shove.

a. How does the effort to get the cart moving with the extra blocks compare to the effort without the blocks?

b. Why do you think there is a difference?

c. All objects have a tendency to resist getting started (and speeding up), some more so than others. Some people have referred to this property as the "holding back" property of objects. Which of the two objects (cart without blocks, or cart with blocks) seems to have a greater **"holding back"** property?

3. Remove the blocks from the cart, and place your hand about 50 cm from the cart. Another group member should give the cart a shove and you should stop it with your fingers, noting the effort required. Then, place the two blocks in the cart, and the other group member should again give it a shove so it would have about the same speed as before.

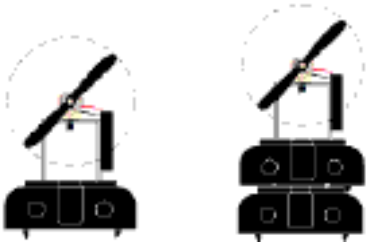
a. How does the effort to stop the cart from moving with the extra blocks compare to the effort without the blocks?

b. All objects have a tendency to resist being stopped (and slowing down), some more so than others. Some people have referred to this property as the "keep going" property of objects. Which of the two objects (cart without blocks, or cart with blocks) seems to have a greater **"keep going"** property?

4. After your experiments in Part I of this activity, what can you say about the affect on the acceleration of an object when you add more mass to it (keeping the unbalanced force the same)? Remember that the acceleration is the rate at which the speed changes.

5. **Explain** your findings from Part I in terms of the "holding back" or "keep going" property of the object.

6. For this step you should share your equipment with another group. Suppose you set up fan units on two tracks. On one track you place one fan unit on top of one cart. On the other track you place one fan unit on top of two stacked carts (or, one fan on top of a cart with some heavy blocks placed in it). See picture.



7. **Imagine** turning both fan units on, and then giving each an **equally strong push** in the direction **opposite** to the direction the fan units would move the carts by themselves. **Predict** whether the single cart or double cart set-up (if either) will slow down more quickly.

How did you decide? Justify your answer in terms of either the "holding back" or "keep going" property of objects.

8. **Test** your prediction by carrying out the experiment with another group. **Be careful, and don't forget to wear gloves**. In this experiment you are assuming that the two fans provide identical strength forces to the carts. To ensure that your two fans are providing forces that are approximately the same strength, turn both on and listen to see if they sound pretty much the same. If not, then try to exchange one of your fans for another one, until you have two that seem to sound about the same, and hence would provide about the same strength of force.

Which unit, if either, slows down more quickly?

Was your prediction confirmed? If not, how can you make sense of the results?

9. The "keep going" and "holding back" properties of an object can be combined into a single property we can call the "resistance to change in motion property" (also known as the **"inertia"** property.) Does it make sense that the amount of **mass** of an object is a quantitative measure of the significance of this property? (For example, does it make sense that the more mass an object has; the more difficult it is to change its motion?)

10. Open up your **Cycle II Idea Journal**. Based on evidence gathered in this activity, add or modify the following: **Mass Idea**; **Motion with an Unbalanced Force Idea**.

Exit Slip: Soda can and brick

A) What was different when the can held the brick, and when it got crushed by the brick?

B) Were the forces the same in both situations? Why or why not?

Physic: Forces and Motion Unit

Day 5: Summative Assessment
Objectives: To assess students understanding of force, motion, rest, inertia, friction, acceleration and velocity and the influence of mass on a given system.

Materials	**Assessment**
30 copies of Final unit assessment	Summative assessment

Time	**Teacher Notes**	**Student**
5 min	Welcome the students into class. Have them prepare for exam.	Prepare for exam
45 min	Administer Summative assessment.	Take Exam
5 min	Debrief unit and exam.	Participate in discussion
15 min	Preview up and coming unit on Newton's Third Law. Congratulate students on a job well done and acknowledge their hard work and thank them for their participation and effort to better understand some difficult concepts.	Have a great weekend

Resources

Driver, Rosalind (Ed.). (2000). *Children's Ideas In Science*. Philidelphia, Penn: Open University Press.

Children's Misconceptions about Science: A list compiled by the Operation Physics Elementary/Middleschool Physics Education Outreach Project of the American Institute of Physics. Author/editor is unknown. Thanks to Bill Weiler of U. Illinois for posting this via the PHYS-L group 9/1998.

Constructing Physics Understanding (CPU), Summer 1998, Motion and Force Activity II-D1 How can you keep and object at rest?

Constructing Physics Understanding (CPU), Summer 1998, Motion and Force Activity II-D5 What Effects do Force and Mass have on Motion?

Robertson, Ph.D, W (2002). *Stop Faking It! Force and Motion*. Arlington, Virginia: NSTA.

Pretest: Constructing Physics Understanding (CPU), Summer 1998, Motion and Force Activity II-E Connections between Force and Motion.

Project 2061 Benchmarks

The Physics Classroom Tutorial Website
http://its.leesummit.k12.mo.us/science.htm#Laws_of_Motion

WebQuest for Newton's Laws of Motion
http://www.uvm.edu/~inquiryb/webquest/fa06/mmarshal/

Simple Machines WebQuest
http://outreach.rice.edu/~dgabby/science/simp_mach/