Force & Motion

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TD 513
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Unit Cover Page

Unit Title: Force and Motion
Grade Level: 5th
Subject/Content & Topic Area(s): Physical Science/Force

Key Words:

- Critically Important/State Assessable: force, balanced force, force strength, mass, relative position, direction of motion, unbalanced force, zero net force, non-zero net force, change of motion, change of direction, magnetic attraction, magnetic repulsion, gravitational force, graph, friction.

- Instructionally Useful: applied force, Newton's Law of Motion, acceleration, kinetic energy, mechanical motion, pulley, deceleration, inertia, velocity, magnitude, lever, inclined plane, simple machine.

Designed By: Melissa Crawford/Prima Dailey/Sarah Gerding/Jennifer Ladd/Krista Miller/Andrea Whan
Time Frame: 5 weeks

Summary of Unit (Benchmarks, Standards & Unit Goals)

Science Inquiry Process:

K-7 Standard S.IP: Develop an understanding that scientific inquiry and reasoning involves observing, questioning, investigating, recording and developing solutions to problems.

Content Statement
S.IP.M.1: Inquiry involves generating questions, conducting investigations, and developing solutions to problems through reasoning and observation.

S.IP.05.11: Generate scientific questions based on observations, investigations, and research.
S.IP.05.12: Design and conduct scientific investigations.
S.IP.05.13: Use tools and equipment (spring scales, stop watches, meter sticks and tapes, models, hand lens) appropriate to scientific investigations.
S.IP.05.14: Use metric measurement devices in an investigation.
S.IP.05.15: Construct charts and graphs from data and observations.

Science Inquiry Analysis & Communication:

K-7 Standard S.IA: Develop an understanding that scientific inquiry and investigations require analysis and communication of findings, using appropriate technology.

Content Statement
S.IA.M.1: Inquiry includes an analysis and presentation of findings that lead to future questions, research, and investigations.
S.IA.05.11: Analyze information from data tables and graphs to answer scientific questions.

S.IA.05.12: Evaluate data, claims, and personal knowledge through collaborative science discourse.
S.IA.05.13: Communicate and defend findings of observations and investigations using evidence.
S.IA.05.14: Draw conclusions from sets of data from multiple trials of a scientific investigation.

Science Reflection & Social Implications:

K-7 Standard S.RS: Develop an understanding that claims and evidence for their scientific merit should be analyzed. Understand how scientists decide what constitutes scientific knowledge. Develop an understanding of the importance of reflection on scientific knowledge and its application to new situations to better understand the role of science in society and technology.

Content Statement
S.RS.M.1: Reflecting on knowledge is the application of scientific knowledge to new and different situations. Reflecting on knowledge requires careful analysis of evidence that guides decision-making and the application of science throughout history and within society.

S.RS.05.15: Demonstrate scientific concepts through various illustrations, performances, models, exhibits and activities.

Science Content Statement:

K-7 Standard P.FM: Develop an understanding that the position and/or motion of an object is relative to a point of reference. Understand forces affect the motion and speed of an object and that the net force on an object is the total of all of the forces acting on it. Understand the Earth pulls down on objects with a force called gravity. Develop an understanding that some forces are in direct contact with objects, while other forces are not in direct contact with objects.

P.FM.M.3: Force- Forces have a magnitude and direction. Forces can be added. The net force on an object is the sum of all of the forces acting on the object. The speed and/or direction of motion of an object changes when a non-zero net force is applied to it. A balanced force on an object does not change the motion of the object (the object either remains at rest or continues to move at a constant speed in a straight line).

P.FM.05.31: Describe what happens when two forces act on an object in the same or opposing directions.
P.FM.05.32: Describe how constant motion is the result of balanced (zero net) forces.
P.FM.05.33: Describe how changes in the motion of objects are caused by a non-zero net (unbalanced) force.
P.FM.05.34: Relate the size of change in motion to the strength of unbalanced forces and the mass of the object.

Reading Grade Level Content Expectations:

R.WS.05.07: In context, determine the meaning of words and phrases including content vocabulary using strategies and resources.
R.CM.05.03: Analyze principles within and across text to create a deeper understanding by drawing conclusions.

Writing Grade Level Content Expectations:

W.GN.05.03: Write a position piece that demonstrates understanding of central ideas and supporting details (e.g., position/evidence organizational pattern) using multiple headings and subheadings.
W.PR.05.01: Set a purpose, consider audience, and replicate authors' styles and patterns when writing a narrative or informational piece.
W.PR.05.02: Apply a variety of pre-writing strategies for both narrative and informational writing (e.g., graphic organizers such as maps, webs, Venn diagrams) in order to generate, sequence, and structure ideas (e.g., role and relationships of characters, settings, ideas, relationship of theory/evidence, or compare/contrast).

Math Grade Level Content Expectations:

N.FL.05.05: Solve applied problems involving multiplication and division of whole numbers.
D.RE.05.01: Read and interpret line graphs, e.g., distance-time graphs.

Big Ideas:

- Every force is part of an interaction between two objects.
- Forces are pushes and pulls that can be contact or non-contact forces.
- Motion is described relative to something else (point of reference).
- A change in motion is due to unbalanced forces.
- No change in motion and an object at rest are due to balanced forces.

Background Information:

- Force is a push or a pull.
- The motion of objects can be changed by forces.
- The size of the change is related to the size of the force.
- The change is also related to the weight (mass) of the object on which the force is being applied.
- If an object does not move in response to a force, it's because another force is being applied to the environment.
- Gravity is a force that pulls down on all objects on the Earth.

References:

Michigan Department of Education. (2007). *K-7 Science grade level content expectations*. Retrieved February 3rd, 2013, from: http://www.michigan.gov/documents/mde/5-Science_COMPLETE_12-10-07_218320_7.pdf.

Michigan Department of Education. (2004). *Fifth grade: English Language Arts grade level content expectations*. Retrieved February 3rd, 2013, from: http://www.michigan.gov/documents/ELA_05_87358_7.pdf.

Michigan Department of Education. (2006). *Fifth Grade: Mathematics Grade Level Content Expectations.* Retrieved February 8th, 2013, from: http://www.michigan.gov/documents/MathGLCE_140486_7.pdf

Misconceptions

Force. Force is essentially an interaction between objects. Often students think that an object in motion requires a force to stay in motion. Their everyday experiences provide evidence for this viewpoint. However, this perception contradicts Newton's first law that a force is not needed to maintain motion, only to change it (Espinoza, 2005).

The work of a large number of researchers, as compiled by Driver, et al., (1994) has identified the following generally held ideas regarding motion:

- If there is motion, there is a force acting.
- There cannot be a force without motion.
- If there is no motion, then there is no force acting.
- When an object is moving, there is a force in the direction of its motion.
- A moving object stops when its force is used up.
- Motion is proportional to the force acting.
- A constant speed results from a constant force.

Students often cannot envision a force acting (such as a table beneath a book) without causing motion. Further, two notions—that force determines speed and that a stronger force makes an object go faster—were found in a number of studies, including Champagne, et al. (1980). Similarly, researchers have found that students strongly believe that an object traveling at a constant speed requires a constant force.

Teachers should be aware of the following common student misconceptions:

- *Objects have a "force inside" that keeps them moving.* The students' idea of force as an acquired property has close links with the pre-Galilean notion of *impetus:* It is conceived to be an inanimate "motive power" or "intrinsic force" that keeps things moving (Hestenes, Wells, & Swackhamer, 1992; Sequira & Leite, 1991). In this view, for an object to move it must be supplied with impetus or "momentum." This is inconsistent with Newton's first law. Hestenes, Wells, & Swackhamer (1992) argue that the impetus concept of motion is the most difficult and usually the last of the alternative conceptions to be overcome in the transition to Newtonian thinking.

- *Motion is seen as a result of a force.* Students have trouble moving from the idea of a force as an innate property to seeing forces as interactions between objects. Students believe that if a body is moving, there is a new force acting upon it in the direction of the movement. If the body is not moving, there is no force acting on it (Watts & Zylbersztajn, 1981).

- *An inanimate and inert object cannot exert a force.* Students do not grasp the third law of motion, which argues that each action creates an equal and opposite reaction. They may think that a table does not exert a force on a book lying on it—it is just "in the way" (Minstrell, 1982).

- *An interaction between objects is seen as a struggle between unequal forces.* It follows from the metaphor that victory belongs to the stronger. In a conflict, the more forceful exerts the greater force. Therefore, students often believe that greater mass implies greater force, or the most active mass? produces the greatest force (Maloney, 1984; Minstrell, 1982; Sadanand & Kess, 1990; Sequeira & Leite, 1991). Brown (1989) used a multiple-choice question in which students were asked to compare the forces that a 16-pound bowling ball and a 4-pound stationary pin exert on each other when the ball strikes the pin. Only 5% of students answered the question correctly (stating that the forces will be equal) after a full year of traditional physics instruction. Most students seemed to think in terms of a "dominance principle," where the bowling ball is "more forceful" because it is moving, is heavier, and is more able to cause damage than the pin. Watts and Zylbersztajn (1981) provide the example of a person winning at a game of tug-of-war; it is very difficult for students to understand how the forces on the rope are equal if one side is clearly winning. In other words, Bao, et al., (2002) argue that while students recognize that both objects exert a force, they fail to appreciate the fact that the forces arising from an interaction are always symmetrical.

- *An applied force is necessary for the continuity of motion at a constant velocity.* It is found that such imagined forces are especially common in explanations of motion that continues in the case of obvious opposing forces. In addition, some students believe that such a force dies out or increases to account for changes in an object's speed (Sadanand & Kess, 1990; Sequeira & Leite, 1991).

References:

Bao, L., Zollman, D., Hogg, K., & Redish, E. F. (2002). *Model analysis for fine structures of student models: An example with Newton's third law.* American Journal of Physics, 70, 766-778.

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Driver, R., Squires, A., Rushworth, P., & Wood-Robinson, V. (1994). *Making sense of secondary science: Research into children's ideas.* Routledge: London and New York.

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Maloney, D. P. (1984). *Rule-governed approaches to physics—Newton's third law.* Physics Education, 19, 37-42.

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Sadanand, N., & Kess, J. (1990). *Concepts in force and motion.* Physics Teacher, 28, 530-533.

Sequeira, M., & Leite, L. (1991). *Alternative conceptions and history of science in physics teacher education.* Science Education, 75, 45-56.

Watts, D. M., & Zylbersztajn, A. (1981). *A survey of some children's ideas about force.* Physics Education, 16, 360-365.

Table of Contents

Dear Parents,

Your Scientists are learning about "Forces and Motion". In this unit, we will build rockets and other hands-on experiments to bring the concept force and motion alive. At the end of the unit your child will be able to recognize how force and motion works in their daily lives, with rocket propulsion, and explain Newton's laws.

Big Ideas

It is my hope that your child will be talking with you about the experiments we are conducting. As we work through the unit, below are some of the main points that each student will be excited to share with you:

- Force is part of an interaction between two objects.
- Forces are pushes and pulls that can be contact or non-contact forces.
- Motion is described relative to something else (point of reference).
- A change in motion is due to unbalanced forces.
- An object at rest is due to balanced forces.

To reinforce the ideas of the unit, we are considering one of two options for a field trip experience. The first is a field trip to Cranbrook Science Institute in Bloomfield Hills. This world-renowned facility offers a hands-on demonstrations and a lot of activities to make the concepts come alive.

Cranbrook's *Science On the Go!* program allows us to host a field trip in our school! Members of Cranbrook's Science Institute will come to our school site to present a 45-minute interactive lesson on force and motion. The students would examine the how and why of motion, including forces, velocity, momentum, and laws of motion by using a trebuchet, hovercraft, sonar unit and more.
(Description found at http://www.science.cranbrook.edu/forteachers/explore-museum-programs)

Fees: The program is available to a small group of 30 for $225 or a large group of 150 students for $300.

More information... If you find that your Scientist wants to explore the principles of Force and Motion further at home, I have listed some fun, interactive websites that they may enjoy. As always, please let me know if you or your Scientist have any questions about the lessons!

Force Motion and Energy Test - It's a Wild Ride

www.netc.org/classrooms@work/classrooms/middleteam/.../rc_test.ht

http://www.easynotecards.com/matching/3582

http://www.physics4kids.com/files/motion_intro.html

http://www.youtube.com/watch?v=PD7a1EjWsTc

sitemaker.umich.edu/.../force_and_motion_jeopardy_questions.doc

May the "Force Be With You!

Mrs. Whan

5th Grade Field Trip Information – Option A

Site / Speaker: Cranbrook Science Center

Street Address: 39221 Woodward Avenue

City, State, Zip: Bloomfield Hills, MI 48303

Telephone: 248.645.3200

Website and/or email: science.cranbrook.edu

Field Trip Information:

Description: Forces and Motion (Grades K-6)
Investigate matter and the qualities scientists use to classify it as solid, liquid or gas. Apply pushes and pulls on simple machines like levers, pulleys and inclined planes to overcome common forces to make work easier. A lot of activities and hands-on demonstrations make this a moving experience!

(Description found at: www.science.cranbrook.edu/forteachers/explore-museum-programs)

Objective or Purpose of the Field Trip: To enhance and help students apply what they have learned in the Force and Motion 5th grade unit. The program at Cranbrook is adapted to include all Michigan benchmarks and GLCES covered in this unit.

Fees: $9 per student, teachers and 1 chaperone per 5 students are free. If we add a 2nd program the cost is $11 per student. Lunch can be provided for $5 per student. Busing will cost approximately $150.

Advance Notice Required: yes
Age Group Range / Limits: K-6 adapted for grade level
Available Times: 10am – 5pm
Group Size Limit: minimum of 20
Length of Tour: program is 45 mins
Guides Available: Yes
Dining Facilities: lunchroom available
Restroom Facilities: Yes
Adult / Student Ratio Required: 1 adult for every 5 student

Miscellaneous Information / Notes:
Due to space limitations, lunchrooms are available on a pre-scheduled basis. If lunch is not being bought on site each child should bring a disposable bag lunch that is identified with the student's name. Storage space is limited, so the museum is unable to store backpacks or lunch boxes.

(Information found at: www.science.cranbrook.edu/forteachers/explore-museum-programs)

5th Grade Field Trip Information – Option B (On-Site)

Site / Speaker: Our School/Cranbrook Science Center Staff

Website and/or email: science.cranbrook.edu

Presentation Information: *Science on the go!* Program comes to our school site to present an interactive lesson on Force and Motion

Description: Science on the go! Program: Forces and Motion (Grades K-8)
Examine the how and why of motion, including forces, velocity, momentum, and laws of motion by using a trebuchet, hovercraft, sonar unit and more.

(Description found at: www.science.cranbrook.edu/forteachers/explore-museum-programs)

Objective or Purpose of the Presentation: To enhance and help students apply what they have learned in the Force and Motion 5th grade unit. The program at Cranbrook is adapted to include all Michigan benchmarks and GLCES covered in this unit.

Fees: $225 for a small group of 30 and $300 for a large group up to 150 students

Advance Notice Required: yes
Age Group Range / Limits: K-6 adapted for grade level
Available Times: during school hours
Group Size Limit: 30 to 150
Length of Tour: program is 45 mins
Guides Available: Yes
Dining Facilities: n/a
Restroom Facilities: n/a
Adult / Student Ratio Required: n/a

Miscellaneous Information / Notes:
Host a field trip in your school! Cranbrook educators share the excitement of science and meet Michigan GLCEs, in your school or classroom. Students learn what Michigan's rocks, minerals and fossils tell us about its geological history, tour the many forms of energy, identify insects using live specimens, and much more! Small Group Programs are ideal for one or two classrooms (up to 30 students maximum) and large group programs can accommodate up to 150 students.

(Information found at: www.science.cranbrook.edu/forteachers/explore-museum-programs)

Pacing Guide

Week 1				
Day 1	*Day 2*	*Day 3*	*Day 4*	*Day 5*
Pre-Test Intro Activity	Cotton Ball Launcher	Cotton Ball Launcher	Cotton Ball Launcher	Cotton Ball Launcher
	S.IP.05.12 S.IP.05.14 S.IP.05.15 S.IA.05.11 S.RS.05.15 P.FM.05.31 P.FM.05.33 P.FM.05.34	S.IP.05.12 S.IP.05.14 S.IP.05.15 S.IA.05.11 S.RS.05.15 P.FM.05.31 P.FM.05.33 P.FM.05.34	S.IP.05.12 S.IP.05.14 S.IP.05.15 S.IA.05.11 S.RS.05.15 P.FM.05.31 P.FM.05.33 P.FM.05.34	S.IP.05.12 S.IP.05.14 S.IP.05.15 S.IA.05.11 S.RS.05.15 P.FM.05.31 P.FM.05.33 P.FM.05.34

Week 2				
Day 1	*Day 2*	*Day 3*	*Day 4*	*Day 5*
Up, Up and Away!	Up, Up and Away!	Up, Up and Away!	Up, Up and Away!	Newton and Me (Reading Connection)
S.IP.05.11 S.IA.05.13 S.RS.05.15 P.FM.05.31 P.FM.05.32 P.FM.05.33	S.IP.05.11 S.IA.05.13 S.RS.05.15 P.FM.05.31 P.FM.05.32 P.FM.05.33	S.IP.05.11 S.IA.05.13 S.RS.05.15 P.FM.05.31 P.FM.05.32 P.FM.05.33	S.IP.05.11 S.IA.05.13 S.RS.05.15 P.FM.05.31 P.FM.05.32 P.FM.05.33	R.WS.05.07 R.CM.05.03 P.FM.05.32 P.FM.05.33

Week 3				
Day 1	*Day 2*	*Day 3*	*Day 4*	*Day 5*
Force and Motion: Do you have Balance?	Force and Motion: Do you have Balance?	Force and Motion: Do you have Balance?	Understanding Force (Writing Connection)	Understanding Force (Writing Connection)
S.IP.05.12 S.IP.05.13 S.IA.05.12 S.RS.05.15 P.FM.05.31 P.FM.05.32	S.IP.05.12 S.IP.05.13 S.IA.05.12 S.RS.05.15 P.FM.05.31 P.FM.05.32	S.IP.05.12 S.IP.05.13 S.IA.05.12 S.RS.05.15 P.FM.05.31 P.FM.05.32	W.GN.05.03 W.PR.05.01 W.PR.05.02 P.FM.05.32 P.FM.05.33	W.GN.05.03 W.PR.05.01 W.PR.05.02 P.FM.05.32 P.FM.05.33

Week 4				
Day 1	*Day 2*	*Day 3*	*Day 4*	*Day 5*
Balanced Forces	Balanced Forces	Balanced and Unbalanced Forces	Balanced and Unbalanced Forces	Newton Math (Math Connection)
S.IP.05.12 S.IP.05.13 S.IP.05.14 S.IA.05.14 S.RS.05.15 P.FM.05.32	S.IP.05.12 S.IP.05.13 S.IP.05.14 S.IA.05.14 S.RS.05.15 P.FM.05.32	S.IP.05.11 S.IA.05.13 S.RS.05.15 P.FM.05.33 P.FM.05.34	S.IP.05.11 S.IA.05.13 S.RS.05.15 P.FM.05.33 P.FM.05.34	N.FL.05.05 D.RE.05.01 P.FM.05.32 P.FM.05.33 P.FM.05.34
Week 5				
Day 1	*Day 2*	*Day 3*	*Day 4*	*Day 5*
Field Trip: Cranbrook Institute of Science	"UN-balancing Act"	"UN-balancing Act"	Post-Assessment: Tic-Tac-Toe	Post-Assessment: Tic-Tac-Toe
	S.IP.05.11 S.IA.05.13 S.RS.05.15 P.FM.05.34	S.IP.05.11 S.IA.05.13 S.RS.05.15 P.FM.05.34		

Materials List

Lesson 1: Cotton Ball Launcher

Classroom Materials:	Materials to Purchase:	Estimated Cost:
Metric rulers	Large paper clips	$1.00
	Small paper clips	$1.00
	Cotton balls	$1.00
	Masking tape	$2.00
	M&M's	$0.69
	Plastic spoons	$1.00
	Rubber bands	$1.00
	Newspapers	$2.00
	Bouncy balls	$1.00
	Total:	$10.69

Lesson 2: Up, Up and Away

Classroom Materials:	Materials to Purchase:	Estimated Cost:
Weights	Large helium balloons (7 groups)	$5.25
	Small helium balloons (7 groups)	$5.25
	Plastic cups	$1.00
	String	$1.00
	Pennies (15x7 groups)	$1.05
	Various types of balloons	$2.00
	Different size cups	$3.00
	Total:	$18.55

Lesson 3: Force and Motion: Do you have Balance?

Classroom Materials:	Materials to Purchase:	Estimated Cost:
Small Weights	Low-friction fan cart kits (5 @ $19)	$95.00
Measuring Tape	Batteries (AA)	$12.00
Markers	Poster Board	$5.00
	Total:	$112.00

Lesson 4: Balanced Forces

Classroom Materials:	Materials to Purchase:	Estimated Cost:
Meter stick	10 film canisters (10 @ $.43)	$4.30
ML droppers	4 hot wheels tracks	$24.99
	12 Antacid tablets	$3.15
	Vinegar	$2.00
	Sand	$3.99
	Plastic Spoons	$1.00
	Total:	$39.43

Lesson 5: Balanced and Unbalanced Forces

Classroom Materials:	Materials to Purchase:	Estimated Cost:
Computers	1 Cup	(use from Lesson 2)
Book	1 Penny	(use from Lesson 2)
	Deck of cards	$1.00
	Rope	$8.00
	Toy car	$1.00
	Total:	$10.00

Newton Math - Math Connection:

Classroom Materials:	Materials to Purchase:	Estimated Cost:
	2 Toy cars (use one from Lesson 5)	$1.00
	Masking tape	(use from Lesson 1)
	Total:	$1.00

Lesson 6: "UN-balancing Act"

Classroom Materials:	Materials to Purchase:	Estimated Cost:
Weights	2 Trucks with open beds	$10.00
Rulers	String	$1.00
Balance Scale	Metal Washers	$1.40
	2 Balls (same size, different mass)	$2.00
	6-2L bottles (empty)	$4.74
	1 medium sized ball	$1.00
	Sand	$3.99
	Funnel	$1.00
	2 boxes (same size)	$2.00
	Total:	$27.13

Unit Materials Total: $218.80

***Reading Connection: Newton and Me - no materials required**
***Writing Connection: Understanding Force - no materials required**

Field Trip Options:

		Estimated Cost:
A	Trip to Cranbrook Institute of Science ($9 per child, approximately 30 children +$150 transportation charge)	$420
B	On-Site Field Trip presented by Cranbook Institute of Science (up to 30 students)	$225

Unit Grand Total (field trip option A): $638.80
Unit Grand Total (field trip option B): $443.80

5th Grade Pre-assessment Test - Force Unit

1. A force can be a _____ or a _____.
2. _____ is a force that pulls all things down to Earth.
3. Explain why for every action there is an equal and opposite reaction.
4. An object at rest will remain at rest and an object in motion will continue moving in a straight line at a constant speed until an outside force acts on it. Who's law of motion is that?
5. Are there forces acting on an object that is standing still or not moving? Explain
6. Given an example of an unbalanced force.
7. What unit of measure do scientists use to measure force?
8. What is friction?
9. This type of force can make a stationary object move or change the direction of a moving object.
10. What does zero-net force mean?

Answer key for Pre-assessment:

1. Push or pull
2. Gravity
3. For every force there is an equal and opposite reaction force. For example, if you weigh 100lbs the Earths gravity is pulling down on you with the weight of 100lbs, but since you do not fall through the floor it means that the floor is pushing up against you with 120lbs of force.
4. Newton
5. Yes- Gravity and the surface the object is standing on will push up with a normal force
6. A person pushing a chair across the floor, a person kicking a ball (answers will vary)
7. A Newton
8. The friction force is the force exerted by a surface as an object moves across it
9. An unbalanced force
10. Zero net force means an object is at rest or moving at a constant speed

Cotton Ball Launcher

Teacher: Krista Miller

Unit title / Lesson title / Grade level: Force and Motion / Cotton Ball Launcher / 5th Grade

Benchmarks GLCE's for this lesson:
P.FM.05.31: Describe what happens when two forces act on an object in the same or opposing directions.
P.FM.05.33: Describe how changes in the motion of objects are caused by a non-zero net (unbalanced) force.
P.FM.05.34: Relate the size of change in motion to the strength of unbalanced forces and the mass of the object.
S.IP.05.12: Design and conduct scientific investigations.
S.IP.05.14: Use metric measurement devices in an investigation.
S.IP.05.15: Construct charts and graphs from data and observations.
S.IA.05.11: Analyze information from data tables and graphs to answer scientific questions.
S.RS.05.15: Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities.

Lesson objective(s):
Students will be able to:

- Define a force as a push or a pull (P.FM.05.31)
- Identify forces in the world around them (P.FM.05.31)
- Justify a change in motion as a result of unbalanced forces (P.FM.05.33)
- Examine the effects of applying different amounts of force to an object (P.FM.05.34)
- Argue that the size of change in motion is related to the strength of the unbalanced forces and the mass of the object (P.FM.05.34)
- Model balanced and unbalanced forces through illustrations and experiments (S.RS.05.15)
- Demonstrate proficiency using metric rulers to measure distance (S.IP.05.14)
- Develop data charts based on data collected (S.IP.05.15)
- Formulate scientific conclusions based on analysis of data tables (S.IA.05.11)
- Design additional experiments with new variables to test (S.IP.05.12)

Materials:

- Large paper clips
- Small paper clips
- Cotton balls
- Metric Rulers
- Masking Tape
- Possible extras for elaborate stage: M&M's, Plastic Spoons, Rubber bands, Newspapers, Bouncy Balls

Time needed to complete entire lesson: 4 class periods (assuming 45 minutes-1 hour of time per day)

ENGAGEMENT:

- Begin this lesson by placing students in pairs sitting on the ground facing one another. Note: Select two students to model how the pairs are to be seated. Ask students to face each other and place their hands chest high with palms facing their partner. Each student places his/her palms on the other's and at your signal, begins pushing. Allow students to push for about 30 seconds. Ask the following questions:
  "What did you feel when your partner pushed against your hand?" (pushing on my hands)
  "What did you do?" (I had to push back)
  "What would happen if you did nothing?" (I would be pushed back or pushed down)

- Now ask students to hold each other's hand and pull. Allow students to pull for about 30 seconds. Ask the following questions:
    - "What did you feel when your partner pulled against your hand?" (pulling on my hands)
    - "What did you do?" (I had to pull back)
    - "What would happen if you did nothing?" (I would be pulled forward)
- Write the word force on the board or chart. Ask students if they can define this word. Allow students to develop a working definition of force as a push or a pull. Add to this definition: "which can cause an object to speed up, slow down, or change direction."
- Ask students if there was a force used when they placed their hands on their partners. (Yes, we pushed and pulled.) Tell students they were applying or using force. Draw two arrows on a chart or board. Ask students:
  "If I wanted to show a force such as a push or a pull, how could I use the arrows to do that?"
  (Students should conclude that the arrows could be used to show the direction of the force that is being applied.)
- Distribute copies of the "Hunting for a Force" worksheet. Tell students they will be taking a field investigation around the school and outside to locate examples of a push or pull force. They are to identify the example and draw an illustration with an arrow that indicates the direction of the force being applied.
- Note: Preview the area you will be taking students so that examples can be found easily for them. Areas may be marked if students need practice identifying objects.

EXPLORATION:

Review with students the term force and how we identify a force that is applied to an object. Tell students they will investigate the change that occurs when a force, such as a push or a pull, is applied to an object. Give a few examples such as pushing someone on a swing or pushing a shopping cart. Be sure to go over safety procedures with students and remind students that goggles should be worn at all times during this investigation.

- Cotton Ball Launcher Activity:
    - Hand out copies of the "Cotton Ball Launcher" worksheet. Divide students into groups of four. Give each group two large paper clips and two small paper clips.
    - Prepare each clip to become a launcher by pulling the inside of the clip out to form a "V" shape. Place the large part of one clip down and tape it to the table so that the small loop is up. Take the other large clip and tape the small loop to the table or floor so that the large loop is up. Note: You may prepare the paper clips if you feel students will not be able to do this independently.
    - Tell students they are to determine who will launch the larger clips and the smaller clips. Students who are not launching will measure and record the data on the investigation sheet. Tell students to place the cotton ball on the "launcher" part of each large paper clip. Pull or push the launcher clip down and release. Launch the cotton ball, measure, and record the distance. Repeat the launch three times and record measurements. Note: Model how the cotton ball should be launched and measured for students.
    - Repeat this investigation with the two smaller clips.

EXPLANATION:

- Collect the data from all groups, and as a class make two charts displaying the data. Discuss results with students. Have students draw conclusions from their results and record their conclusions in their science journals.
- Discuss questions from "Cotton Ball Launcher" lab write-up.
- Define critically important terms that have been touched on during this activity: Force, Balanced Force, Unbalanced Force, Direction of Motion, Mass and Relative Position by relating each to the cotton ball launcher activity.
- Read, "The Magic School Bus Plays Ball" to further enhance understanding of forces.
- Have students work with a group to complete the worksheet labeled "The Force."

ELABORATION:

- Encourage students to revisit the Cotton Ball Launcher activity, and make some changes of their own. Get their minds going by asking,
  "What were you wondering about while we were doing this experiment? Was there anything you wanted to try differently?
- Give students time to test new variables. They may design their own catapults and experiment with the effect of applying more force to the same object. They may change the object they are launching, perhaps trying to launch bouncy balls or pieces of candy (such as M&Ms).
- Ask students to make predictions before actually engaging in their experiments and to provide reasons for their predictions. They will then conduct their experiments and will record measurements and make comparisons to previous data, as well as comparing results to their predictions.

EVALUATION:

GLCE: P.FM.05.31: Describe what happens when two forces act on an object in the same or opposing directions.
Objective: Students will be able to define a force as a push or a pull.
Objective: Students will be able to identify forces in the world around them.
Evaluation: Formatively assess students during opening engagement activity. Check for ability to demonstrate balanced and unbalanced forces through modeling (pushing and pulling on their partner and explaining the results) by observing their interactions with their partner. Individually assess students' ability to identify pushes and pulls and the direction of force by reviewing the "Hunting for a Force" worksheet.

GLCE: P.FM.05.33: Describe how changes in the motion of objects are caused by a non-zero net (unbalanced) force.
Objective: Students will be able to justify a change in motion as a result of unbalanced forces.
Evaluation: Collect "The Force" worksheet and evaluate to ensure that students can identify the result of unbalanced forces being applied to an object. Students will justify this change during class discussion in the explanation stage.

GLCE: P.FM.05.34: Relate the size of change in motion to the strength of unbalanced forces and the mass of the object.
Objective: Students will be able to examine the effects of applying different amounts of force to an object.
Objective: Students will be able to argue that the size of change in motion is related to the strength of the unbalanced forces and the mass of the object.
Evaluation: Lead class discussion of questions 1-3 from the "Cotton Ball Launcher" worksheet to measure their understanding of the effects of applying varying amounts of force. Students will then partner up and argue whether or not the size of change of motion is related to the force applied and mass of the object using their elaborate experiments as evidence.

GLCE: S.IP.05.12: Design and conduct scientific investigations.
Objective: Students will be able to design additional experiments with new variables to test.
Evaluation: Monitor students as they test new variables and design their new experiments. Check for depth of understanding by discussing their predictions and the actual results of their activities.

GLCE: S.IP.05.14: Use metric measurement devices in an investigation.
Objective: Students will be able to demonstrate proficiency using metric rulers to measure distance.
Evaluation: Have students collect and record data, using metric rulers to measure the distance their cotton balls traveled. Evaluate their efforts by collecting the "Cotton Ball Launcher" worksheet and checking data tables for reasonable data.

GLCE: S.IP.05.15: Construct charts and graphs from data and observations.
Objective: Students will be able to develop data charts based on data collected.
Evaluation: During the explanation stage, construct data charts as a class, based on the data students collected. Formatively assess understanding as students participate in constructing the charts.

GLCE: S.IA.05.11: Analyze information from data tables and graphs to answer scientific questions.
Objective: Students will be able to formulate scientific conclusions based on analysis of data tables.
Evaluation: Review students' science journal entries to clarify their ability to formulate these conclusions.

GLCE: S.RS.05.15: Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities.
Objective: Students will be able to model balanced and unbalanced forces through illustrations and experiments.
Evaluation: Observe participation in opening activity and during Cotton Ball Launcher activity and elaboration.

References:

Michigan Department of Education. (2007). *K-7 Science grade level content expectations*. Retrieved February 3rd, 2013 from: http://www.michigan.gov/documents/mde/5-Science_COMPLETE_12-10-07_218320_7.pdf.

Pennsylvania Department of Education Standards Aligned System. (2013). *Pushing and Pulling*. Retrieved from http://www.pdesas.org/module/content/resources/13894/view.ashx.

Hunting for a Force

Object	Pull	Push
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

Cotton Ball Launcher

	Large paper clip: Small part up	Large paper clip: Large part up	Small paper clip: Small part up	Small paper clip: Large part up
Trial 1				
Trial 2				
Trial 3				
Trial 4				

1) Was the force that was applied a push or a pull?

2) Compare the distances the cotton ball traveled. Which paper clip caused the cotton ball to travel furthest? Explain the possible reasons for this.

3) On the photo below, draw one arrow to show where the force (push or pull) is applied to launch the cotton ball and another arrow that shows the direction the cotton ball would travel. Please label the arrows "force" and "direction of motion."

The Force

Directions: Draw a picture illustrating each phrase. Then place arrows to show the direction of force being applied.

Two students pressing their hands together during a “high five”

Students pulling on a rope (tug-of-war)

Someone pushing a rock up a small hill

Up, Up and Away!

Teacher: Sarah Gerding

Unit title / Lesson title / Grade level: Force / Up, Up and Away! / 5th Grade

Benchmarks GLCE's for this lesson:
P.FM.05.31: Describe what happens when two forces act on an object in the same or opposing directions.
P.FM.05.32: Describe how constant motion is the result of balanced (zero net) forces.
P.FM.05.33: Describe how changes in the motion of objects are caused by an unbalanced (non-zero net) force.
S.IP.05.11: Generate scientific questions based on observations, investigations, and research.
S.IA.05.13: Communicate and defend findings of observations and investigations using evidence.
S.RS.05.15: Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities.

Lesson objective(s):
Students will be able to:
- Describe a force as a push or a pull
- Explain that no change in motion is due to balanced forces
- Explain that a change in motion is due to unbalanced forces
- Construct new questions to explore based on findings
- Defend and communicate thoughts regarding observations
- Illustrate and/or model what is happening during experiments and explain why

Materials:
- Helium Balloons (one small and one large per group)
- plastic cups (one per group)
- string (one strand per group)
- pennies (15 per group)
- worksheets (1 of each worksheet per student)
- Additional possible materials for the elaborate stage include different size cups, different types of balloons, different objects to use for weights (both lighter and heavier than pennies), etc.

Worksheet Reference: http://www.fitnessforlife.org/sample-middle-school

Time needed to complete entire lesson: 4 class periods (1 hour per class)

ENGAGEMENT:
- Ask students if they have ever seen a helium balloon at a birthday party, etc. then ask them if they can think of any movies that exhibit the power of helium balloons.
- Once someone answers "Up!" (or you are prompted to mention it yourself), ask the students if they think that could ever happen in real life. Then show the class the YouTube video about recreating the scene from Up! In which balloons lift a house off the ground to illustrate the upward force of helium.
  YouTube Reference: http://www.youtube.com/watch?v=rV6rNqin4P8
- Ask the students to describe what they see in the video and tell them that they will be using a helium balloon to investigate how force acts on an object.

EXPLORATION:
Working in groups of 2-3, students will add pennies to a helium balloon with a cup attached by a string. The students will record the effect each penny has on the movement of the cup and note the direction the cup moved (up, down, sideways, stayed still).

Students will use the attached worksheet (Up, Up, and Away) to complete the following experiments and lab drawing activity:

- Experiment #1:
  - Students will test how many pennies it takes to hold down a cup attached to a small helium balloon and a cup attached to a big helium balloon.
  - They will record the number of pennies, the direction the cup accelerated, and hypothesize why they think it takes different amount of pennies to hold down each cup.

- Experiment #2:
  - After putting all the pennies in the cup, the students will slowly remove the pennies one at a time until the cup lifts off the table (they will do this for both the small and the large balloon).
  - They will record the number of pennies, the direction the cup accelerated, and why they think there were different amounts of pennies on each cup when it lifted off the table.

- Experiment #3:
  - Either by adding or removing pennies the students will try to balance the upward force of the balloon with the downward force of the pennies and cause the cup to hover in the air (they will do this for both the small and large balloon).
  - Students will record the number of pennies, the direction the cup accelerated, and why they think the cup hovered.

- Lab Drawing Activity:
  - Students will draw diagrams of each of the 3 balloon experiments.
  - Using arrows to show force and direction they will label the forces in each experiment to indicate how they are thinking about force and its relationship to motion.
  - Once the diagrams are completed, each group will share one part of their diagram stating the forces and if there is acceleration.

EXPLANATION:

When the groups have finished, ask students to make observations about the data they collected. Use the following questions to aid in eliciting responses from the students in their own words.

- Why do you think the cup lifts up when it's attached to the balloon?
- What, if anything, happened that kept the cup from lifting up in the experiment?
- By adding and removing the pennies you were able to make the cup float in the air. What do you think caused this?
- What is the balloon doing?
- What are the pennies doing?

After the class discussion the teacher will explain the following:

- That a force is a push or a pull that causes an object to accelerate (speed up, slow down and/or change direction) in the direction of its application.
- The terms balanced and unbalanced forces. Two forces acting on an object in opposing directions can be of unequal strength and, therefore, are unbalanced (non-zero net force). The result will be motion (starting or speeding up) in the direction of the stronger force.
  - Ask the students to define these terms in their own words.
  - Ask the students to give examples of when the forces were unbalanced in the helium balloon activity.

- That two forces acting on an object in opposing directions can be of equal strength and are, therefore, balanced. The result will be that if the object is at rest it will stay at rest and if it is moving, it will continue to move a constant speed in a straight line.

    - Ask the students to give an example of when the forces were balanced in the helium balloon activity and what forces were balanced.

Keep in mind critically important vocabulary: Force, Balanced Force, Unbalanced Force, Zero Net Force, Non-Zero Net Force

ELABORATION:

- First, have the students complete the front of the Direction of Forces worksheet. Then have the students flip their worksheets over and put their pencils down. The students will spend some time while thinking and looking around to come up with their own example of something that involves a push or a pull force. After 1-3 minutes ask them to draw a diagram of their example on the back of the worksheet. They should indicate the forces and their magnitude with the arrows and should indicate which way there is movement. By taking the time for them to think of an example themselves they are beginning to integrate what they are learning about forces into familiar aspects of their life. This will help with them gaining a complete and correct understanding of the concept as well as helping them personally connect with the material.
- Second, ask the students to reunite with their groups and brainstorm different variables they could change in order to recreate the experiments they just performed that might shed new light on what they have learned about force. Let them brainstorm and monitor their progress. If they seem as though they are not able to come up with new ideas, offer a few suggestions: using different types of balloons, using different weights (either lighter or heavier than pennies), using different size or shape of cups, wind, barometric pressure, etc.
- If the materials are available, allow the students to carry out their new experiment ideas. If only some of the group's materials are available, allow groups to merge into 1 or 2 larger groups to carry out the new experiments. Ask them to share their findings with the group and to elaborate on what new ideas their experiments may have caused and/or how these experiments possibly supported (or did not support) their initial findings in the exploration phase. A short write up of the experiment conducted and their findings will be required.

EVALUATION:

GLCE: P.FM.05.31: Describe what happens when two forces act on an object in the same or opposing directions.
Objective: Describe a force as a push or a pull
Evaluation: This will be asked of the student during the Explanation phase (in a group discussion) and will also be a short answer question on a summative assessment.

GLCE: P.FM.05.32: Describe how constant motion is the result of balanced (zero net) forces.
Objective: Explain that no change in motion is due to balanced forces
Evaluation: This will be asked of the student during the Explanation phase (in a group discussion) and will also be a short answer question on a summative assessment. In addition, during the Explanation phase they are required to provide specific examples of balanced forces from the experiments.

GLCE: P.FM.05.33: Describe how changes in the motion of objects are caused by a non-zero net (unbalanced) force.
Objective: Explain that a change in motion is due to unbalanced forces
Evaluation: This will be asked of the student during the Explanation phase (in a group discussion) and will also be a short answer question on a summative assessment. In addition, during the Explanation phase they are required to provide specific examples of unbalanced forces from the experiments.

GLCE: S.IP.05.11: Generate scientific questions based on observations, investigations, and research.
Objective: Construct new questions to explore based on findings
Evaluation: During the Elaboration stage, the groups are required to generate a short write up detailing their new ideas for an experiment to further explore the original experiments.

GLCE: S.IA.05.13: Communicate and defend findings of observations and investigations using evidence.
Objective: Defend and communicate thoughts regarding observations
Evaluation: During the Exploration, Explanation and Elaboration stage, the students are asked to communicate their findings as a group with the rest of the class (make sure to ask to hear from every student during some part of the lesson so that not just one person from each group is sharing every time).

GLCE: S.RS.05.15: Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities.
Objective: Illustrate and/or model what is happening during experiments and explain why
Evaluation: Completion of the Up, Up and Away worksheet, along with the Direction of Force worksheet will be evaluated (both contain areas to illustrate what they believe is happening and why throughout various stages of the lesson).

References:

Michigan Department of Education. (2007). *K-7 Science grade level content expectations*. Retrieved February 3rd, 2013 from: http://www.michigan.gov/documents/mde/5-Science_COMPLETE_12-10-07_218320_7.pdf.

Worksheet Reference: http://www.fitnessforlife.org/sample-middle-school

YouTube Reference: http://www.youtube.com/watch?v=rV6rNqin4P8

Direction of Force

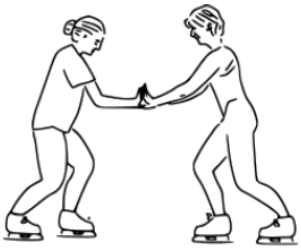
Name: _____
Date: _____

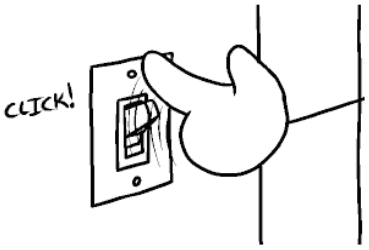
Look at the pictures below. In the space below each picture:

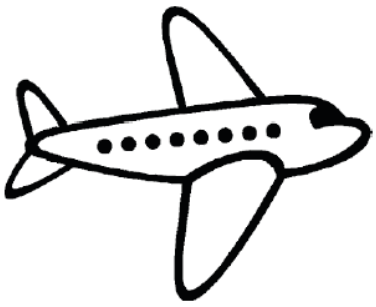
1. Draw a line with an arrow to show the direction of the force that is being applied. Label the line with “F” (for force).

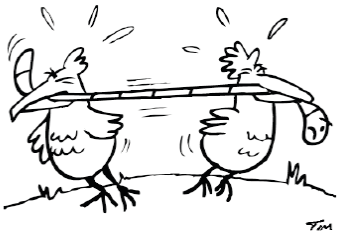
2. Draw another line with an arrow to show the direction of movement that results from that application of force. Label this line “M” (for movement).

Note: Use different size arrows for strong and weak forces, smaller for smaller forces, bigger for bigger forces and the same for equal forces.









Up, Up, and AWAY!

Name: _____
Date: _____

Directions: Using the helium balloons and the pennies, follow the instructions for each experiment below. Some answers will be circled and some will be fill in the blanks.

EXPERIMENT #1:
1. While one person holds the cup, start with 0 pennies and slowly add a single penny at a time to the cup. Continue adding pennies to the cup until the cup drops down to the table or floor.

How many pennies did it take to hold down the cup? _____

2. Hold the cup out in front of you with the pennies still inside and let it go.

What direction did your balloon move? Up / Down / Sideways / Stays Still

Why do you think it took this many pennies to hold down the cup?
_____
_____

EXPERIMENT #2:
1. While one person holds the cup put all the pennies you have in the cup of your balloon. Slowly remove one penny at a time from the cup until it is able to float up.

How many pennies were in the cup when it lifted up? _____

2. Hold your cup out in front of you, with the pennies still inside, and let it go.

What direction does the cup move? Up / Down / Sideways / Stays Still

3. Why do you think you had to remove some pennies but not all for the cup to rise?
_____
_____

EXPERIMENT #3:
1. For this experiment your goal is to get the cup to stay in the same spot in the air. While one person holds the cup have another slowly add pennies to the cup. Slowly add or remove pennies to the cup and try to get it to float.

How many pennies were in the cup when it floated? _____

What direction does the cup move? Up / Down / Sideways / Stays Still

2. Why do you think the cup was able to float in the same spot?

_____
_____
_____

Experiment Diagrams: Below draw a diagram of each experiment. Use arrows to show how strong or weak the up or down motion was in each experiment. Use different size arrows for stronger and weaker forces; smaller for smaller forces, bigger for bigger forces and the same for equal forces.

Newton and Me – Reading Connection

Teacher: Prima-Marie Dailey

Subject Area: Language Arts - Reading

Grade Level: 5th

Unit Title: Force

Lesson Title: Newton and Me

Reading GLCE's/Objectives:
GLCE: R.WS.05.07: Determine the meaning of content vocabulary using strategies and resources.
Objective: Students will be able to paraphrase the vocabulary learned in the reading.
Evaluation: Students will paraphrase the vocabulary learned in the reading through the reading strategy, "Think/Pair/Share".

GLCE: R.CM.05.03: Analyze principles within and across text to create a deeper understanding by drawing conclusions.
Objective: Students will be able to examine principles/concepts learned in the reading.
Evaluation: Students will examine principles/concepts learned in the reading through the reading comprehension questioning strategy, "Thick and Thin".

Science GLCE's/Objectives:
GLCE: P.FM.05.32: Describe how constant motion is the result of balanced (zero net) forces.
Objective: Students will be able to describe Newton's First Law of Motion.
Evaluation: Students will be able to describe Newton's First Law of Motion by filling out a web graphic organizer.

GLCE: P.FM.05.33: Describe how changes in the motion of objects are caused by a non-zero net (unbalanced) force.
Objective: Students will be able to describe how motion plays a part of an unbalanced force.
Evaluation: Students will be able to describe how motion plays a part of an unbalanced force by writing in their own words in their journals how friction played a part in the anticipatory set.

Anticipatory Set:

The students will watch two YouTube clips on Newton's First Law of Motion. Then to get students up and out of their seat, the teacher will have the students gather around a table for a short activity on Inertia:

The teacher will demonstrate how to remove a sheet of paper from under an object without moving the object on top. The students will write down what they think will happen.

- Place the piece of paper on a flat, smooth surface.
- Put the textbook with the glossy cover on top of the paper.

- Quickly (and in one smooth motion) yank the paper out from under the book.
- Write down what happens.
- Try the experiment again using a book with a rough or non-glossy cover.
    - What do you notice?
    - Can you explain how this experiment relates to Newton's First Law of Motion?

Upon completion of the demonstration, the teacher will have the students sit back down to discuss the results of this activity: The book should move little, if at all. The book did not move because of inertia, which is explained by Newton's First Law of Motion: A body at rest will remain at rest unless acted upon by an outside force.

Note that the objects move less when friction is reduced. This permits us to see that Newton's First Law is correct. Remind the students that the objects move hardly at all when the paper is pulled from under the glossy-covered book and a little more when they pulled it from under the book with the non-glossy cover.

http://www.youtube.com/watch?v=pxWHWOYVov4
http://www.youtube.com/watch?v=yfeiD1nq-v4

Input:

The teacher will have the students read aloud Newton's First Law of Motion from their textbook. Students will do this through choral reading in class.

Upon completion of the choral reading, the teacher will give a minilesson on Think/Pair/Share.

Think/Pair/Share Minilesson

- Think: The teacher provokes student's thinking with a question or prompt. The students should take a few moments just to THINK about the question.
- Pair: Using designated partners, students PAIR up to talk about the answer each came up with. They compare their mental or written notes and identify the answers they think are best, most convincing, or most unique.
- Share: After students talk in pairs for a few moments, the teacher calls for pairs to SHARE their thinking with the rest of the class. This can be done by going around in round-robin fashion, calling on each pair; or can take answers as they are called out (or as hands are raised). The teacher will record these responses on the board or on the overhead.

After the minilesson, the teacher will prompt the Think/Pair/Share session with a question from the reading: "Paraphrase the following terms - Force, Unbalanced Force, Velocity and Inertia." Once the teacher has brought the students back together after the "Think" and "Pair", they will ask each pair to give their paraphrased definition to each term.

The teacher will then teach another minilesson on a comprehension questioning strategy, "Think and Thin".

Thick and Thin Minilesson

The teacher explains the difference between thick (inferential) and thin (factual) questions and then models how to compose questions by thinking aloud while reading. Students observe how to gather information about the topic and write it down in their journals. Students practice composing thick and thin questions and monitor their comprehension by using T-Charts given out in class (see attached). This practice extends knowledge of the topic and engages readers in active comprehension.

Guided Practice:

Upon completion of the choral reading, the "Think/Pair/Share" and "Thick and Thin" minilesson, the teacher will pass out an "anticipation guide" (see attached) that includes clear, concise agree/disagree statements about Newton's First Law of Motion. Students will complete the anticipation guide independently.

Upon completion of the anticipation guide, the teacher will work in a small group setting (5 people/group) one group at a time. *(The rest of the students will start working on their in class assignment that is listed under the independent practice section, to be completed for homework.)* The teacher will work with each group to ensure they grasp Newton's First Law of Motion by going through each answer on the anticipation guide. Each student will take a turn reading and answering a statement. The teacher will then ask the group who agrees or disagrees with the statement. If someone disagrees with the student who answered, then they will have to defend their answer as to why they disagree.

> For example: a student reads: "Forces act on objects at rest" and says they disagree with this statement. The teacher then asks the other four students what they said. A student who agrees with this statement must provide a reason why: An object at rest simply has a constant velocity of zero, so it needs an outside force to start moving.

Independent Practice:

Students will fill out a graphic organizer (see attached) to prove to the teacher they know and understand the vocabulary that was learned during the "Think/Pair/Share" minilesson: Force - Push or pull. Force can give energy to an object, causing it to move, stop moving, or change direction; Unbalanced force - Always cause a change in speed or direction; Velocity - Speed of an object and its direction of motion; Inertia - The tendency of an object to resist any change in its motion. The center space will be filled in with "Newton's First Law of Motion" or "Newton's First Law of Inertia".

Finally, in class the students will write in their own words how friction played a part in the anticipatory set activity in their journals and hand them in for a grade. Their responses will mirror this reason: Objects move less when friction is reduced. This permits us to see that Newton's First Law is correct. Objects move hardly at all when the paper is pulled from under the glossy-covered book and a little more when they pulled it from under the book with the non-glossy cover. The journal entry will also include four questions (two inferential and two factual) that the students posed on their T-Chart during the "Thick and Thin" minilesson.

References:

Michigan Department of Education. (2004). *Fifth grade: English Language Arts grade level content expectations*. Retrieved February 3rd, 2013, from: http://www.michigan.gov/documents/ELA_05_87358_7.pdf.

Michigan Department of Education. (2007). *K-7 Science grade level content expectations*. Retrieved February 3rd, 2013 from: http://www.michigan.gov/documents/mde/5-Science_COMPLETE_12-10-07_218320_7.pdf.

http://www.vrml.k12.la.us/5th/scien/activity_by_Unit/Unit3/act2/un3_act2.htm

http://science.jrank.org/pages/3857/Laws-Motion-Newton-s-three-laws.html

http://swift.sonoma.edu/education/newton/newton_1/html/newton1.html

http://www.readingquest.org/strat/tps.html

http://www.readwritethink.org/classroom-resources/lesson-plans/questioning-comprehension-strategy-small-408.html

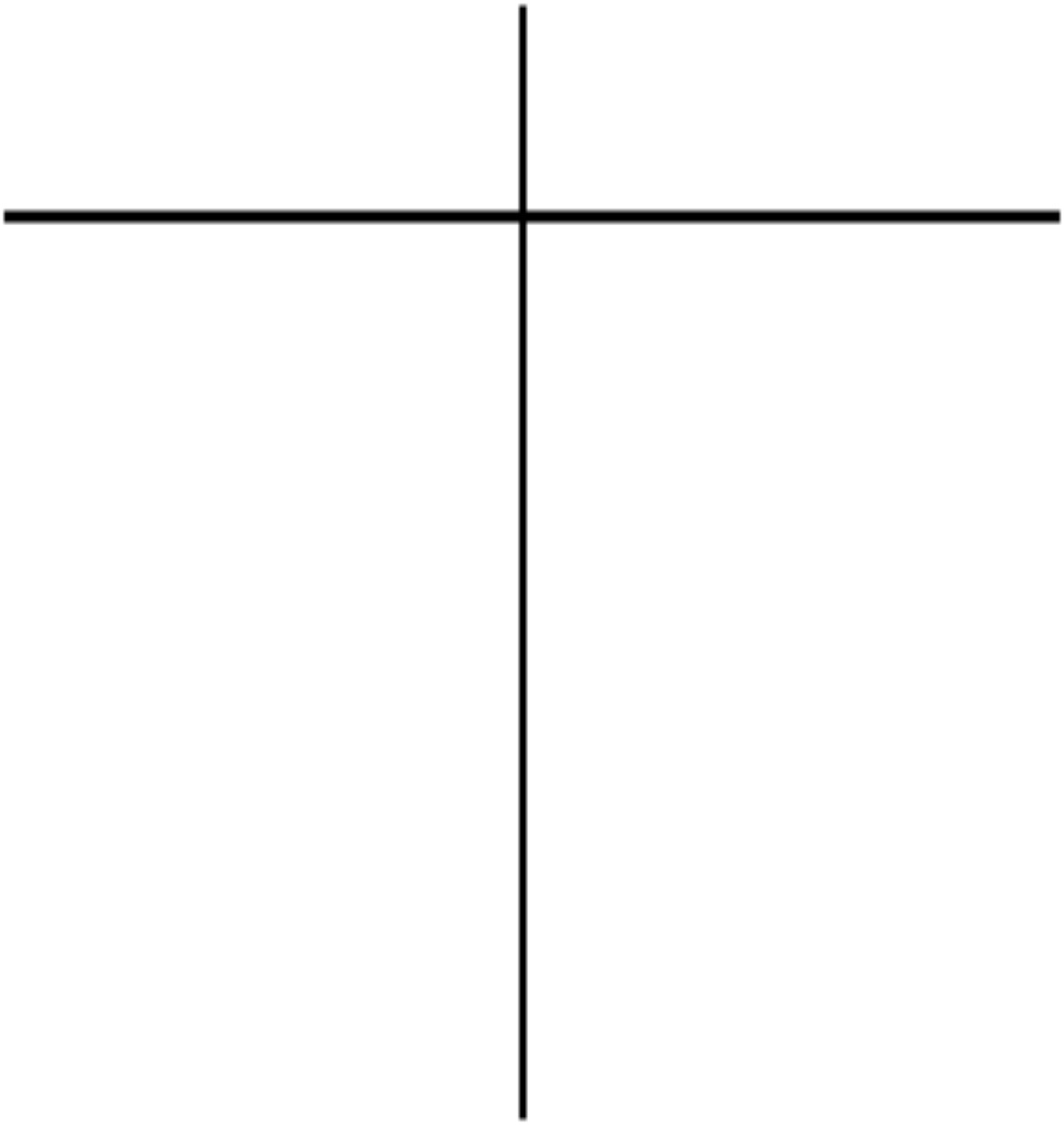
Force and Motion Anticipation Guide

Before the lesson, read each statement about force and motion. Circle "A" if you agree with the statement or circle "D" if you disagree with the statement. After the lesson, you will read the statements again and mark whether you agree or disagree with each statement.

Agree/Disagree	Statement	Agree/Disagree
A D	1. If there is motion, then a force is acting.	A D
A D	2. If there is no motion, then there is no force acting.	A D
A D	3. There cannot be a force without a motion.	A D
A D	4. Objects can continue moving in a straight line without applying force.	A D
A D	5. When an object is moving, there is always a force in the direction of its motion.	A D
A D	6. Moving objects stop when their force is used up.	A D
A D	7. Forces act on objects at rest.	A D
A D	8. The stronger the force, the faster the object moves.	A D
A D	9. Constant speed results from constant force.	A D
A D	10. A force is necessary in order to change the direction of motion.	A D

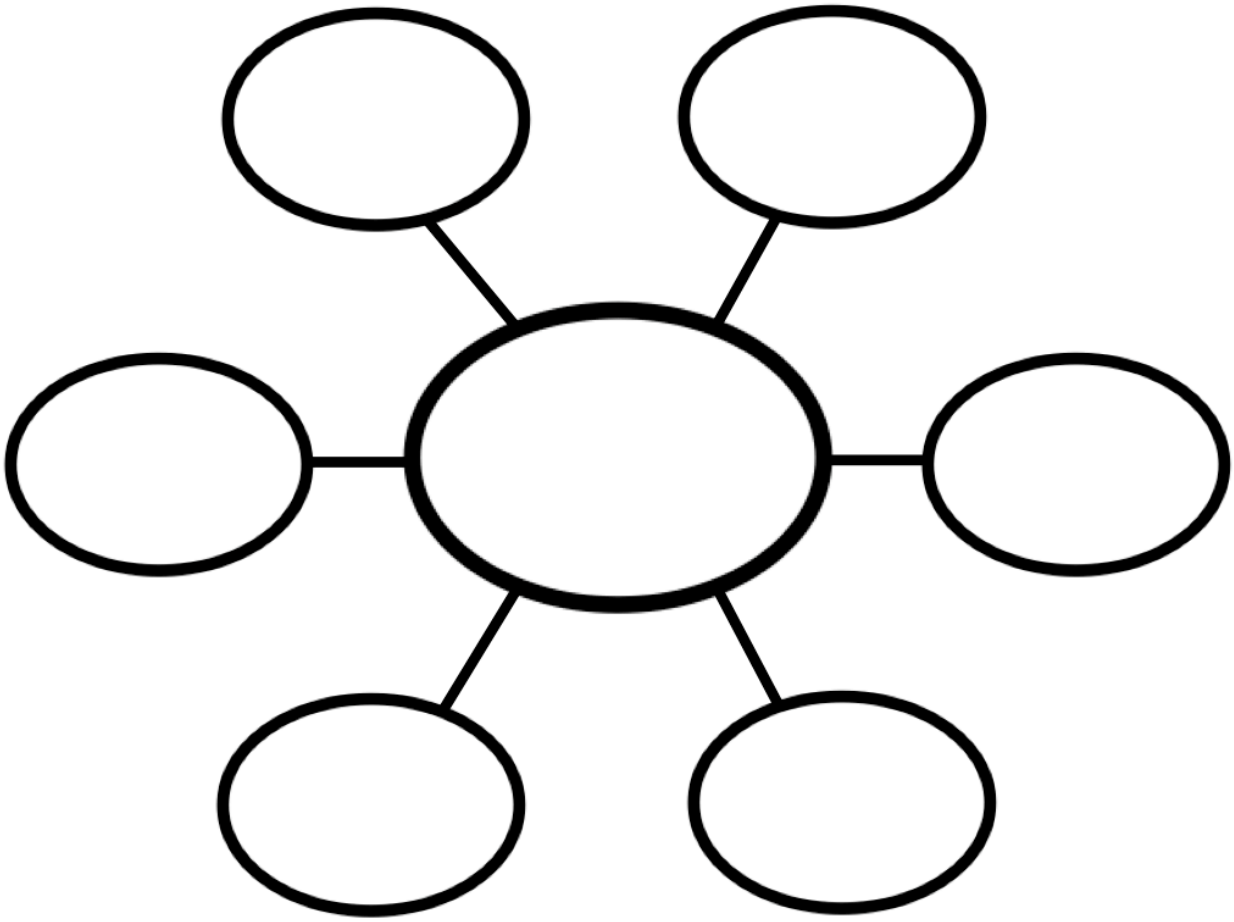
Thick and Thin T-Chart

Name: _____
Date: _____



Newton's First Law of Motion
Graphic Organizer

Name: _____
Date: _____



Force and Motion: Do you have Balance?

Teacher: Jennifer Ladd

Unit title / Lesson title / Grade level: Force / Force and Motion: Do you have Balance? / 5th Grade

Benchmarks GLCE's for this lesson:
P.FM.05.31: Describe what happens when two forces act on an object in the same or opposing directions
P.FM.05.32: Describe how constant motion is the result of balanced (zero net) forces
S.IP.05.12: Design and conduct scientific investigations on motion and changes in motion
S.IP.05.13: Use tools and equipment (stop watches, meter sticks and tapes, models, balances) appropriate to scientific investigation of motion
S.IA.05.12: Evaluate data, claims, and personal knowledge through collaborative science discourse about motion
S.RS.05.15: Demonstrate scientific concepts about motion through various illustrations, performances, models, exhibits, and activities

Lesson objective(s):
Students will be able to:

- Compare and contrast balanced and unbalanced forces (P.FM.05.31)
- Explain the effects balanced and unbalanced forces have on the motion of an object (P.FM.05.31)
- Describe constant motion and how it is affected by balanced and unbalanced forces (P.FM.05.32)
- Demonstrate balanced and unbalanced forces through experimentation with the correct usage of scientific instruments (S.IP.05.13)
- Chart and graph quantifiable data showing the effects of balanced and unbalanced forces on the distance a fan cart can move during experimentation (S.IA.05.12)
- Design and test new ways to demonstrate balanced and unbalanced forces using fan cart kits (S.IP.05.12)
- Design and present a poster illustrating an activity or experiment that explains balanced and unbalanced forces (S.RS.05.15)

Materials:

- Low-friction fan cart kits
- Batteries
- Small weights
- Measuring tape
- Poster paper
- Markers

Time needed to complete entire lesson: 3 class periods (1 hour per class)

ENGAGEMENT:

- Show Youtube videos on Balanced and Unbalanced forces from the Science Geeks and Tutorvista: Tutorvista youtube video: http://www.youtube.com/watch?feature=player_detailpage&v=HEJOybRxclk Science Geeks youtube video on Force and Balance: http://www.youtube.com/watch?feature=player_detailpage&v=qHFE1G4Rix0
- Have students write out what they think the definitions of balanced and unbalanced forces are. Have students brainstorm examples of balanced and unbalanced forces.
- Demonstrate examples of unbalanced and balanced forces: Book on table, pushing a stationary chair, pulley system.
- Have two student volunteers demonstrate balanced forces by having them push their hands against each other so they do not fall.

- Have the students engage in a balance game- Have students pick a partner. Students sit on the floor back to back and interlock their arms. Students use force and balance to work together to stand up. Have a class discussion on how this game demonstrates force and balance.

EXPLORATION:

The Fan Cart activity/experiment:

1) Divide students into groups. 2) Have students help in the assembly of the carts. 3) Groups of students will place carts on the floor and place fans in different positions to investigate balanced and unbalanced forces on the cart (one fan blowing one direction, two fans blowing opposite directions, two fans blowing in same direction). 4) Students will use a measuring tape to record, in chart form, how far their cart moved in a set amount of time in each scenario. Students should repeat each scenario at least 3 times to obtain enough distance data to graph. 5) Students will place the data on a graph (template provided by the teacher) in their scientific journals and discuss/interpret their findings with their groups and present their findings during class discussion. This data will be used as the "control" for the next experiment involving testing new variables with the fan carts. Clarify the dependent (time) and independent variables in the experiments.

EXPLANATION:

- Revisit the student's initial definitions or examples of balanced and unbalanced forces. Give students the official definitions of balanced and unbalanced forces to record in their notebooks.
- Have student volunteers demonstrate all the scenarios of the Fan Cart activity to show both unbalanced and balanced forces. Have student volunteers explain the Fan Cart activity and how it demonstrated balanced and unbalanced forces. Have groups report their findings (one group report finding with one fan one direction, one group report findings on two fans one direction, one group report findings on two fans two directions).
- Revisit the Balance game and discuss the similarities/differences between the Balance game and the Fan Cart activity.
- Give students real life examples of balanced and unbalanced forces (boat floating on water, a person standing or sitting in a chair, how small objects like wedges can move bigger objects etc.).
- Revisit, discuss and assess for understanding of key/CI vocabulary: Force, balanced force, change in direction, force strength, friction, direction of motion, unbalanced force, Newton's, zero-net force and non-zero net force. Have students add all CI vocabulary to their scientific journal.
- Play a game of "Force and Balance Jeopardy" using concepts from the lesson and some of the key/CI vocabulary. The class is divided into teams and the teams answer the questions.

ELABORATION:

- Give students class time to demonstrate/experiment with different variables they can add to the fan cart to affect the balance and forces acting upon it (weights, more batteries, plastic sails etc. "variables" can be found in the fan cart kits and from materials available in the classroom). Students will need to use the same measuring tape to record how far the fan cart traveled with each of the new variables. Student should test each new variable at least three times. Students will record new findings in scientific journals in chart form.
- Students will place their new data on a graph (graph template provided by teacher) and record the differences in the first and second Fan Cart experiments in their scientific journals. Students will discuss their new findings and explain any differences during class discussion.
- Divide students into groups. Each group will come up with their own activity to show balanced forces and be ready to present a poster with illustrations to the class.

EVALUATION:
GLCE: P.FM.05.31: SWBAT compare and contrast balanced and unbalanced forces.
Evaluation: Choral response, group responses from "Force and Balance Jeopardy" game and exit slips from first day's class activities and discussion and check of Venn diagram from lab activity worksheets.

GLCE: P.FM.05.31: SWBAT explain the effects balanced and unbalanced forces have on the motion of an object.
Evaluation: Choral and group responses from "Force and Balance Jeopardy" game and exit slips.

GLCE: P.FM.05.32: SWBAT describe constant motion and how it is affected by balanced and unbalanced forces.
Evaluation: Students write three sentences to describe of how fan placement affected the movement of the fan cart on their Lab Activity worksheet.

GLCE: S.IP.05.13: SWBAT demonstrate balanced and unbalanced forces through experimentation with the correct usage of scientific instruments.
Evaluation: Teacher observation during experimentation and check of charts and graph in student scientific journals.

GLCE: S.IA.05.12: SWBAT chart and graph data showing the effects of balanced and unbalanced forces on the distance a fan cart can move during experimentation.
Evaluation: Check of charts and graphs in student scientific journals. Groups will share results of graphs with the class and each group will pick the variable they think affected the movement of the cart the most and each students will write a few sentences on how that variable affected the distance the cart moved.

GLCE: S.IP.05.12: SWBAT design and test new ways to demonstrate balanced and unbalanced forces using fan cart kits.
Evaluation: Students will write up a short lab report (template provided by teacher) to include: what new variables they used, how they thought the new variable would affect the movement of the fan cart, the data from their chart and graph, how the outcome of the experiments compared to what they thought would happen and the differences in the first fan cart experiment and the second fan cart experiment. Teacher observation of individual participation in activity.

GLCE: S.RS.05.15: SWBAT design and present a poster illustrating an activity or experiment that explains balanced and unbalanced forces.
Evaluation: Groups present and submit posters illustrating their activity or experiment and be graded with the poster rubric.

References:

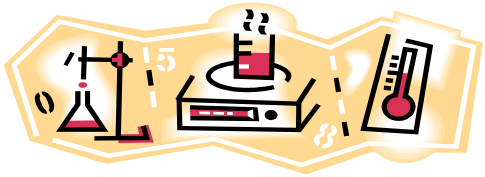
Michigan Department of Education. (2010). 5-7 Science grade level content expectations companion document. Retrieved January 29, 2011, from: http://www.michigan.gov/documents/mde/5-7_Science_GLCE_Companion_Document_v.1.09_2_264472_7.pdf

Teaching Tips Machine
http://www.teaching-tips-machine.com/venn_diagram.htm

Tutorvista youtube video
http://www.youtube.com/watch?feature=player_detailpage&v=HEJOybRxclk

Science Geeks youtube video on Force and Balance:
http://www.youtube.com/watch?feature=player_detailpage&v=qHFE1G4Rix0

Do You Have Balance? Fan Cart Lab Activity Write Up



Name: _____
Date: _____

Date of Lab: _____

Describe the Fan Cart lab activity:

_____
_____
_____
_____
_____

List the scientific tools used in this lab:

- _____
- _____
- _____
- _____
- _____

List the steps you used to carry out Fan Cart Experiment #1:

- _____
- _____
- _____
- _____
- _____
- _____
- _____

Before you conduct Fan Cart Experiment #2- Make a hypothesis of how you think testing new variables might change the data you collect.

_____
_____
_____
_____

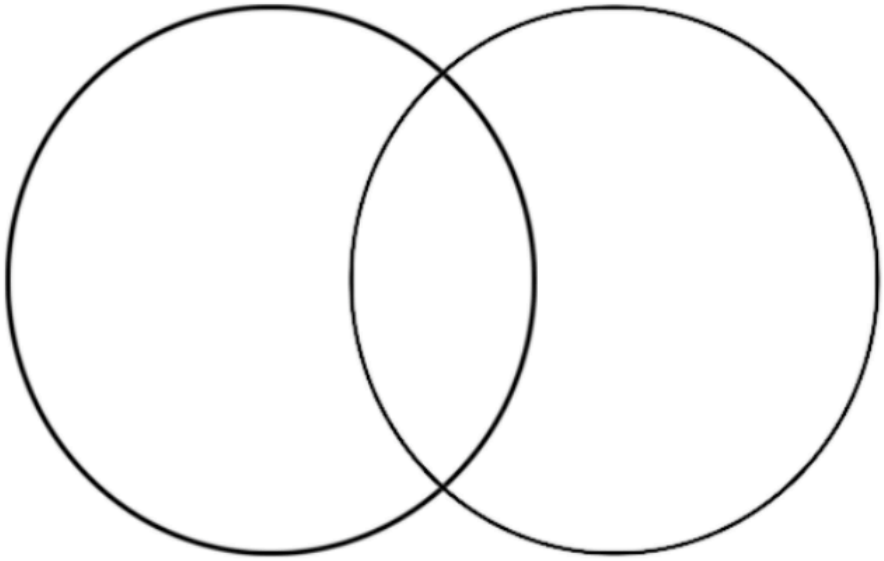
List the steps you used to carryout Fan Cart Experiment #2 including new variables tested. What are your independent and dependent variables?

- _____
- _____
- _____
- _____
- _____
- _____

Did the data and outcome of Experiment #2 match your predictions? Explain:

_____
_____
_____
_____
_____

Use the Venn diagram below to show the similarities and differences in Fan Cart Experiment #1 and Fan Cart Experiment #2:



What can you conclude from the data you collected in Fan Cart Experiment 1 compared to the data you collected in Fan Cart Experiment #2?

_____
_____
_____
_____

Feedback: What was your favorite part of this Lab Activity? What was your least favorite part? What could you change to make it better?

_____

_____

_____

Do you have balance? Fan Cart Lab Report

Name:	Date:

Problem: (how will the change in variables (independent) affect the outcome of data (dependent)
Hypothesis:
Materials/tools used during Fan Cart Lab:
Procedures: List steps of Fan Cart experiments 1 and 2
Observations: What did you observe during the Fan Cart experiments?
Analysis: What did you learn? Explain data. (Hint: Use information from Lab Activity worksheet)
Conclusion: Did the results from the Fan Cart Experiment #2 match your prediction?

Fan Cart Data Sheet

	Trial #1	Trial #2	Trial #3
Experiment 1 1 fan 1 direction			
Experiment 1 2 fans 2 1 direction			
Experiment 1 2 fans 2 directions			
Experiment 2 Variable 1:			
Experiment 2 Variable 2:			
Experiment 2 Variable 3:			

Do you have Balance? Poster Rubric

Teacher name: Mrs. Ladd

Student Name: _____

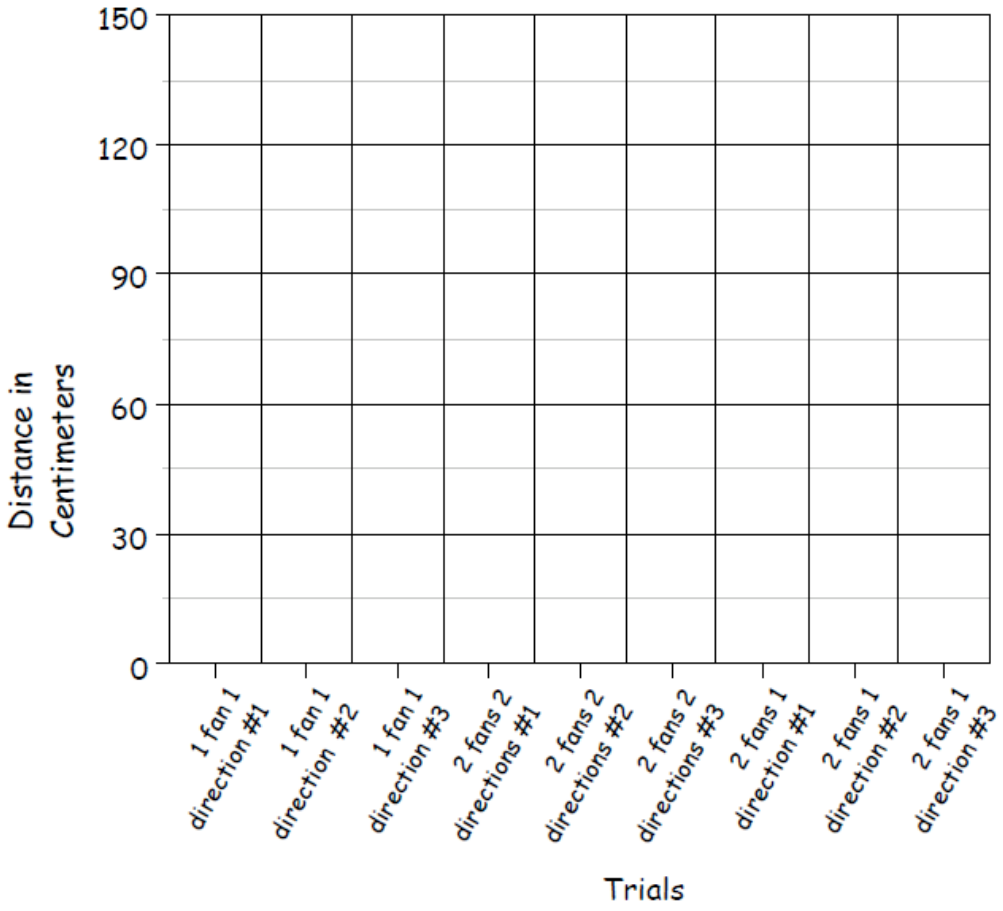
Date: _____

CATEGORY	4	3	2	1
Required Information	The poster includes all required information: a short paragraph that explains the experiment and how it shows balanced and unbalanced forces, names of group members, name of experiment and a colorful illustration of the experiment	Poster includes most of the required information but may be missing one required element.	Poster includes most of the required information but is missing two required elements.	Several required elements were missing and there is no paragraph explaining balanced and unbalanced forces.
Labels	All important features of the experiment are illustrated on the poster and are clearly labeled.	Almost all items of importance on the poster are clearly labeled.	Many items of importance on the poster are clearly labeled.	No important items on the poster are labeled.
Visual layout of poster	The poster is colorful and very attractive in terms of design, layout, and neatness.	The poster is attractive in terms of design, layout and neatness.	The poster is acceptable, though it may be a bit messy.	The poster is unattractive and distractingly messy or very poorly designed.
Group Presentation of Poster	All group members participated in presentation. Poster was explained clearly and within a 5-minute timeframe.	All group members participated in presentation. Poster was explained clearly but not within timeframe given.	Most group members participated in presentation. Poster was explained but lacked clarity in presentation.	Less than half of the group participated in the presentation. Poster was not explained clearly.
Grammar	There are no grammatical mistakes on the poster.	There are 1-2 grammatical mistakes on the poster.	There are 3-4 grammatical mistakes on the poster.	There are more than 4 grammatical mistakes on the poster.

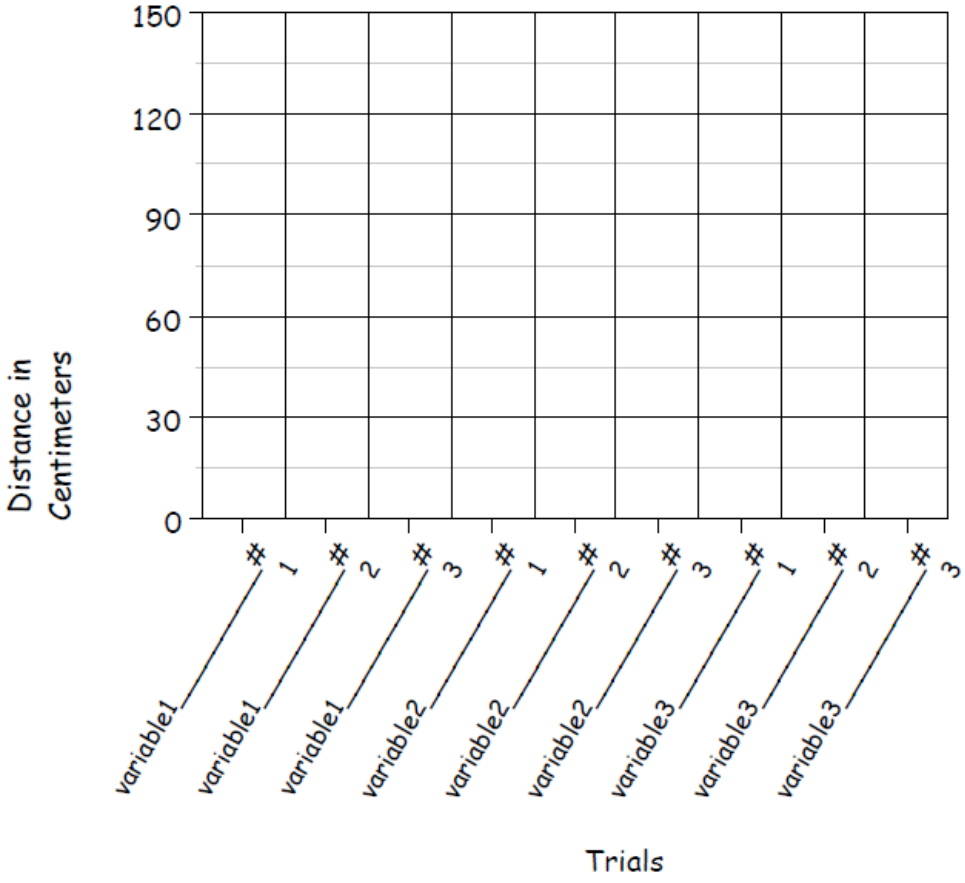
Force and Motion Jeopardy Game Questions:

1. This is a push or a pull that acts on an object. Answer: What is a force
2. This is the unit we use to measure force. Answer: What is a Newton
3. This is the type of force that changes an objects motion. Answer: What is an unbalanced force
4. An evenly matched game of tug of war is an example of what kind of force. Answer: What is a balanced force
5. An object a rest is an example of this kind of force. Answer: What is a balanced force.
6. The force pulls us toward the Earth. Answer: What is gravity.
7. An object moving at constant velocity is an example of this kind of force. Answer: What is a balanced force
8. What is explained as two objects rubbing against one another? Answer: What is friction.
9. This will most likely happen if two balanced forces act upon an object. Answer: What is the object will not move.
10. This is the result of balanced forces acting on an object. Answer: What is a zero-net force.

Fan Cart Experiment #1



Fan Cart Experiment #2



Understanding Force – Writing Connection

Teacher: Melissa Crawford

Subject Area: Language Arts - Writing

Grade Level: 5th

Unit Title: Force

Lesson Title: Understanding Force

Objectives:

- Students will be able to classify changes in motion caused by balanced and unbalanced forces.
- Students will be able to support evidence to justify their findings.
- Students will engage in a writing component that involves learning how to write an informational piece while effectively communicating what they have learned.
- Students will be able to write using a specific writing form and provide content of the writing.
- Students will be able to write using a topic sentence, providing evidence and examples from their investigation to back up their claim and finally stating their conclusion based on their evidence.

Writing GLCE's:
W.GN.05.03: Write a position piece that demonstrates understanding of central ideas and supporting details (e.g., position/evidence organizational pattern) using multiple headings and subheadings.
W.PR.05.01: Set a purpose, consider audience, and replicate authors' styles and patterns when writing a narrative or informational piece.
W.PR.05.02: Apply a variety of pre-writing strategies for both narrative and informational writing (e.g., graphic organizers such as maps, webs, Venn diagrams) in order to generate, sequence, and structure ideas (e.g., role and relationships of characters, settings, ideas, relationship of theory/evidence, or compare/contrast).

Science GLCE's:
P.FM.05.32: Describe how constant motion is the result of balanced (zero net) forces.
P.FM.05.33: Describe how changes in the motion of objects are caused by a non-zero net (unbalanced) force.

Anticipatory Set:

Invite students to explain their understanding of force and motion.
Show a video describing both balanced vs. unbalanced forces.
(http://www.engineeringinteract.org/resources/parkworldplot/flash/concepts/balancedandun.htm)
After the video use probing questions to have students begin thinking of what they know about force and motion.

- What is an example of a force?
- Can nature act as a force to move objects? If so, what are some examples?

- Why do objects always fall to the ground?

Before beginning the writing session review what we concluded at the end of the last science session.

Objective/Purpose:

Students will be able to classify changes in motion caused by balanced and unbalanced forces. Students will be able to support evidence to justify their findings. Students will engage in a writing component that involves learning how to write an informational piece while effectively communicating what they have learned. Students will be able to write using a specific writing form and provide content of the writing. Students will be able to write using a topic sentence, providing evidence and examples from their investigation to back up their claim and finally stating their conclusion based on their evidence.

Input:

Students will engage in an inquiry-based activity that will emphasize force. This inquiry-based activity will allow the students to gain the following knowledge and understanding. For example, the students will understand that forces have a magnitude and direction. Also, forces can be added. Students will be able to explain that the net force on an object is the sum of all of the forces acting on the object. In addition, they will be able to identify that the speed and/or direction of motion of an object changes when a non-zero net force is applied to it. Lastly, how a balanced force on an object does not change the motion of the object (the object either remains at rest or continues to move at a constant speed in a straight line).

Once students are actively engaged the teacher will introduce the independent writing component. The teacher will begin with a mini-lesson by modeling certain writing phrases and structures –and then the students will contribute their observations, evidence, and thinking that constitutes the content of the writing. At this time we will conduct shared writing where the teacher shows how to begin with a topic sentence, how to support my claim by providing evidence from the investigation, and point out when enough evidence has been given to conclude their paper. The teacher will provide the following tips:

- Words from the question (topic sentence)
- “For example,” (introduce data)
- “But” (introduce data from the other end of the range of data)
- “Therefore,” (introduce concluding statement)

The teacher will end the lesson by having students brainstorm using a graphic organizer (web, map, list) of their choice in order to organize their thoughts.

Guided Practice:

After a few minutes students will discuss their ideas with a partner and engage in a think-pair-share. This will allow students to gain outside information before beginning their writing. Students will discuss the changes in an objects motion caused by balanced and unbalanced forces. As students discuss with one another the teacher will circulate and ask specific questions regarding the science unit such as “what happens when there is a zero force being added to an object as opposed to force being added to an object?” Most of the questions will be open-ended to ensure each student is able to explain or illustrate an understanding of the key concepts. Once students have prepared a list and shared we will spend time as a

class reviewing the concepts and examples associated with changes in motion in terms of balanced and unbalanced forces. At this time the teacher will assess whether the students are prepared to start independent writing. Lastly, the teacher will discuss and summarize the independent writing assignment. Lastly, the teacher will answer any questions or correct any misconceptions before the students begin. Once students are ready independent writing will begin.

Independent Practice:

Students will write three to four paragraphs demonstrating an understanding of force. Students should be able to classify changes in motion caused by balanced and unbalanced forces. In addition, students should be able to use the evidence found to support findings. It's important that students use their graphic organizer and additional information they gathered during think-pair-share to organize ideas and evidence. Also, students should be able to show how to formulate a topic sentence, provide supporting evidence, and provide a conclusion. This paper will show the teacher that students understand the concepts and are able to provide evidence to support claims. Lastly, this paper will be started in class and students will be given time in class the following day to finish. If assignment isn't completed then it will be assigned as homework.

References:

Balanced and Unbalanced Forces. (2010). Retrieved from http://www.engineeringinteract.org/resources/parkworldplot/flash/concepts/balancedandun.htm.

Fulwiler, B. (2007). Writing and Science. Retrieved from http://www.heinemann.com/shared/onlineresources/E01070/chapter2.pdf.

Fifth Grade English Language Arts Grade Level Content Expectations http://www.michigan.gov/documents/ELA_05_87358_7.pdf.

Fifth Grade Science Grade Level Content Expectations http://www.michigan.gov/documents/mde/5-Science_COMPLETE_12-10-07_218320_7.pdf.

Force and Motion Unit Guide. Retrieved from http://www.sciencea-z.com

Writing Rubric

CATEGORY	
Content	- Addresses scientific content or conceptual understanding - Uses clear, complete, descriptions, facts and explanations to develop the controlling idea - Information is relevant and appropriate to the subject - Includes main idea(s) with 3 or more supporting details with developed elaboration
Organization	- Has an effective introduction with topic sentence - Has a clear sequence with a beginning, middle, and end - Uses effective transitions between sentences and paragraphs - Has a strong effective conclusion that summarizes ideas
Style (Voice, Word Choice, Fluency)	- Includes use of scientific vocabulary - Uses a sense of scientific authority that a student expresses through the writing - Uses purposeful and varied sentences - Attempts complete, complex sentences - Has fluent writing
Language Conventions	- Clear and correct, simple, complex, and compound sentences with correct punctuation - No errors in mechanics - Consistent use of spelling strategies
Presentation	- Neat handwriting

Balanced Forces

Teacher: Andrea Whan

Unit title / Lesson title / Grade level: Force and Motion / Balanced Forces / 5th Grade

Benchmarks GLCE's for this lesson:
P.FM 05.32 Describe how constant motion is the result of balanced (zero net) forces.
S.IP.05.12 Design and conduct scientific investigations on motion and changes in motion.
S.IP.05.13 Use tools and equipment (stop watches, meter sticks and tapes, models, balances) appropriate to scientific investigation of motion.
S.IP.05.14 Use metric measurement devices in the investigation of motion.
S.IA.05.14 Draw conclusions from sets of data from multiple trials of a scientific investigation on motion and changes in motion.
S.RS.05.15 Demonstrate scientific concepts about motion through various illustrations, performances, models, exhibits and activities.

Lesson objective(s):
Students will be able to:

- Explain the role of force in motion plays in rocket propulsion as force is exerted on the rocket in the opposite direction (P.FM.05.32).
- Construct a film canister rocket to demonstrate how unbalanced forces create motion (S.I.P.05.12).
- Analyze force in motion by designing rockets using film canisters, various metric measurements of vinegar and bicarbonate to determine rocket propulsion height (S.IP.05.13).
- Metrically illustrate results regarding the acceleration and balanced forces (S.IP.05.14).
- Compare recordings using various amounts of the materials to determine the results (S.IA.05.14).
- Complete the illustration the size and direction of any force that is acting on the rocket as identified on the Thinking About Science worksheet (S.RS.05.15).

Materials:

- Film canisters
- Hot Wheels tracks
- Meter tape or stick
- Antacid tablets with sodium bicarbonate broken in half
- Vinegar
- Sand
- ML droplets
- Plastic spoons

Time needed to complete entire lesson: 90 minutes (Estimated)

ENGAGEMENT:
Show clips of various examples of force in nature in a montage (Visual)

- Wily E. Coyote involved in various examples of force. http://www.youtube.com/watch?v=n8Bmo6tDEGI.
- Show the clips of the force of the Tsunami in Japan, 11 Mar 12 http://www.telegraph.co.uk/news/worldnews/asia/japan/8375996/Japanese-tsunami-wave-approaches-shore.html; http://www.asiantsunamivideos.com.
- Read passages of Snowstruck: In the Grip of Avalanche by Jill Fredston for accounts of an avalanche's movement, sound, and force (Auditory) http://video.nationalgeographic.com/video/environment/environment-natural-

disasters/avalanches/avalanche-skier/.

- Give each table two marbles and ask them how they think fast the marble would go if it went down a ramp up a ramp and if it collided into another (Tactile).

Perform a KWL to see what the students believe to know about force and motion through the examples.
Possible questions to ask and do:

- After reviewing these clips ask what they have in common?
- Have you seen these actions of force in your daily life?
- Describe a time where you have seen force in nature.
- How many have ever seen bicarbonate like Alka Seltzer? Demonstrate what it does. Explain what it is and how and why the bubbles go to the top so quickly. Poll students regarding whether the bubbles are powerful enough to move anything.

Explain:
Inform the students that they are going to make a film canister rocket using bicarbonate and vinegar. This experiment develops understanding of force and motion through rocket propulsion and investigating the amount of vinegar that will make the rocket go the highest.

The chemical reaction between bicarbonate and vinegar produces carbon dioxide gas. When the lid of the film canister is sealed, pressure builds up inside the canister until the lid pops off and the rocket is launched upwards.

Newton's third law
This law states that, for every action, there is an equal and opposite reaction. The action is that gases are pushed out the bottom of the film canister rocket. The reaction is that the rocket is pushed upward. If pressure is able to build up inside the canister before the lid pops off, the gases will be pushed out faster so the rocket will be pushed upward faster and will reach a greater height.

Momentum and gravity
Once the lid has come off the rocket and the rocket is moving upward, its momentum will keep it moving upwards. The force of gravity acts on the rocket and pulls it back towards the Earth. This force remains the same throughout the flight and makes the rocket slow down, momentarily stop and then keep speeding up as it falls back down.

Fair testing
A variable is anything that might affect the results. The main variables that might affect the height reached by the film canister include the amount of vinegar, and the amount of bicarbonate. For the initial experiment students will keep all variables the same except the amount of vinegar. They will experiment to find out the amount of vinegar that produces the greatest height before having a class.

EXPLORATION:
Explain the challenge: to make a film canister into a rocket and to find out its maximum propulsion.

THE CONTROL:

- Draw marks at 1 cm intervals on the outside of the canister measuring from the closed end. (These are the guides for filling vinegar for each trial.)
- To launch the rocket: Fill the indent in the lid with one piece of bicarbonate – so there is the same amount used for each launch.

- Make sure the edges of the lid and the canister are wiped clean so there are no leaks at launch time. Start with 1 cm of vinegar in the canister.
- Once at the launch site, hold the canister firmly in one hand and use the palm of your other hand to snap the lid closed, being careful to keep holding the rocket vertically so that the vinegar and baking soda don't mix.
- Turn the rocket over, give it a brief shake, place it on the ground and step well back. If the rocket does not launch after about 20 seconds, carefully approach from a low side-on stance and give it another quick shake. If you can see bubbles and liquid escaping from the canister, it is possible that the lid was not cleaned well enough to seal or that the seal is broken.
- Rinse out the rocket and repeat for 2, 3 and 4 cm of vinegar. Clean the edges of the lid well between launches.
- Have students complete their testing and complete the 'Recording sheet' section of the student worksheet as they go. Height could be recorded as a comparison with other objects such as twice the height of the classroom or half the height of the netball hoop or estimated in meters. If there is time, students may like to try half-centimeter amounts.
- After 30 minutes of building and testing, announce the competition and give students 5 minutes to get their rockets filled with the amount of vinegar they think will make their rocket go the highest.
- For the class competition, have one student from each pair lined up along a line ready to launch. The other students should be off to the side to help with judging. You may also like to give prizes for the highest rocket, nicest flight and prettiest rocket.
- Have students complete the 'Thinking about science ideas' section of the student worksheet and discuss the results:
    - Who was expecting more vinegar to increase propulsion?
    - What amount of vinegar created the highest lift?
    - Why do you think that amount worked?

EXPLANATION:

Review the KWL responses to check for understanding:

- Discuss what makes a rocket go up. (Pressure inside the rocket pushes gases out one end really fast, which pushes the rocket in the other direction.)
- Discuss how we could build up pressure inside the film canister rocket. (Students may suggest hydrogen gas or kerosene – explain that they will use a method without flames: water reacting with bicarbonate.)
- Discuss what things might affect how high the rocket will go. Explain that something that might affect the results is called a variable, and to work like scientists, they should only change one variable and keep all the others the same.
- Constant variable– amount of bicarbonate placed in the lid.
- The one variable to change – amount of vinegar.
- The one thing to measure as a result – height reached by the film canister.
- Hand out copies of the student worksheet Make and launch a film canister rocket, and working in pairs, have students make rockets.
- When all the rockets are ready, proceed to a designated testing area outside – a clearly marked section of level flat concrete on a path or court works well. Emphasize safety. Make sure students stay well away from the launch zone when not launching.
- Describe the testing procedure. Ask the students for a show of hands for which amount of vinegar (1, 2, 3 or 4 cm) they think will make the rocket travel the highest. Ask for reasons.

Video clips of NatGeo for video and an explanation of rocket propulsion

- http://video.nationalgeographic.com/video/science/weird-science-sci/idkt-how-rockets-work/.

ELABORATION:

Ask about different possibilities of making the rocket demonstrate force and motion. If the canister was turned on its side, would that effect its momentum? Use the Hot Wheel tracks to determine if the information changes in any way. Experiment with sand, additional bicarbonate and vinegar.

ENGAGEMENT

- Create an experiment where the canisters move in equal distance, and when they do not move. Evaluate how this can happen.
- Create their own independent variable experiments to identify balanced forces using sand.
- Create their own independent variable experiments to identify unbalanced forces with cotton.
- Possible independent variable experiments include varying amounts of bicarbonate.
- Possible dependent variables that students can explore: time of movement, horizontal movement
- Students complete a data table of quantifiable analysis of the additional testing on bicarbonate using science investigation sheet the Recording Sheet.
- Students compare the success of their independent variables with the class in graph form on the Thinking About Science.

EVALUATION:

GLCE: P.FM 05.32 Describe how constant motion is the result of balanced (zero net) forces.
Objective: Explain the role of force in motion plays in rocket propulsion as force is exerted on the rocket in the opposite direction.
Evaluation: The teacher will evaluate the students understanding of force m\by their differentiating how changes in speed or direction of motion are caused by forces using the Thinking About Science worksheet.

GLCE: S.IP.05.12 Design and conduct scientific investigations on motion and changes in motion.
Objective: Create a propulsion experiment to demonstrate force in motion using bicarbonate and vinegar.
Evaluation: The students will construct and operate rockets varying the ingredients to determine the correct combination to achieve the highest height. Understanding will be formatively evaluated by the collection and review of the Recording Sheets.

GLCE: S.IP.05.13 Use tools and equipment (stop watches, meter sticks and tapes, models, balances) appropriate to scientific investigation of motion.
Objective: Analyze force in motion by designing rockets using film canisters, various metric measurements of vinegar and bicarbonate to determine rocket propulsion height.
Evaluation: Teacher have students argue their predictions in a Think-Pair-Share and and access after the experiment; adjusting where necessary. Using the Recording Sheet, students will identify conduct tests and examine the patterns for force through their models and activities.

GLCE: S.IP.05.14 Use metric measurement devices in the investigation of motion.
Objective: Metrically illustrate their results regarding the acceleration and balanced forces.
Evaluation: Teacher will formatively evaluate the students understanding by asking students to verbally interpret their findings and reviewing the recorded findings on the Recording Sheet.

GLCE: S.IA.05.14 Draw conclusions from sets of data from multiple trials of a scientific investigation on motion.
Objective: Compare their recordings using various amounts of the materials to determine the results.
Evaluation: Based on the results, students should be able describe the role of force in each experiment to explain the height of the rocket. They should be able to support their conclusions based on their individual recordings of the various amounts of vinegar used each trial.

GLCE: S.RS.05.15 Demonstrate scientific concepts about motion through various illustrations, performances, models, exhibits, and activities.
Objective: Complete the illustration the size and direction of any force that is acting on the rocket as identified on the Thinking About Science worksheet.
Evaluation: Utilize the "Thinking About Science" worksheet as a summative assessment. Collect and review the worksheet to determine if the students successfully identified the combination of vinegar and bicarbonate to elevate the rocket the highest. And Support the phenomena by explaining how the motion of an object can be graphically represented by its position, direction of motion, and the speed.

References:

Michigan Department of Education. (2007). *K-7 Science grade level content expectations*. Retrieved February 3rd, 2013 from: http://www.michigan.gov/documents/mde/5-Science_COMPLETE_12-10-07_218320_7.pdf.

May the "Forces" be with You Billups, Ellis, Long

tannerc1.wikispaces.com/file/.../Forces+%26+Motion+Unit+Map.doc...

Science, Life Skills and Innovations in American Automobile Racing | Teacher Guide

thehenryford.org/education

www.sciencelearn.org.nz

http://www.rockets4schools.org/images/Newtons.Laws.of.Motion.pdf

Recording sheet

1. Draw and label your rocket:

2. What amount of vinegar do you think will make the rocket go the highest? Give a reason for your answer.

3. Record your results for each amount of vinegar as you do it. Clean your rocket well between trials.

Amount of vinegar	Height (If outside, estimate metres or relate it to the height of a nearby object, e.g. 1.5 times the height of the classroom) Use the taped meter sticks located on each wall.
1 cm	
2 cm	
3 cm	
4 cm	

4. What amount of vinegar did you use for the class competition? ____ cm of vinegar

5. How high did your rocket go?

6. How much vinegar did the winning rocket have?

7. How high did the winning rocket go?

8. What is your conclusion about what makes a film canister go the highest?

9. What else might you try to make your film canister go even higher?

Thinking about science ideas

1. What is pushing on a film canister rocket to make it start going up?

2. Why does the rocket keep moving upwards once the lid has already come off?

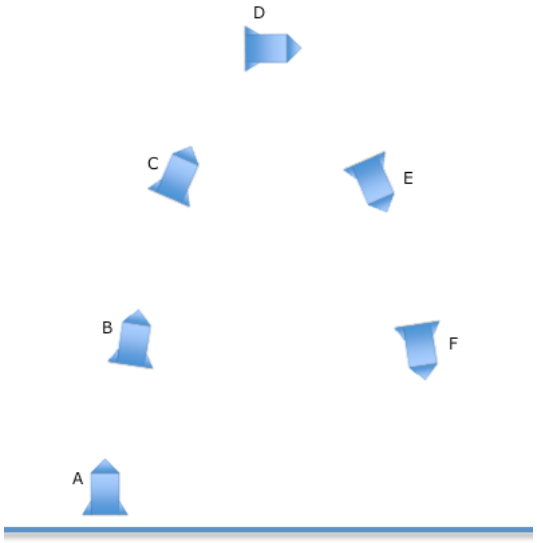
3. What makes the rocket slow down and then come back to the ground?

4. Look at the diagram at the bottom of the page. Describe what is happening to the speed of a film canister rocket at each stage of its motion:

Stage of motion	What is happening to the force and speed? (e.g. balances, unbalanced, getting faster, staying the same, slowing down) The film canister rocket is…
A. While the lid is being pushed off	
B. Just after the lid has been pushed off	
C. Nearly at the top	
D. At the top	
E. On its way back down	
F. Nearly all the way down	

5. On the diagram below, use a ruler to draw an arrow to show the size and direction of the speed for each of the rocket images. Use a smaller arrow if it is travelling more slowly. Label each of these arrows with 'speed'.

6. On the diagram below, use a ruler and a different color to draw an arrow to show the size and direction of any force that is acting on the rocket for each of the rocket images above. (A force is something that is pushing or pulling on the rocket.) Use a smaller arrow if the force is less. Label each of these arrows with 'force'.



Post Evaluation

Each student will answer the questions below to demonstrate their post-test understanding:

An unbalanced force acting on an object causes the object to _____.

The _____ pressure in a rocket's combustion chamber pushes it through space.

A force that is NOT matched by an opposing force is called a _____ force.

To properly describe force we need to know the amount of force and the direction that the force is heading. An unbalanced _____ accelerates an object in the direction in which the _____ is acting.

When the amount of bicarbonate increased, it generated greater force within the canister. This force produces a_____ acceleration than a smaller force on the same object.

Please explain why:
For every action, there is an equal and opposite reaction.

Any force applied always results in a reaction.

accelerate
balanced
unbalanced
force, force
larger

Balanced and Unbalanced Forces

Teacher: Melissa Crawford

Unit title / Lesson title / Grade level: Force / Balanced and Unbalanced Forces / 5th Grade

Benchmarks GLCE's for this lesson:
P.FM.05.33: Describe how changes in the motion of objects are caused by a non-zero net (unbalanced) force.
P.FM.05.34: Relate the size of change in motion to the strength of unbalanced forces and the mass of the object.
S.IP.05.11: Generate scientific questions based on observations, investigations, and research.
S.IA.05.13: Communicate and defend findings of observations and investigations using evidence.
S.RS.05.15: Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities.

Lesson objective(s):
Students will be able to:
- Predict the change in motion of an object when an unbalanced force is applied to the object
- Discuss how the size of change in motion relates to the strength of unbalanced forces and the mass of an object.
- Illustrate what is happening during the experiment and simulation and explain what is happening.
- Defend and communicate their findings using evidence through whole group and small group discussion.

Materials:
- One cup, one penny, and one playing card or stiff piece of paper for demonstration.
- 1 computer per student if possible, otherwise they can work in pairs or groups. Can work as a class on the projector if student computers are unavailable.
- The "PhET" interactive simulation (http://phet.colorado.edu/en/simulation/forces-and-motion)
- Rope
- Book
- Toy car

Time needed to complete entire lesson: 2 class periods (1 hour per class)

ENGAGEMENT:
- Ask students: what do you know about gravity? Student responses: gravity pulls down, gravity holds us down. Gravity is a force right? Gravity is a force that pulls objects toward Earth. Throw a penny into the air and describe how gravity pulls it back toward the ground.
- Conduct the penny/water glass/ playing card demonstration for the class. Place a playing card over a glass of water and place the penny on top of the card. Ask the students: why doesn't a penny fall into the water? Student responses: it is on the card; the card is holding it up. Is gravity still applying a force to the penny? Students: no / yes. Yes gravity is still acting on the penny. Gravity is still applying a downward force on the penny. Draw a free body diagram on the board. The forces are balanced and cancel each other out. The force holding the penny up is equal to the force of gravity pushing down so the penny is not moving; it has balanced forces acting on it. Flick the card out from under the penny so the penny falls into the glass of water. Ask students what happened? Explain how the card was removed so the upward force pushing up on the penny was removed so the only force left was gravity and it pulled the penny into the water. The forces became unbalanced so gravity pulled the penny into the glass. When an unbalanced force is present, an object will move.

EXPLORATION:
Draw a picture (free body diagram) of a bow being pulled to provide tension in the string before being released to shoot an arrow (a toy bow and arrow would be helpful but not necessary). Students will explore how unbalanced forces cause objects to move, while using a computer simulation to do so. Students will go to a computer (partners if necessary or

teacher demonstration if necessary) and go to the "intro" tab on the Force and Motion PhET simulation (http://phet.colorado.edu/en/simulation/forces-and-motion). Before the simulation pass out the Force and Motion worksheet that will guide the students. The worksheet will help students organize student observations. Students will then explore and play with the simulation for 5 minutes and try to figure out how to use it. If students need help, explain buttons and features. While students are navigating through the simulation the worksheet should be used to take notes.

Evaluation:
Allow each student time to explore and learn how a change in an objects motion is caused by a non-zero net (unbalanced) force. Also, review the Force and Motion worksheet students are completing to assess any misconceptions. In addition, prompt students to consider and predict what happens when both a balanced force and unbalanced force is present on an object.

EXPLANATION:
The teacher should explain and define non-zero net (unbalanced) force. In addition, describe how changes in the motion of objects are caused by non-zero net (unbalanced) force.

Explaining the video of the bow and arrow:
We provide a pulling force on the string to pull the string back. If we hold it in place while pulled back, it is a balanced force because the force of us pulling is equal to the string pulling back. It is not moving so the forces are balanced.
Questions for students: What happens when the string is released?
Students: the arrow will shoot and move forward.
Why?
Students: the force used to pull the string allows the arrow to shoot forward.
Yes, the forces are now unbalanced because we are no longer pulling on it. If the forces are unbalanced, the object will move. Does it matter if you pull harder on the string?
Yes, the harder we pull it back the farther it will shoot. It has a greater unbalanced force so it shoots farther.

Explain/discuss the simulation:
Teacher should have students respond to the questions as a small group. After a couple minutes of collaboration with one another have a whole group discussion.
Questions for students: What have you all noticed?
Student responses: It is hard to get the bigger objects to move; we have to push harder to get the bigger/heavier objects to move; when you put the objects on ice it goes faster and keeps going.
Hand out a worksheet for the students to work through for the PhET simulation. Students may work in pairs, talk to your neighbors if you need help or raise your hand if you need help.

Evaluation:
Throughout the discussion check for misconceptions regarding concepts of non-zero net (unbalanced) force. Continue with explanation stage before moving on to the elaboration stage if students are having a hard time describing the key concepts of the lesson. Allow students to communicate and defend their observations with one another by using what they have learned and gathered through the PhET simulation and class discussion.

ELABORATION:
Allow students to consider how other unbalanced forces cause a change in motion. Encourage students to come up with new ways to test new variables that explain how unbalanced forces cause a change in motion. Allow time for students to formulate their own examples before providing examples. At this time suggest looking around the room and in their desks for other variables. During this time have students discuss with one another to determine examples. Such examples could

include both balanced and unbalanced forces to ensure students know the difference. Examples could be: tug of war, dropping a book, pushing a car. These examples could be demonstrated and/or illustrated by students in the class, at this time have them explain what is happening. It's important to see if the students can make the connection with new variables (tug of war, dropping a book, pushing a car).

Evaluation:
Once examples have been established via student or teacher have students discuss as a whole or small group what is happening given a specific example. Students should be able to differentiate what happens to an object when a balanced and unbalanced force is placed on an object.

EVALUATION:
Informally assess the students throughout the engagement, exploration, and explanation stages. At any time students seem confused address any questions or misconceptions. Students will be evaluated through choral response and discussions throughout the exploration and explanation stages. This will include a variety of questions where the students will describe, explain, and illustrate they understand the difference between balanced and unbalanced forces. All of the students will answer a set of questions that will demonstrate their understanding of the concepts within this lesson.

GLCE: P.FM.05.33: Describe how changes in the motion of objects are caused by non-zero net (unbalanced) force.
Objective: Predict the change in motion of an object when an unbalanced force is applied to the object.
Evaluation: Students will describe how changes in the motion of objects are caused by non-zero net (unbalanced) force. They will use evidence from class discussions (small and whole group), experiment, and simulation to defend their answers.

GLCE: P.FM.05/34: Relate the size of change in motion to the strength of unbalanced forces and the mass of the object.
Objective: Discuss how the size of change in motion relates to the strength of unbalanced forces and the mass of an object.
Evaluation: Students will discuss in both small and whole groups how the size of change in motion relates to the strength of unbalanced forces and the mass of the object.

GLCE: S.IP.05.11: Generate scientific questions based on observations, investigations, and research.
Objective: Construct new questions to explore based on their findings.
Evaluation: Throughout the lesson the students will make observations while investigating and formulating questions. This will be shown through a whole class discussion. Also, students will generate questions based observations and investigation through the PhET simulation.

GLCE: S.IA.05.13: Communicate and defend findings of observations and investigations using evidence.
Objective: Defend and communicate their findings.
Evaluation: Students will communicate and defend their observations in both small and large group discussions. Students will be given the opportunity to communicate and defend their findings by using evidence to support their claim.

GLCE: S.RS.05.15: Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities.
Objective: Illustrate what is happening during the experiment and simulation and explain what is happening.
Evaluation: Students will demonstrate and/or illustrate balanced and unbalance forces acting on the object. In addition, they will explain what is happening.

References:

Michigan Department of Education. (2007). *K-7 Science grade level content expectations*. Retrieved February 3rd, 2013 from: http://www.michigan.gov/documents/mde/5-Science_COMPLETE_12-10-07_218320_7.pdf.

Lesson Plan: http://l-dody-scienceportfolio.weebly.com/lesson-plans.html

Simulation: http://phet.colorado.edu/en/simulation/forces-and-motion

Worksheet: http://phet.colorado.edu/en/contributions/view/3423

Forces and Motion Simulation Worksheet

Name: _____
Date: _____

Learning Objectives:

- Be able to identify when unbalanced forces are acting upon an object.
- Be able to predict the change in motion when a force is applied to an object.

Part 1: Understanding balanced and unbalanced forces

1. Open the **Forces and Motion Simulation** by clicking the icon on your computer's screen.

2. Play with the first tab of the sim for about 5 minutes. **What do you find?**

3. Using the simulation for help, draw pictures showing Joe, the file cabinet and **force arrows**.

Scene 1: Joe not pushing	**Scene 2: Joe pushing but cabinet not moving**	**Scene 3: Joe pushing and cabinet moving**

Describe what is necessary to start the file cabinet moving.

4. Determine whether the forces are **balanced or unbalanced** in each scene.

Force and Motion Exit Pass

Name: _____
Date: _____

1. Describe how changes in the motion of objects are caused by non-zero net (unbalanced) force.

2. Explain in your own words how the size of change in motion relates to the strength of unbalanced forces and the mass of an object.

3. Throughout the lesson you have generated questions and tested them based on your observations and investigations. Using the evidence and information you gathered to briefly explain what would be different if you moved a book, instead of a file cabinet?

4. As we tested new variables we noticed how other unbalanced forces caused a change in motion. Please name at least one example? Also, explain what is happening?

5. Draw a diagram showing how a balanced force acts on an object.

6. Draw a diagram showing how an unbalanced force acts on an object.

Newton Math - Math Connection

Teacher: Sarah Gerding

Subject Area: Math

Grade Level: 5th

Unit Title: Force

Lesson Title: Newton Math

Objectives/GLCE's:

P.FM.05.32: Students will be able to describe how constant motion is the result of balanced (zero net) forces.
P.FM.05.33: Students will be able to describe how changes in the motion of objects are caused by an unbalanced (non-zero net) force.
P.FM.05.34: Students will be able to relate the size of change in motion to the strength of unbalanced forces and the mass of the object.
N.FL.05.05: Students will be able to solve applied problems involving multiplication and division of whole numbers.
D.RE.05.01: Students will be able to read and interpret line graphs, e.g., distance-time graphs.

Anticipatory Set:

Ask students to split into two teams to complete an activity. Tell approximately ¾ of the students to move to one side of the room and the remaining ¼ to move to the other side of the room. On each side of the room there will be a small start and finish line (use tape on the floor) with equal distance between the lines for each team. Tell them that the goal for each team is going to be to push a toy car across the finish line the fastest and whichever team wins will get a prize. At that point, based on the unequal division of the teams, ask them if they think this is going to be fair and why or why not? Look for answers regarding the larger group having more people (i.e., strength, mass, etc.) to help push the car than the smaller group.

Next, bring out two toy cars: one very small and light and the other larger and much heavier. Give the light car to the group with more people and the heavy car to the group with less people. Ask them again if this would seem fair and why or why not? Look for answer regarding the weight of the cars.

Have the children sit back down in their seats and explain that we will be reviewing the concepts of force, mass and acceleration and solving math problems using these variables.

Input:

Review Newton's first law of motion:

- If forces are balanced, Newton's first law of motion predicts that the objects will not be in motion (give examples of an object not moving while sitting on a desk).

- Ask the students to describe the movement of this object and make sure they understand that there is no movement. Then explain that when an object is not moving, there are balanced forces acting on it. Have the students draw a picture of what they think this looks like.
- An object will only accelerate if there is a net (or unbalanced) force acting upon it.

Review Newton's second law of motion:
- Pertains to the behavior of objects when all existing forces are not balanced.
- Acceleration of an object depends on the net force (directly) and the mass of the object (inversely).
- Force increased: acceleration increased. Mass increased: acceleration decreased (Give example of a person: a large adult would need to be pushed much harder than a small child in order for the two to move the same distance).

Introduce the equation: Force = Mass x Acceleration
Reference for Input: http://www.physicsclassroom.com/class/newtlaws/U2l3a.cfm

Guided Practice:

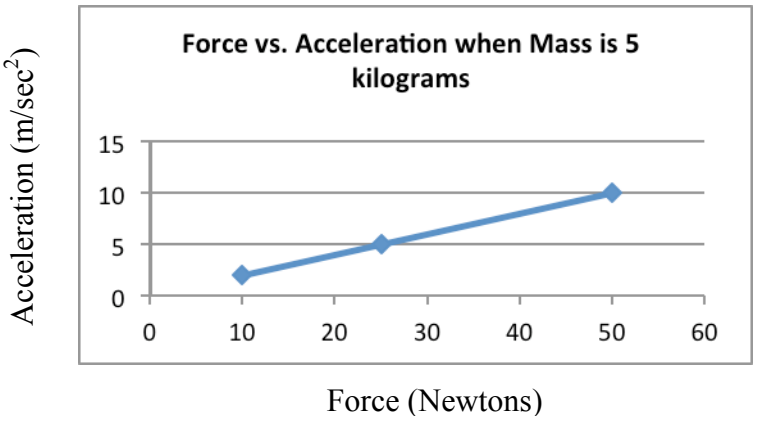
Go through sample problems on the board (do several types of problems: some with Mass and Acceleration known and Force unknown, some with Force and Mass known and Acceleration unknown, etc.). Frame the problems in terms of different toys cars with different masses.

Depending on the complexity of the problems, students may be allowed to use calculators (however, the problems can be made so that they are able to solve the equations without calculators).

Next, focus on a story problem regarding a car that weighs 5 kilograms (the mass) and complete a few equations using 5 kilograms as the mass. Have the students help you create a table that includes several Force and Acceleration answers when Mass equals 5 (example below):

Force	Mass	Acceleration
10	5	2
25	5	5
50	5	10

- Show the students how you would plot these points on a line graph (example below):



Ask the students several questions about the line chart such as “Can someone estimate what the Acceleration would be when the Force was 20 using only the graph?”

Independent Practice:

For end of class work (or homework) have student complete attached worksheet which includes basic questions regarding force, mass and acceleration, practices solving the F = M x A equation and interpreting a new line graph.

Math Connection Lesson Plan Worksheet

Name: _____
Date: _____

Complete the following questions. Remember, **Force = Mass x Acceleration**.

1) Circle the correct answer in the following sentences:

   a. The force acting on an object that **IS NOT** moving is an example of Balanced **– or – Unbalanced** forces.
   b. The force acting on an object that **IS** moving is an example of Balanced **– or – Unbalanced** forces.
   c. If two objects have the same amount of force acting on them, which one will accelerate at a greater speed: **Lighter object – or – Heavier object**?

2) Explain why you circled the answer you did for question 1c:

   _____
   _____

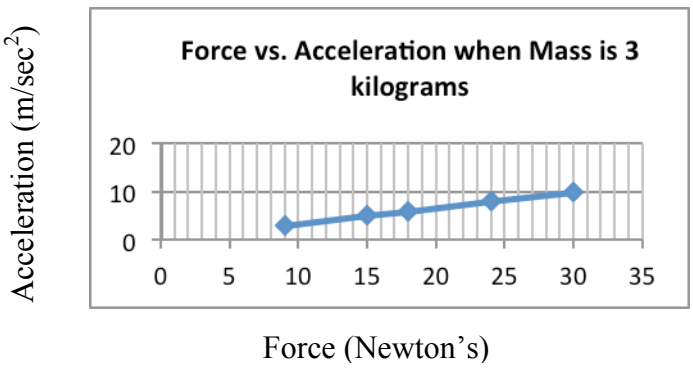
3) Complete the blank boxes in the following table using the F = M x A equation:

Force	Mass	Acceleration
	3	3
15		5
	3	6
24	3	
30		10

4) Look at the graph below.

   a. Does this line graph contain all of the points from the table above?
      Circle One: Yes or No

   b. According to this graph, what would the Acceleration be when the Force is 12? _____



Math Connection Worksheet (Answer Key)

1) Balanced, Unbalanced, Lighter Object

2) Answers may vary (Example: The lighter object will accelerate quicker than the heavier object because it has less mass. If the forces are equal, the object with less mass will travel farther.)

3)

Force	Mass	Acceleration
9	3	3
15	3	5
18	3	6
24	3	8
30	3	10

4) Yes, 4

"UN-Balancing Act"

Teacher: Prima-Marie Dailey

Unit title / Lesson title / Grade level: Force & Motion / "UN-balancing Act" / 5th Grade

Benchmarks GLCE's for this lesson:
P.FM.05.34: Relate the size of change in motion to the strength of unbalanced forces of an object.
S.IP.05.11: Generate scientific questions based on observations, investigations and research.
S.IA.05.13: Communicate and defend findings of observations and investigations using evidence.
S.RS.05.15: Demonstrate scientific concepts about motion through various illustrations, performances, models, exhibits, and activities.

Lesson objective(s):
Students will be able to:
- Define a balanced and unbalanced force
- Write new questions based on their findings
- Defend their results from experiments and observations
- Demonstrate motion when an object is at rest and when force is applied

Materials:
- Push or pull worksheet - "Is it a Push or Pull?" (see attached)
- Truck w/ an open bed (2)/string (2)/weight (2)/metal washer (1)/ruler/table
- Balance scale/same size balls, different masses (2)
- Empty 2 liter bottles (3)/2 liter bottles w/ 1 cup of sand ea. (3)/ball (1)/funnel
- Same size box (2)/bag of sand(1)/will use the same ruler as in station 1
- PowerPoint presentation (see attached)/journal (Pens)/station signs (3)/lab rules

Time needed to complete entire lesson: 2 Class Periods (1 hour per class)

ENGAGEMENT:
- Students will complete a push or pull worksheet - Is it a Push or Pull? (see attached). Teacher and students will revisit this worksheet and discuss each scenario during the explanation stage.

EXPLORATION:
Students are broken up into three groups and are given directions on what they will do in each station. Students are directed to record their observations and results before, during and after each station in their journal.

- Station 1: Force = mass x acceleration
  - Tie a string of equal length on the front of each truck
  - Tie a weight onto the other end of each string
  - Put a washer in the bed of one truck
  - Align the two trucks next to each other on the "starting" edge of the table allowing the weights to hang off the end of the table, while using the ruler as a stopper
  - Measure the trucks to ensure they are at equal length from the end of the table
  - Have the person holding onto the ruler lift it so the trucks are able to move at the same time
  - Have a student at the end of the table be ready to catch the trucks
  - Have students measure the distance the trucks traveled with an explanation why they traveled as they did and record the data in their journals

Result
The truck that does not have the washer in the bed is lighter (less mass), thus moves further ahead than the truck with the washer in the bed.

- Station 2: Unbalanced Forces
    - Place the balance scale on a flat-leveled table
    - On one side place one ball in that scale
    - On the other side, place the second ball in that scale
    - Have students record their data which is the weight of each side of the balance scale with an explanation why they weigh as they do in their journals

Result
The object with more mass will cause the scale to sink due to its mass, while the object with lighter mass will rise higher due to its lighter mass causing the scale to become unbalanced. Objects of the same mass will balance the scale.

- Station 3: Motion
    - Find an open area on a flat surface floor
    - Fill three 2 liter bottles w/ 1 cup of sand using a funnel
    - Place the 2 liter bottles on one end of the floor in a triangular formation
    - Take 12 steps back
    - Write what you observe before you throw the ball
    - Take the ball and roll it gently toward the "pins"
    - Repeat set up for the three empty 2 liter bottles and take 12 steps back
    - Take the ball and roll it gently toward the "pins"
    - Have students record their data which is their observations of the "pins" movements during each trial with an explanation why they moved as they did in their journals

Result
When the "pins" are lined up, they are at rest. As the ball hits the "pins", it applies force that changes their state of rest to a state of motion. When sand is added to the bottles, it changes their mass, thus the "pins" move in response to the appropriate force that is applied.

EXPLANATION:
The teacher will show a brief PowerPoint presentation (see attached) that allows for an open discussion between teacher and students. The teacher will guide this process as the students respond to the questions on each slide. This presentation will go through the push or pull worksheet from the engagement stage, discuss each station from the exploration stage, introduce vocabulary terms listed below and answer any questions and/or concerns the students may have encountered thus far.

Vocabulary Terms:
- Force: Push or pull. Force can give energy to an object, causing it to move, stop moving, or change direction
- Mass: The amount of matter an object contains
- Balanced forces: Do not cause a change of speed or direction
- Unbalanced forces: Always cause a change in speed or direction
- Newton's 2nd Law: Force= mass x acceleration
- Motion: When an object's distance to a set point changes
- Acceleration: Is a rate at which an object's velocity changes with time
- Velocity: Speed of an object and its direction of motion

ELABORATION:
Students will test new variables & discuss how force relates to their everyday lives. It is up to the students (with the teachers guidance and approval) to come up with new variables to test. One simple way is listed below. (New variables being tested: box; sand; mass)

- Newton's 2nd Law
    - Take two boxes that are the same size and place them on the floor
    - In one box, place a bag of sand inside
    - Do not allow the students to pick up the box or touch the boxes prior to the experiment
    - Now ask the student to kick one box so that it will slide across the floor
    - Have the students measure the distance that the box traveled after the kick
    - Now have the same student kick the second box on the floor
    - Have the student's measure the distance that the box traveled after the kick. Have students measure the distance each box traveled with an explanation why they traveled as they did and record in their journals (correct responses will match the result noted below and their grade will be assessed as such)

Result
The boxes were at rest and stayed at rest until acted upon by a force (kick). Once the force was applied to each box, each box then moved forward. The box with the least amount of mass moved further because it was lighter than the box with a larger mass when the same amount of force was applied.

EVALUATION:
GLCE: P.FM.05.34: Relate the size of change in motion to the strength of unbalanced forces of an object.
Objective: Students will be able to define a balanced and unbalanced force.
Evaluation: During the explanation stage, students will define what a balanced force is and what an unbalanced force is through a choral response. The choral responses for a balanced force will be: do not cause a change of speed or direction. The choral responses for an unbalanced force will be: always cause a change in speed or direction

GLCE: S.IP.05.11: Generate scientific questions based on observations, investigations and research.
Objective: Students will be able to write new questions based on their findings.
Evaluation: Students will implement their new questions in the elaboration stage upon approval from the teacher.

GLCE: S.IA.05.13: Communicate and defend findings of observations and investigations using evidence.
Objective: Students will be able to defend their results from experiments and observations.
Evaluation: Students will hand in their writing journals for a grade. Within the journals, the students will include the results from each station and also defend those results to back up their claim.

GLCE: S.RS.05.15: Demonstrate scientific concepts about motion through various illustrations, performances, models, exhibits, and activities
Objective: Students will be able to demonstrate motion when an object is at rest and when force is applied.
Evaluation: Students will demonstrate knowledge of the scientific concept of balanced and unbalanced forces by successfully completing three stations of the exploration stage.

References:

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"UN-Balancing Act" PowerPoint

"UN-Balancing Act"

Continuing our learning on Force

"Is it a Push or Pull?"

You tell me...

Scoring a goal in football

Opening a car door

Opening a bag of potato chips

Stapling papers together

Picking apples off of a tree

"Is it a Push or Pull?"

You tell me...

Putting on a pair of pants

Cutting food

Throwing a ball

Using the brakes on a bicycle

Typing on the computer keyboard

Station 1: Force = mass x acceleration

Let's chat...

What did you do in this station?

What happened to the trucks after you lifted the ruler?

Why did this happen as a result of this activity?

Other observations, questions, concerns?

Station 2: Unbalanced Forces

Let's chat...

What did you do in this station?

What happened to each side of the balance scale after you added each ball?

Why did this happen as a result of this activity?

Other observations, questions, concerns?

Station 3: Motion

Let's chat...

What did you do in this station?

What happened to the pins after you added the sand?

Why did this happen as a result of this activity?

Other observations, questions, concerns?

Vocabulary Terms:

- **Force** - Push or pull. Force can give energy to an object, causing it to move, stop moving, or change direction
- **Mass** - The amount of matter an object contains
- **Balanced forces** - Do not cause a change of speed or direction
- **Unbalanced forces** - Always cause a change in speed or direction

Vocabulary Terms:

- **Newton's 2nd Law** - Force= mass x acceleration
- **Motion** - When an object's distance to a set point changes
- **Acceleration** - Is a rate at which an object's velocity changes with time
- **Velocity** - Speed of an object and its direction of motion

Is it a Push or Pull?

Name: _____
Date: _____

Please indicate whether the action is a **push** or a **pull**.

1.) Scoring a goal in football: _____

2.) Opening a car door: _____

3.) Opening a bag of potato chips: _____

4.) Stapling papers together: _____

5.) Picking apples off of a tree: _____

6.) Putting on a pair of pants: _____

7.) Cutting food: _____

8.) Throwing a ball: _____

9.) Using the brakes on a bicycle: _____

10.) Typing on the computer keyboard: _____

References:

First School Years. (2006). *Forces and Motion (Pushes and Pulls).* Retrieved on February 24th, 2013 from: http://firstschoolyears.com/science/forces/forces.html

Unit Post-Test

In order to demonstrate what you have learned during the Force Unit, you will be completing a Tic-Tac-Toe assignment. Please complete 3 of the assignments from the grid below. Be sure to choose 3 that are in a row (vertically, horizontally or diagonally).

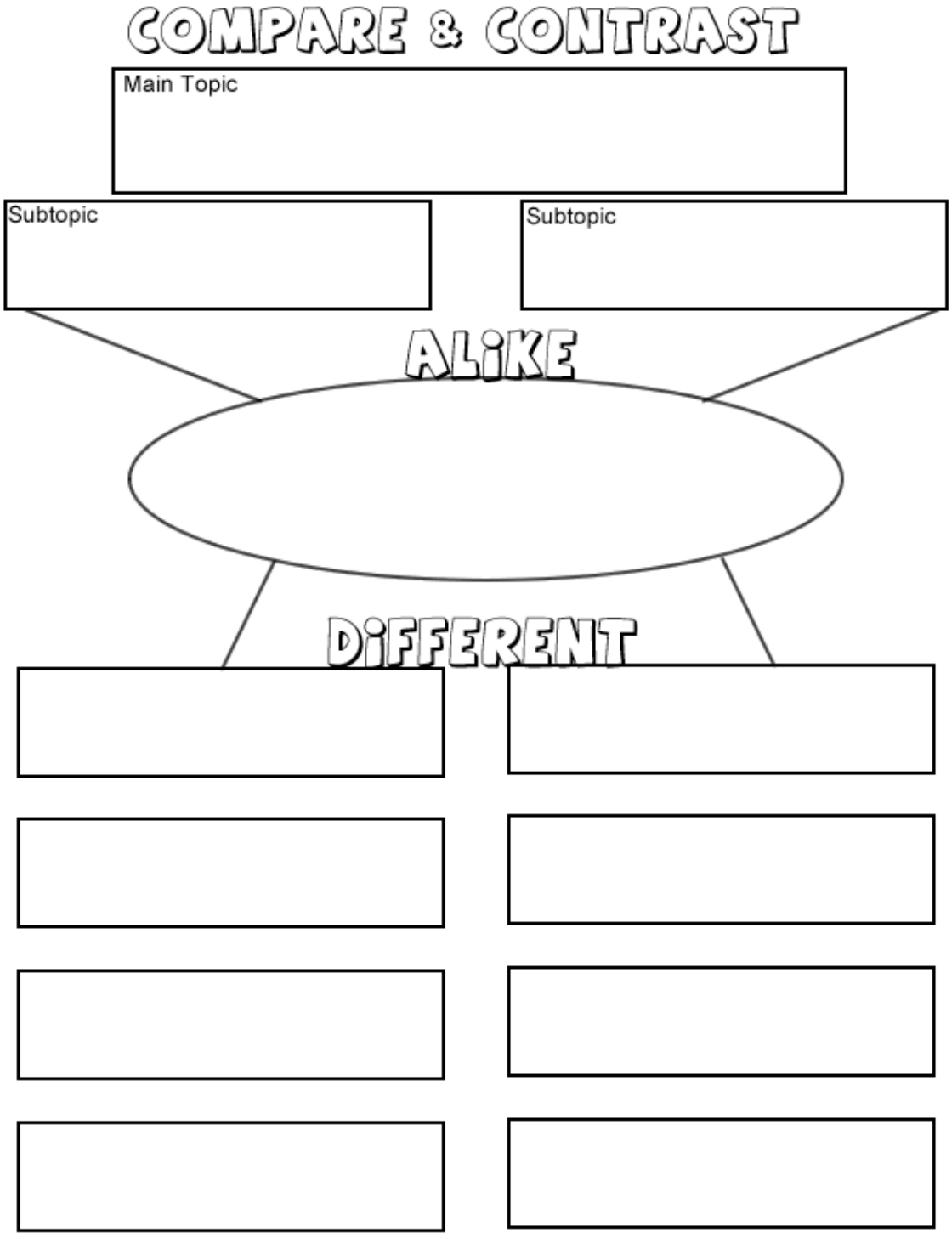
In paragraph form, explain in your own words what happens when two forces act on an object in the same or opposing directions P.FM.05.31	Create a poster depicting different forces using magazine cutouts, drawings, pictures, etc. (be sure to label each force) P.FM.05.33, S.RS.05.15	Construct a model that demonstrates balanced forces P.FM.05.32, S.RS.05.15
Using the attached list of terms discussed in this unit, create a crossword puzzle which displays your knowledge of force and motion using these terms P.FM.05.31, P.FM.05.32, P.FM.05.33, P.FM.05.34	Design an experiment that tests balanced and unbalanced forces P.FM.05.32, P.FM.05.33, S.IP.05.11 S.IP.05.12, S.IP.05.12	Create a video that shows at least 5 forces you find around the school, your house, etc. Narrate the video and explain the type of force and what makes it a force P.FM.05.32, P.FM.05.33, S.RS.05.15
Write a song about force and motion to play or perform for the class P.FM.05.31, P.FM.05.32, P.FM.05.33, P.FM.05.34, S.RS.05.15	Using the graphic organizer provided, compare and contrast unbalanced (non-zero net) and balanced (zero net) forces P.FM.05.32, P.FM.05.33	Build a model rocket to show to the class. On a poster board, illustrate and discuss the forces in action and the resulting motion that occurs when a rocket takes flight P.FM.05.31, P.FM.05.32, P.FM.05.33, P.FM.05.34, S.RS.05.16,

List of terms from this unit (to be used for the crossword puzzle assignment):

- force
- balanced force
- force strength
- mass
- relative position
- direction of motion
- unbalanced force
- zero net force
- non zero net force

Graphic Organizer

(to be used for the compare and contrast assignment):



References and Resources

Teacher:

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Maloney, D. P. (1984). *Rule-governed approaches to physics—Newton's third law.* Physics Education, 19, 37-42.

Minstrell, J. (1982). *Explaining the "at rest" condition of an object*. Physics Teacher, 20, 10-14.

Sadanand, N., & Kess, J. (1990). *Concepts in force and motion*. Physics Teacher, 28, 530-533.

Sequeira, M., & Leite, L. (1991). *Alternative conceptions and history of science in physics teacher education*. Science Education, 75, 45-56.

Watts, D. M., & Zylbersztajn, A. (1981). *A survey of some children's ideas about force*. Physics Education, 16, 360-365.

Student:

<u>Books</u>

Cole, J. (1997). The Magic School Bus Plays Ball: A Book About Forces. New York: Scholastic.

Dalton, C.D. (2001). How can I experiment with...? Gravity. Vero Beach, FL: Rouke.

Gianopoulos, A. (2007). Isaac Newton and the laws of motion. Mankato, MN: Capstone Press.

Gordon, M. (1995). Push and pull. New York: Thomson Learning.

Mayer, L. & Rogers, S. (2010). Newton and me. Mount Pleasant, SC: Sylvan Dell Pub.

Websites:

http://www.physics4kids.com/files/motion_intro.html

Videos:

http://www.youtube.com/watch?v=PD7a1EjWsTc

http://www.youtube.com/watch?feature=player_detailpage&v=qHFE1G4Rix0

http://firstschoolyears.com/science/forces/forces.html