FORCE AND MOTION

Grade Level: 8th Grade-Science
Presented by: Trish Eckles, Pat Jefferson, Chris Alexander
Length of Unit: 18 days

I. ABSTRACT

The focus of this unit is Newton's Three Laws of Motion. The students will be able to discuss, explain, and demonstrate the three laws of motion. The culminating activity will require students to create a fan-powered vehicle

II. OVERVIEW

A. Concept Objectives (Texas Essential Knowledge and Skills, Science 8.3E and 8.7A)
   1. Students will understand the difference between mass, weight, and gravity.
   2. Students will distinguish between speed, velocity, acceleration, and momentum.
   3. Students will understand Newton's 3 Laws of Motion and the effects of friction on motion.

B. List of Specific Core Knowledge Content
   1. Motion (p.198)
      Velocity and speed
      The velocity of an object is the rate of change of its position in a particular direction. Speed is the magnitude of velocity can involve changes in speed or per unit of time. Changes in velocity can involve changes in speed or direction or both.
      Average speed=total distance traveled divided by the total time elapsed
      Formula: Speed=Distance/Time (S=D/T)
      Familiar units for measuring speed: miles or kilometers per hour
   2. Forces (p.198)
      The concept of force: force as a push or pull that produces a change in the state of motion of an object
      Examples of familiar forces (such as gravity, magnetic force)
      A force has both direction and magnitude.
      Measuring force: expressed in units of mass, pound in English system, newtons in metric system
      Unbalanced forces cause changes in velocity.
      If an object is subject to two or more forces at once, the effect is the net effect of all forces.
      The motion of an object does not change if all the forces on it are in balance, having net effect zero.
      The motion of an object changes in speed or direction of the forces on it are unbalanced having net effect other than zero.
      To achieve a given change in the motion of an object, the greater the mass of the object, the greater the force required.

C. Skill Objectives to be taught (Texas Essential Knowledge and Skills, Science 8.1A, 8.2D, 8.2E, 8.3E, 8.4A, 8.4B, 8.5A, 8.5C and 8.7A)
   1. Students will state and explain mass, gravity, and weight.
   2. Students will state and explain force and friction.
   3. Students will state and explain motion with respect to observer's frame of reference.
   4. Students will state and explain velocity, speed, average speed, and acceleration.

5. Students will state and explain vector.
6. Students will explain and demonstrate Newton's 3 Laws of Motion.
7. Students will calculate speed, average speed, acceleration(positive and negative), and velocity.
8. Students will calculate the force of an object using acceleration and mass.
9. Students will calculate momentum.
10. Students will construct graphs representing speed, velocity, acceleration and momentum.

III. BACKGROUND KNOWLEDGE

A. For Teachers:
   1. Knowledge of matter and gravity
   2. Knowledge of speed, velocity, and acceleration
   3. Knowledge of force and momentum
   4. Knowledge of Newton's 3 Laws of Motion
   5. Knowledge of potential and kinetic energy

B. For Students:
   1. Knowledge of matter and gravity
   2. Knowledge of potential and kinetic energy

IV. RESOURCES

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V. LESSONS

Lesson One: Force, Motion, and Gravity (up to 2 days)

A. Daily Objectives
   1. Concept Objectives
      a. Students will understand the difference between mass and weight.
      b. Students will understand the relationship, which exists between mass and gravity, which further, creates weight. They will establish how mass does not change but weight does change depending on the force of gravity.
      c. Students will determine force using the Newton rather than the pound.
   2. Lesson Content

a. Motion
b. Force

3. Skill Objectives (Texas Essential Knowledge and Skills-Science 8.1A, 8.2B, 8.2D, and 8.4A)
   a. Students will compare forces that act in everyday situations.
   b. Students will observe and calculate the mass and weight of objects.
   c. Students will observe how gravitational force acts on falling objects.

B. Materials

1. *Science Insights* textbooks and study guides
2. Metric balances
3. Spring scales with newtons
4. String
5. Small plastic cups
6. Objects for comparison of mass and weight
   a. Large ball bearings
   b. Large bolts
   c. Large washers
   d. 20 milliliters of sand
   e. 30 milliliters of water
7. Graduated cylinder
8. Newton's Action Lab #2

C. Key Vocabulary

1. Force-A push or pull that starts, stops or changes the direction of an object
2. Gravity-The force that tends to draw objects toward the center of the Earth
3. Mass-The amount of matter in an object
4. Weight-The force of gravity acting on the mass of an object
5. Newton-The amount of force needed to cause one kilogram of mass to accelerate 1 m/s2 (9.8m/s2 on Earth)
6. Pound-The U. S. customary unit for expressing the pull of gravity upon an object

D. Procedures/Activities

1. Students will conduct a lab in which they construct a chart, which compares the mass and weight (pounds and newtons) of five different objects.
2. Prior to the lab the instructor will attach a string loop to a small plastic cup. This will allow the cup to be attached to the spring scale and hold each object easily.
3. The students will use the balance to get the initial mass of the cup and string. They will record this mass to later be subtracted from the initial mass of each object and cup.
4. The students will place the cup on the balance and find the mass of the ball bearing, bolt, washer, sand and water. Each object should be measured separately.
5. Students should convert mass to kilograms.
6. Students will attach cup with string to spring scale. Students will calibrate scale to zero. Students will measure the weight of each object in newtons and record their data.
7. Students will use their calculators to convert newtons to pounds for comparison. Discuss data with students. Analyze data and develop conclusions.
8. The following day instructor introduces vocabulary and notes. Students will use textbook and study for further research.

E. Evaluation/Assessment

1. The instructor will observe and evaluate student's ability to complete lab and recognize the difference between mass and weight.

2. The instructor will grade and evaluate study guide for student understanding of material. If a student scores below 70, then the student must attend tutorials for reteach of material.

Lesson Two: Force and Friction (up to 3days)

A. Daily Objectives

1. Concept Objectives
   a. Students will observe that a force is a push or pull.
   b. Students will observe how air resistance on the surface area of different objects provides friction.
2. Lesson Content
   a. Force
   b. Motion.
3. Skill Objectives (Texas Essential Knowledge and Skill-Science 8.1A, 8.2B, 8.2D, 8.3E, 8.4A, 8.7A)
   a. Students will discover how gravitational force and friction affect the motion of falling objects.
   b. Students will find that the time it takes each object to fall varies according to its surface area rather than its mass.
   c. Students will discover the positive and negative effects of friction.

B. Materials

1. *Science Insights* textbook and study guide
2. Newton's Action Lab #8 and #21
3. 2 equal sized "bean bags" one filled with polyester stuffing and the other with beans
4. Decks of cards
5. Sheets of paper
6. Stopwatches
7. Wooden beads
8. Clay balls equal in size to beads
9. Balances
10. Thermometers
11. Cans of soda
12. 10x40 piece of wood
13. Nails
14. Spring scales

C. Key Vocabulary

1. Force-A push or pull on an object that causes motion or change in motion
2. Friction-The force of resistance that occurs when movement takes place between any 2 objects or substances that make contact.
3. Air Resistance-Friction caused by surface area of an object coming in contact with are and causing the object to slow in speed
4. Surface Area-The area of all the sides of an object.
5. Terminal Velocity-The maximum velocity of a falling object, occurring when the force of friction equals the force of gravity.

D. Procedures and Activities

1. The instructor will provide notes and vocabulary to the students.
2. Students will complete study guide over material related to force and friction.
3. The following day the instructor will demonstrate with the two "bean bag" that even though two objects have different masses, but same surface areas will fall at a rate of 9.8m/s2.

4. The instructor will compare this to Galileo's experiment with bowling balls and the leaning Tower of Pisa.
5. Explain that the same acceleration due to gravity is affecting each "bean bag" therefore they fall at the same rate due to the same surface area. The bags are experiencing the same amount of friction due to air pressure.
6. Have the students take two pieces of paper. Leave one flat and then crumple up the other. The students can relate that the two sheets of paper have the same mass. Ask the students to compare orally the surface area of the two pages.
7. The students will drop both papers from the same height and compare the rate at which each falls. Ask students to make conclusions on why the crumpled piece falls faster than the flat piece.
8. Explain that air resistance is the force of friction that acts against the surface of each object on Earth. Explain to students that there is no air resistance where there is no atmosphere. Have them predict the motion of a baseball thrown in outer space. The ball, because there is little to no air resistance, would continue in straight-line motion, if gravity was nor present.
9. The students will now take the ball of clay and the wooden bead with similar surface areas and get the mass. Students will then drop both simultaneously from the same distance. They should record their observations.
10. Have students drop one card simultaneously with a deck of cards. They must record their observations. Discuss results with students.
11. Ask the students the following question: Which skydiver will fall faster? Why?
12. Explain the idea of terminal velocity.
13. Ask students which object, a penny or a feather, will reach terminal velocity soonest and latest. Explain that the feather will reach it soonest and the penny latest.
14. Students next investigate friction, using Action Lab #8, by seeing the change in temperature of their hands before and after rubbing them together.
15. Students will then predict and test the effects of weight on friction.
16. Students will take teacher made sleds and attach a spring scale to it. Students will check the force required pulling the sled across the table with one, two three, four, and five cans of soda.
17. Students will record their observations, analyze their data, and develop conclusions. Class will discuss the positive and negative effects of friction.

E. Evaluation/Assessment

1. Instructor should observe and question students about objectives during time of study guide and lab work.
2. Instructor will administer tutorials if any student scores below 70 on study guide or labs.

Lesson Three: Newton's First Law of Motion (up to 2 days)

A. Daily Objectives

1. Concept Objectives
   a. Students will understand Newton's First Law of Motion.
   b. Students will understand the term inertia.
2. Lesson Content
   a. Force
3. Skill Objectives (Texas Essential Knowledge and Skills-Science 8.1A, 8.2A, 8.2B, 8.2D, 8.4A, 8.4B, and 8.7A)

a. Students will state Newton's first law of motion. An object at rest will remain at rest and an object in motion will remain in motion unless acted upon by an outside force.
b. Students will identify inertia and explain how to overcome it.
c. Students will define operationally how friction occurs in everyday situations.
d. Students will infer how forces act on each other.
e. Students will observe Newton's first law of motion.
f. Students will take part in a lab, collect data, analyze data, and form conclusions.

B. Materials

1. Newton's Action Lab #13
2. Large child's wagon
3. Students
4. Cups
5. Coins
6. Index cards
7. Checkers
8. Newspapers
9. Rulers
10. Pencils
11. Raw eggs
12. Hardboiled eggs
13. Science Insights textbook and study guide

C. Key Vocabulary

1. Force-a push or pull that produces a change in the state of motion of an object.
2. Inertia-matter's resistance to change.

D. Procedures/Activities

1. Introduce Newton's 1st law and vocabulary to students and allow them to add information to their notes.
2. Demonstrate for students Newton's First Law by having one or two students sit in a wagon.
3. Tell the class that the wagon is an object at rest and tends to remain at rest.
4. Now have one student try to pull the wagon and get it moving and keep it moving about 15 meters.
5. Have this student describe to the class the amount of force required to get the wagon moving initially and how it compares to the amount of force required to keep the wagon moving.
6. Ask the student to describe the amount of force required to stop the wagon after it is moving as compared to the amount to force required to keep the wagon moving.
7. Remind the students about Newton's First Law of Motion.
8. Allow students to try the wagon demonstration for themselves.
9. Students will do further experiments with inertia by placing an index card on the top of a cup. Place a quarter on top of the index card. Flick the card. The quarter has inertia and therefore falls into the cup. Students record the observation.
10. Have the students make a stack of five checkers. Students predict what will happen to the stack of checkers when a sixth checker is flicked into the stack. Place a mark on the checker that is being flicked into the stack so that the

students will see that this checker ends up in the stack and another checker is knocked out.
11. Students run test and record observation.
12. Students predict what will happen when they slowly strike a pencil held halfway between a paper that is placed on the side of a desk.
13. Students test and then record observation.
14. Students predict what will happen when the pencil is struck sharply and rapidly as it rests between the newspaper on the side of a desk.
15. Students test and record observation.
16. Students obtain a raw and hardboiled egg. They will predict the motion of the eggs that will result once they are sent spinning and then stopped.
17. Students test and record their observations.
18. Students develop conclusions about inertia and share with class.
19. Students will complete study guide using textbook.

E. Evaluation/Assessment

1. Instructor will evaluate student's success and understanding of Newton's First Law by reading student's conclusions in their lab reports.
2. Instructor will grade student's study guide. Students will score 70 or higher. If the student does not reach the minimum score, then he will attend tutorials for reteach of concept.

Lesson Four: Motion (up to 2days)

A. Daily Objectives

1. Concept Objectives
   a. Students will distinguish between speed and velocity.
   b. Students will present the formula for speed. Speed =Distance/Time.
2. Lesson Content
   a. Motion
3. Skill Objectives(Texas Essential Knowledge and Skills-Science 8.1A, 8.2B, 8.2D, 8.2E, 8.4A, 8.4B, 8.7E)
   a. Students will conduct lab experiments, make predictions, collect data, analyze data and make conclusions.
   b. Students will calculate speed as distance/time.
   c. Students will graph distance–time data.

B. Materials

1. PS7 Lesson 1 and 2(*Ready to Use Physical Science Activities*)
2. Meter Sticks or vinyl rain gutters
3. Tape
4. Stopwatches
5. Balls
6. Stacks of Books
7. Walking Feet Lab(*Teaching Physics with Toys*)
8. Speed and Velocity Worksheets Page 15, 16, 18, & 19(*100Reproducible Activities-Physical Science*)
9. Calculators
10. *Science Insights* text book and study guide
11. Wind up toys

C. Key Vocabulary

1. Speed-The distance traveled in a given amount of time.
2. Velocity-The speed and direction of movement.

3. Frame of Reference-A place or object that is assumed to be fixed and by which the movement of other objects is determined.

D. Procedure/Activities

1. Explain frame of reference, speed and velocity to students and allow them add information to their notes.
2. Students will complete study guide over text relating to frame of reference, speed, and velocity.
3. Have students complete Lesson1 from PS7. Students will see the formula: Speed=distance/time. Explain that velocity is speed in a particular direction. It is a more accurate description of an object's motion.
4. Students will graph distance versus time information and answer questions based on the graph.
5. Students will review S=d/t and then set up a ramp using either meter sticks and tape or a rain gutter.
6. Students will roll a ball down the ramp and time the process using the stopwatch. Record observations.
7. Students can complete a second lab to test speed and velocity by placing a meter stick flat on the floor and timing a wind up toy going from end to end of the meter stick.
8. Students make observations and record their data. They will graph the results in a distance(cm) versus time(s) graph.
9. Have students practice calculating speed and velocity using the worksheets from *100 Reproducible Activities-Physical Science*

E. Evaluation/Assessment

1. Instructor will evaluate student's ability to observe, collect, and analyze data. Instructor will also evaluate student's ability to calculate speed and velocity using a meter stick as a frame of reference.
2. Instructor will evaluate the success of student's ability to calculate speed, distance or time when provided two out of three of the quantities. Students will score 70 or better. Students that do not master concept will attend tutorials for the reteaching of concept.

Lesson Five: Speed and Acceleration (up to 2 days)

A. Daily Objectives

1. Concept Objectives
   a. Students will define operationally the acceleration of an object.
   b. Students will contrast acceleration and constant speed.
2. Concept Objectives
   a. Motion
3. Skill Objectives(Texas Essential Knowledge and Skills-Science 8.1A, 8.2B, 8.2D, 8.2E, 8.4A, 8.4B, 8.7A)
   a. Student will observe and collect data during lab.
   b. Student will graph acceleration data and analyze.
   c. Student will analyze data and make conclusions.
   d. Students will calculate acceleration.

B. Materials

1. Acceleration Problems(Pg. 17, 20, & 21 from *100 Reproducible Activities*)
2. PS7 Lesson 3 and 4(*Ready to Use Physical Science Activities*)
3. *Science Insights* textbook and study guide
4. Metric rulers
5. Stacked books

6. Balls
7. Stopwatches

C. Key Vocabulary

1. Acceleration-the rate at which velocity changes
2. Velocity-the speed and direction of movement
3. Positive Acceleration-speed that is constantly increasing
4. Negative acceleration-speed that is constantly decreasing. This type of change in velocity is deceleration.

D. Procedure/Activities

1. Provide notes and vocabulary to students.
2. Assign students to read and complete text and study guide over acceleration.
3. Students will use PS7 Lesson 3 t graph velocity versus time information.
4. Students will make conclusions and answer questions using completed graph.
5. Students will set up a ramp using materials requested in Lesson4. Students will release a ball and measure the change in velocity at different points on the meter stick using a stopwatch.
6. Students will observe and collect data.
7. Students will graph the results and analyze data.
8. Students will discuss their conclusions.
9. Students will complete a quiz over speed, velocity and acceleration.(PS7)
10. Instructor may use the acc3lration problem worksheets for more reinforcement if needed.

E. Evaluation/Assessment

1. Instructor will observe and evaluate student ability to test for the change in velocity and calculate acceleration.
2. Student will score 70 or better on the study guide and quiz. Those students who do not score 70 will attend tutorials for a reinforcement of concept and objectives.

Lesson 6: Newton's Second Law of Motion and Momentum (3 days)

A. Daily Objectives

1. Concept Objectives
   a. Students will understand Newton's Second Law of Motion .
   b. Students will understand the Law of Conservation of Momentum.
   c. Students will understand vectors.
2. Lesson Content
   a. Motion
   b. Forces
3. Skill Objectives (Texas Essential Knowledge and Skills-Science 8.1A, 8.2B,8.2D, 8.2E, 8.4B, 8.7A)
   a. Students will conduct a lab, which will allow them to make observations, collect data, analyze data, and make conclusions related to Newton's Second Law.
   b. Students will create a model to show how force acts during circular motion.
   c. Students will make calc ulations using information relating to mass, force, and acceleration.

B. Materials

1. PS8 Lesson and Lab Sheets (Ready to Use Physical Science Activities)
2. Newton's Action Lab #14
3. Force Diagrams & Force/Acceleration Problems (100 Reproducible Activities)
4. *Science Insights* textbook, study guide, and force problems

5. Marbles
6. Notebook paper
7. 2 sizes of ball bearings
8. Metric rulers
9. Bar magnets
10. String
11. Styrofoam balls
12. Nails
13. Calculators
14. Coins of different sizes

C. Key Vocabulary

1. Acceleration-a change in velocity, or the rate at which this change occurs.
2. Force-the push or pull on an object that causes motion or change.
3. Mass-the amount of matter in an object.
4. Momentum-the product of the mass and velocity of an object. Momentum = mass x velocity
5. Vector-line with an arrow, which represents magnitude and direction of force. The length of the line drawn to scale represents magnitude. The angle of the line can represent the direction. Vectors are represented on a graph.
6. Resultant-the third vector, which connects the tail of one vector to the head of another vector.

D. Procedures/Activities

1. The instructor will provide notes and vocabulary to students.
2. The instructor will assign a study guide worksheet and text pages for students to complete.
3. Students will participate in Newton's Action Lab #14.
4. Students will set up a ramp using stacked books and ruler. They will place lined paper below ramp. Place a magnet at the bottom of the ramp as shown in lab diagram.
5. Roll marble down the full ramp, past the magnet. Mark the spot where the marble left the lined paper. Roll a small ball bearing down the ramp and mark the spot where it left the lined paper. Have the students observe and record what happened when the small ball bearing went past the magnet. Roll the large ball bearing down the ramp, past the magnet. Have the students observe and record what happened when the large ball bearing went past the magnet.
6. Discuss with the students that the magnetic force remains the same throughout the lab, but the mass changed with the small and large ball bearings, and perhaps the acceleration.
7. In the second half of the lab, have the students obtain 1.2 meters of string, nail, and a styrofoam ball.
8. Tie the string securely to the nail and then push the nail halfway into the ball.
9. Have the students go outside and whirl the ball around their heads gently. Have them speed up the rotation until the ball leaves the nail. Observe the path of the loose ball.
10. The following day, have the students use lesson #2 from PS8.
11. Set up a path between two metric rulers as the lab diagram indicates.
12. Demonstrate for the students, how to propel small, medium, and large coins through the path at a low, medium, and high rate of speed.
13. The students will then run the lab and record the distance traveled by each coin in each trial. Remind students to try and shoot coins with the same force each time.

14. Students will analyze data and make conclusions. They will conclude that the more massive objects require more force to move them a greater distance, and that the force of an object increases with its velocity. Summarize their results by writing Newton's Second Law of Motion on the board. F = m x a.
15. Students will calculate force, mass, and acceleration using PS8 lesson 3.

E. Evaluation/Assessment
1. Instructor will observe and evaluate the students' ability to test for force and acceleration during the lab.
2. Instructor will grade student study guide sheets. If students score below a 70, the students affected will have to attend tutorials for reteach of the objectives.

Lesson Seven: Newton's Third Law of Motion (up to 4 Days)

A. Daily Objectives
1. Concept Objectives
   a. Students will understand Newton's Third Law of Motion.
   b. Students will understand balanced and unbalanced force.
2. Lesson Content
   a. Motion.
   b. Forces.
3. Skill Objectives (Texas Essential Knowledge and Skills-Science 8.1A, 8.2B, 8.2D, 8.2E, 8.4A, 8.4B, and 8.7A)
   a. Students will predict how forces interact in lab situations.
   b. Students will conduct a lab to test Newton's Third Law of Motion.
   c. Students will build a fan cart and sails to test and relate balanced and unbalanced forces.
   d. Students will collect data from observations. They will analyze data and make conclusions.

B. Materials
1. Newton's Action Lab 15
2. *Science Insights* textbook and study guide worksheet
3. String
4. Several sizes of balloons
5. Straws
6. Tape
7. Meter sticks
8. Several tin cans
9. Several 1"x 4" wood blocks
10. *Science Source* directions to build fan carts
11. 1/2" PVC pipes and coupling
12. Solo plastic plates
13. Craft sticks
14. 5" Propeller
15. 1.5V DC motor
16. Jumper leads
17. Battery holder (4AA)
18. 1/2" wood dowel
19. AIMS Lab-Balloon rockets

C. Key Vocabulary
1. Force-the push or pull on an object that causes motion or change.
2. Newton's Third Law of Motion-for every motion there is an equal and opposite reaction

D. Procedures/Activities

1. Provide students with notes and vocabulary for Newton's Third Law of Motion.
2. Students will read text and complete the study guide worksheet for Newton's Third Law of Motion.
3. Take students outside and divide them into groups of 4-5.
4. Give them 2 or 3 different sizes of balloons , to create balloons rockets and test.
5. Thread string through a straw and have two students hold each separate end. Another student will inflate the balloon and, using tape, attach it to the straw.
6. Students will release the balloon 5 different times and measure the distance the balloon travels each time. Students record their data and calculate the average distance the balloon travels.
7. Have the students predict how far the second balloon, a different size, will travel in comparison to the first. Test the balloon five times. Collect data and make calculations for mean distance.
8. Discuss, with students, that the balloon is in motion because the air in the balloon is moving outward, and causing the balloon to move in the opposite direction. Discuss with students why each balloon traveled a different distance. Air resistance and aerodynamics can be discussed.
9. Students receive Newton's Action Lab #15 and a tin can. They will punch holes in both ends of the can, so that they can attach string through the can and suspend it in the air.
10. Students will then punch a hole near the bottom of the can and twist the nail sideways. Students will repeat these steps on the other side of the can.
11. Students will pour water into the can and watch it spin, due to Newton's Third Law of Motion. Discuss results with students.
12. Students will then take *Science Source* Lab and materials mentioned inside it to build fan carts. This is the culminating activity, and will be described in more detail in the denoted area.

E. Evaluation/Assessment

1. Instructor will observe and evaluate the students' ability to test for Newton's Third Law of Motion.
2. Instructor will evaluate students' understanding of Newton's Third Law of Motion by grading the study guide worksheet. Students that score below a 70 must attend tutorials for reteach of objectives.

VI. CULMINATING ACTIVITY

Student will receive the materials, listed in lesson 7, and the Science Source- fan cart provided in the appendix. They will follow the instructions and build a fan cart, which will be attached to a frictionless cart. They will predict if the cart will require a sail in order to move. They will find that the cart will move without the sail, because of the motion of the air, generated by the fan pushing off the atmospheric air. Movement occurs because of Newton's Third of Motion. Discuss why the model would not move with the sail, as a sailboat moves.

VII. HANDOUTS/STUDENT WORKSHEETS

1. The Science Source-Fan Cart (not included with this unit)

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