**CURRICULUM GUIDE FOR**

# Energize Me

**(Based on STC Motion and Design Kit)**

Wallingford Public Schools
Fifth Grade
Science

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*These science content background notes were created for teacher use only. We anticipate that these notes provide you, the teacher, with some useful background as you facilitate inquiry activities for your students. These notes are not meant to be an overview of the unit, but as*

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# UNIT SUMMARY

This unit invites students to explore the physics of motion and to apply what they have learned to design technology. Using construction materials, weights, rubber bands, sails, and propellers, students design, build, and test their vehicles. Students use their findings to redesign the vehicles so that they move more efficiently. Concepts such as push and pull, and forces that impact motion such as friction, gravity and air resistance are explored.

Students will also explore the responsibility of society to conserve and protect our natural resources and to develop alternative energy sources. Students will be exploring alternative energy sources by reading, researching, and listening to various sources of information to gain a deeper understanding and the potential impact on human society. Each elementary school has literature resources housed in the school library media center to support this unit.

This kit has been adapted from the STC Motion and Design kit.

# STAGE 1- IDENTIFY DESIRED RESULTS

*What should students understand, know, and be able to do? Stage one identifies the desired results of the unit including the related state science content standards and expected performances, enduring understandings, essential questions, knowledge and skills.*

| **Enduring Understandings**<br>*Insights earned from exploring generalizations via the essential questions (Students will understand THAT…) K-12 enduring understandings are those understandings that should be developed over time, they are not expected to be mastered over one unit or one year.* | **Essential Questions**<br>*Inquiry used to explore generalizations* |
|---|---|
| *Forces and Motion*<br>• Forces cause objects to move, change position or direction, or stop.<br>*Energy Transfer and Transformations*<br>• Energy provides the ability to do work. (K-12)<br>• Energy can exist in many forms that can be described, organized, and classified for understanding.(K-12)<br>• Energy is transferable and transformable.<br>*Science and Technology in Society*<br>• Society has a responsibility to conserve and protect our natural resources and to develop alternative energy sources.<br><br>*Inquiry* | *Forces and Motion*<br>• How do forces govern motion? How are they used to predict motion?<br>*Energy Transfer and Transformations*<br>• How do we use energy to do work in everyday life?<br>• How can energy be described and classified?<br>• What evidence do we have that energy can be changed?<br>*Science and Technology in Society*<br>• How can we conserve and protect our energy resources?<br>• How have the energy sources we rely on today changed and how will they be different in the future?<br>*Inquiry* |

| | |
|---|---|
| • Designing and planning is a continuing process that changes based on function and/or circumstance.<br>• Inquiry is the integration of process skills, the application of scientific content, and critical thinking to solve problems. (K-12) | • How does asking and investigating questions about energy help me to understand it better?<br>• How does new information change ideas? |

**Knowledge and Skills**

*What students are expected to know and be able to do*

**The knowledge and skills in this section have been extracted from Wallingford's K-5 Science Scope and Sequence.**

***Knowledge***

*Forces and Motion*

K1. Conclude that push and pull are the basic forces that influence motion.
K2. Recognize that work is moving an object a certain distance.
K3. Analyze the effect of force on objects with different mass.
K4. Demonstrate some forces that resist motion, like friction, gravity, and air resistance.

*Energy Transfer and Transformations*

K5. Identify forms of energy, such as electrical, nuclear, sound, heat, light, chemical, mechanical, and magnetic.
*K6.* Explain that energy can be transformed (changed). *See Teacher Background Notes.*
*K7.* Explain that energy can be transferred (moved). *See Teacher Background Notes.*

*Science and Technology in Society*

K8. Evaluate the advantages and disadvantages of sources of energy, such as fossil fuels, solar, hydroelectric, wind, and nuclear.

***Skills***

S1. Generate investigable and non-investigable questions
S2. Observe objects (K'nex vehicles, falling weights, rubber bands, propellers, and sails) and their motion and describe commonalities and differences among them.
S3. Classify in a variety of ways based on observations - the properties of vehicle design and energy sources.
S4. Predict
- An object's motion when friction, gravity, or air resistance are applied
- How a force changes an object's motion
- How mass and force affect motion
- How energy affects motion

S5. Design a fair test to answer an investigable question
S6. Revise plan based on observation/ results
S7. Conduct simple investigations
S8. Collect and record data using appropriate tools, such as metric ruler, timer, calculator
S9. Organize appropriate and accurate measurements and observations , using
- Graphic organizers
- Charts and graphs

- Illustrations or diagrams
- Journaling

S10. Draw conclusions based on data, observations, or findings.

S11. Communicate results or information in an appropriate manner, using
- Presentations
- Visuals
- Simple reports

| **State Science Content Standard(s)**<br>*Generalizations about what students should know and be able to do.* | |
|---|---|
| **Content Standards**<br>(CSDE Science Framework 2004) | **Primary Expected Performances**<br>(CSDE Science Framework 2004) |
| *Forces and Motion- What makes objects move the way they do?*<br>**4.1 The position and motion of objects can be changed by pushing or pulling.**<br>• The size of the change in object's motion is related to the strength of the push or pull.<br>• The more massive an object is, the less effect a given force will have on its motion. | B8. Describe the effects of pushes and pulls on the motion of objects.<br>B9. Describe the effect of the mass of an object on its motion. |
| *Energy Transfer and Transformations- What is the role of energy in our world?*<br>**7.1 Energy provides the ability to do work and it can exist in many forms.**<br>• Work is the process of making objects move through the application of force.<br>• Energy can be stored in many forms and can be transformed into the energy of motion. | C14. Describe how different types of stored (potential) energy can be used to make objects move. |
| *Science and Technology in Society- How do science and technology affect the quality of our lives?*<br>**3.4 Earth materials provide resources for all living things, but these resources are limited and should be conserved.**<br>• Decisions made by individuals can impact the global supply of many resources. | B7. Describe how Earth materials can be conserved by reducing the quantities used, and by reusing and recycling materials rather than discarding them. |
| *Scientific Inquiry* | B INQ.1 Make observations and ask questions about objects. |

| | |
|---|---|
| | B INQ.3 Design and conduct simple investigations. |
| *Scientific Literacy* | B INQ.6 Analyze, critique, and communicate investigations using words, graphs and drawings. |
| *Scientific Numeracy* | B INQ.10 Use mathematics to analyze, interpret and present data. |

**Common Misconceptions Children Have**

*By identifying misconceptions early, teachers can design appropriate lessons to address and change student misconceptions.*

- Energy is lost, rather than conserved.
- Variables do not affect the outcome; that is, you can change things but the results will still be the same.
- Energy exists only when it is visible.
- Cold energy exists as opposed to the absence of heat.
- Temperature and heat are the same thing; i.e., that there's more heat energy in a cupful of boiling water than in a bathtub.

# STAGE 2 – DETERMINE ACCEPTABLE EVIDENCE

*How will we know if students have achieved the desired results and met the content standards? How will we know that students really understand? Stage two identifies the acceptable evidence that students have acquired the understandings, knowledge, and skills identified in stage one.*

| **Performance Task(s)**<br>*Authentic application in new context to evaluate student achievement of desired results designed according to GRASPS (Goal, Role, Audience, Setting Performance, Standards)* | **Other Evidence**<br>*Other methods to evaluate student achievement of desired results* |
|---|---|
| **Student-Designed Design Challenge**<br><br>*Lesson 5 of Motion and Design Kit: Lunar Vehicle Design Challenge*<br>• Lesson ideas, writing prompts and suggested rubric (contact Science Resource Teacher for additional lessons)<br><br>*Lesson 14: Final Design Challenge in the Motion and Design kit*, students will independently design their own challenge based on the given model, design a vehicle, move the vehicle, and test its motion. Through repeated evaluation, students improve their designs to meet their selected requirements. How does the vehicle incorporate what the student has learned throughout the unit? | • Journaling (science notebook)<br>• Quiz about the transfer of energy (teacher designed)<br>• Vocabulary Quiz<br>• Sail Concept and Performance Quiz (see appendix)<br>• Self- Assessments A and B from Motion and Design kit (see teacher's manual)<br>• Observation of Student Performance (see teacher's manual)<br>• Assorted writing prompts<br>• Science notebook/journal assessment (see appendix)<br>• Unit Test |

# STAGE 3 – LESSON ACTIVITIES

*What will need to be taught and coached, and how should it best be taught, in light of the performance goals in stage one? How will we make learning both engaging and effective, given the goals (stage 1) and needed evidence (stage 2)? Stage 3 helps teachers plan learning experiences that align with stage one and enables students to be successful in stage two. Lesson activities are suggested, however, teachers are encouraged to customize these activities to their own students, maintaining alignment with stages one and two.*

*The suggested lesson activities are not sequenced in any particular order. Teachers may select which lesson activities will best meet the needs of their students and the unit objectives. Each lesson activity is coded with the corresponding knowledge (K) and/or skill (S) objectives that are found in stage one.*

## FORCES AND MOTION

**DESIGN CHALLENGE ONE INQUIRY INVESTIGATION**

This inquiry investigation combines several lessons the STC Motion and Design manual into an inquiry investigation. (Combined lessons can include lessons 1, 4, & 7)
Approximate time: 9 lessons
K1, K2, K3, K4, K6, S1, S2, S4, S5, S6, S7, S8, S9, S10
SEE PAGE 22 FOR INQUIRY TEMPLATE

- *How do forces govern motion? How are they used to predict motion?*
- *How do we use energy to do work in everyday life?*
- *How does asking and investigating questions about energy help me to understand it better?*

**MOTION AND DESIGN KIT LESSONS 1 THROUGH 16**

By experiencing various sources of energy for their K'nex cars, students will understand that successful vehicle design requires an understanding that energy, force and friction affect their motion.
Approximate time: varies depending on how lessons are combined
K1, K2, K3, K4, K6, S1, S2, S3, S4, S5, S6, S7, S8, S9, S10
Motion and Design Teacher's Manual

- *How do forces govern motion? How are they used to predict motion?*
- *How do we use energy to do work in everyday life?*
- *How can energy be described, organized, and classified?*
- *What evidence do we have that energy can be changed?*

**MAKE A CLASS WORK COLLAGE**

Students will bring in pictures of work. Discuss whether or not pictures belong in the collage based upon criteria that defines work. Develop criteria prior to student discussion of pictures. Students will categorize these pictures by theme.
Approximate time: Ongoing – 10 minute time frames.

K2 , S2, S3, S10
Utilize various magazine resources.

- *How do we use energy to do work in everyday life?*

**MY FRICTION, GRAVITY AND AIR RESISTANCE JOURNAL**

Students will keep a journal for a determined time period (ex. One week). Observe and record examples of friction, gravity, water, and air resistance. Students will organize their journal in the following way:

| Activity | Force Observed | Explanation |
|---|---|---|
| Washing a car | Friction | Using a sponge to increase friction to remove dirt. Water resistance will remove soap and dirt. |

Approximate time: Ongoing – allow time for student discussion daily and final discussion (30 – 40 minutes)
K1 , S2, S3

- *How do forces govern motion?*
- *How do we use energy to do work in everyday life?*

**SPORTY SCIENCE**

Students will choose a sport and explain how friction, gravity, and air resistance impact play.
Approximate time: 45 minute time frame.
K1, S2, S3

- *How do forces govern motion?*
- *How do we use energy to do work in everyday life?*

**CAREER CONNECTIONS**

Students will interact with an expert to discuss how blueprints are used as a scale. See School to Career Handbook/Contact School to Career Coordinator.
Approximate time: 45 minutes
S10

- *How does new information change our ideas?*

**PAPER HELICOPTERS AND AIRPLANES**

Students will make a paper helicopter and explore conditions for flight through variables such as mass, size, shape, and construction materials.
Approximate time: 2 – 3 45 minutes
K1, K2, K3, K4, S1, S2, S3, S4, S5, S6, S7, S8, S9, S10
See Microsoft Publisher (in school computer lab) for four types of airplane designs

- *How do forces govern motion? How are they used to predict motion?*
- *How does asking and investigating questions about energy help me understand it better?*

- *How does asking and investigating questions about energy help me to understand it better?*
- *How does new information change ideas?*

## ENERGY TRANSFER AND TRANSFORMATIONS

Energy exists in many forms and provides the ability to do work. Through transformation (change in form) and transfer (movement from one place to another), energy can be described, classified and organized.

**INQUIRY: FOR SAIL!**

Students will design a vehicle that uses a sail for motion. While exploring this challenge, students will raise questions for further investigation. This lesson can be designed as open inquiry, guided inquiry or as a challenge activity, depending on available time and the interest of the students. (SEE PAGE 41 FOR INQUIRY TEMPLATE)

Sail variables can include:

- Shape of the sail
- Size of the sail
- Sail material
- Position of sail on vehicle, and
- Number of sails on vehicle

Other variables to explore and/or identify:

- Size and shape of vehicle
- Energy source (fan)
  - position of fan and air stream
  - strength of air stream

Approximate time: 3-5 days

K6, S5, S6, S7, S8

- *What evidence do we have that energy can be changed?*
- *How do forces govern motion?*
- *How does new information change ideas?*

Connections:

Social Studies: Age of Exploration – sailing ships

Westward Movement – prairie schooners,

Math: Finding area and perimeter

Technology: Investigating alternative energy sources, windmills and wind farms

Recreation: Sail surfing, sail boats, kites

See Page 41 for Inquiry Template.

## SCIENCE AND TECHNOLOGY IN SOCIETY

By reading, researching, and listening to various sources of information about energy sources, students will understand that society has a responsibility to conserve and protect our natural resources and to develop alternative energy sources.

**ENERGY SOURCE NON-FICTION LITERATURE BASED INQUIRY**

In this inquiry, students will identify information and questions about sources of energy. Use the Grade 5 energy sources literature from your school library. Use the FQR strategy in order to record Facts, Questions, and Reactions to their reading about sources of energy. Utilize questions from the book pass as the basis of a personal inquiry. Students can classify questions by energy source.

Approximately 12 to 15 lessons

K8, S1, S3, S6, S7, S9

Contact the Science Resource Teacher for additional documents related to this investigation.

- *How can energy sources be described and classified?*
- *How is information organized?*
- *How do readers prepare for reading?*
- *What can a reader do when they don't understand?*
- *In what ways are ideas/findings communicated effectively?*

Examples of energy source web sites that may be used as additional resources:

**Energy? What Sources Will We Use in the 21st Century?**
http://curry.edschool.virginia.edu/go/edis771/98webquests/student/sdianeschnoor/

**Energy WebQuest** http://webtech.kennesaw.edu/hpowell/wquest.htm

**Energize Me! A WebQuest on Renewal Energy**
http://coe.west.asu.edu/students/scondojani/webquest.htm

**Energy Resource WebQuest** http://www.berksiu.k12.pa.us/webquest/Wertz/

**Energy Resources** http://www.community.k12.mo.us/webquest/sommer/energy.htm

**Renewable Energy WebQuest**
http://www.sandwich.k12.ma.us/webquest/renewable/renewable.htm

**Energy Crisis in Our Town** http://www.personal.kent.edu/~mfadel/webquest.htm

**EXPERT SPEAKERS**

Use expert speakers on each source of energy. For example, invite someone who works for the electric plant or at Millstone Nuclear Power Plant. See the School to Career Handbook. Contact School to Career Coordinator for assistance.

Approximate time: varies based on number of speakers.

K8

- *How can we conserve and protect our energy resources?*
- How have the energy sources we rely on today changed and how will they be different in the future?

**ENERGY SOURCE INVENTIONS**

Design an invention that will conserve or better use an energy source. Investigate existing inventions that fit that purpose. (Use STEP teacher as a support for this activity.)

Approximate time: 3-4 weeks

K8, S2, S3, S9

- How can we conserve and protect our energy resources

# LITERATURE RESOURCES

*These literature resources have been purchasde to supplement the kit and are housed in each elementary school library.*

**Physical Science Literature Circle/Guided Reading Sets (6 copies per school)**

*Kids Discover Magazine: Energy* (class set)

*The Real McCoy: The Life of an African-American Inventor*, Wendy Towle

*Come Back, Salmon*, Molly Cone

*A River Ran Wild*, Lynne Cherry

*Wilbur and Orville Wright: The Flight of Adventure,* Louis Sabin (with audio cassette)

*Rachel Carson: Pioneer of Ecology,* Kathleen Kudlinski

*Full of Energy*

*Science Alive Series*,The Wright Group (6 pack of each)

- *Nature's Energy*
- *People and Energy*
- *Exploring Matter*
- *People and Matter*

*Energy Forever*

**Fiction (6 copies per school)**

*The Mouse and the Motorcycle*, Beverly Cleary

**Physical Science Read Alouds (1 copy per school)**

*The 21 Balloons*, William Penne duBois

*Ben and Me*, Robert Lawson

*The Lorax,* Dr. Seuss

*Marie Curie*, Ann Fullick

*Michael Faraday*, Anita Ganeri

*Exploring Energy* (Big Book)

*Energy and its Sources* , Scholastic (Big Book)

**Additional Teacher Resources That Are Suggested**

*Energy*, Creative Teaching Press

Usborne Energy Internet Book

# Materials List
## Energize Me – Grade 5

Revised August 2004
(Based on the STC Motion and Design Kit)

| | | | |
|---|---|---|---|
| 1 | Teachers guide STC Motion and Design | 100 | #16 rubber bands |
| 25 | Student books Motion and Design | 40 | #64 rubber bands |
| 1 set | K"NEX building pieces | 10 | Rolls adding machine tape |
| 11 | Buckets w/lids | 20 | Pieces cardboard |
| 10 | Measuring tapes | 10 | Pieces of cloth 8 ½ X11 |
| 10 sets | Colored pencils | 10 | Pieces of plastic 8 ½ X11 |
| 1 pkg | Graph paper | 25 | Brass eyelets |
| 1 | Sharpie marker | 11 | Propellers |
| 10 | Circle templates | 11 | Screw hooks |
| 1 | Black light string | 4 | Electric fans – various sizes |
| 1 roll | cotton string | 5 | Screen 8 ½ X11 |
| 1 box | Jumbo paper clips | 5 | Post its |
| 30 | Large washers | 1 pk | Sentence strips |
| 220 | Small washers | 2 | Masking tape |
| 10 | 1 oz plastic cups | 2 pk | 5 X 8 Index Cards |
| 10 | Bookends | | |
| 10 | Timers | | |
| 20 | Wood blocks | | |
| 60 | Red dots | | |
| 60 | Blue dots | | |
| 60 | Green dots | | |

Safety Considerations:

- Review safe use of rubber bands with students prior to beginning investigations.

# Teacher Background Notes

*These science content background notes were created for teacher use only. We anticipate that these notes provide you, the teacher, with some useful background as you facilitate inquiry activities for your students. These notes are not meant to be an overview of the unit, but as background information for you that go beyond the content of this particular unit. These notes should not be replicated for your students; however, you may share some of the content when appropriate for the developmental level of your students.*

**These notes have been prepared by Sandra Justin, Ph. D, veteran science teacher and educational consultant.**

## FORCE & MOTION

**Motion**: A movement from one place to another

**Force**: An push or pull applied to change the motion of an object

**Work:** The result of an object moved by a force, through a distance**.**

**Object:** May be solid, liquid or solid - anything which has mass

**Matter**: Anything that has mass and takes up space.
Light, gravity, magnetic attraction and sound are *not* considered to be matter.

**Types of forces**:
Forces that affect motion: *Push* and *pull* may start, stop, change direction, slow down or speed up an objects motion.
Forces that affect motion: Gravity and friction
*Gravity*: A force that exists between all objects
*Friction*: A force that opposes the motion between two surfaces.

**Types of friction:**
*Rolling friction*: balls, cylinders, wheels
*Sliding friction*: runners, ice skates, skis
*Starting friction*: energy necessary to start an object into motion
*Fluid friction:* air or water resistance: the movement of an object through air or water.
Examples: belly flop, aerodynamic characteristics of planes/boats
*Buoyancy*: an upward force resisting gravity

Friction can affect motion. Reducing or increasing the amount of friction can both be beneficial.
*Reducing friction* can improve motion.
Example: Smooth tires offer less friction, therefore they can increase speed on a smooth surface (racing tires).
Examples: Sharpening a knife reduces friction as it cuts through matter.

Example: Aerodynamic shapes reduce friction as they move through air and water.

*Increasing friction* can improve motion.

Example: Mountain bikes have knobbed tires in order to increase traction (friction).

Example: Sand is spread on streets and sidewalks to increase friction on icy surfaces.

Example: Golf and baseball shoes have cleats that grip the soil to increase friction.

## Newton's Laws of Motion

**1. Inertia: An object in motion will stay in motion unless acted upon by a force. An object at rest will stay at rest unless acted upon by a force**

**1.** To change motion, speed up, slow down or stop, an external force must be applied

Example: Seat belts and air bags are installed in vehicles to prohibit passengers from moving forward through the windshield.

Example: An object in a car will continue to move forward if the car suddenly stops.

Example: If a bicycle hits a curb, the bicycle will stop and the rider will continue to move forward.

Example: In space, a space ship will continue to travel in a straight line and at a constant rate, unless acted on by a force.

**2. F = MA: Force, mass and acceleration are directly related**.

- The bigger the mass, the more force is necessary to cause acceleration.
- Acceleration is a change in direction or speed of an object.

Example: Two vehicles are rolling down a hill. One is a Corvette and the other is a large truck. The Corvette has less mass, so it will take less force to stop in a certain distance than the truck.

Example: The faster the object, the more force it contains. A straw in a windstorm exerts enough force to penetrate a brick.

**3. For every action (force) there is an equal and opposite reaction (force)**.

Example: Jumping on a trampoline or off a diving board. The force is directed down in the jump and the object reacts by pushing upward.

Example: The force of a rocket is directed downward allowing the rocket to go up.

## Law of Gravity

All objects that have mass have gravity. The more massive the object, the greater the gravitational force.

Mass and distance affect gravity.

Example**:** There are less molecules of air at the peak of Mt. Everest than at sea level because gravity is greater at sea level.

Example: The sun exerts the greatest amount of gravitational force in the solar system. The effects of gravitational force from small objects are not noticed. A paperclip has very little gravity.

**Mass: The amount of matter in an object.** The amount of matter depends on the number and size of the atom.

**Weight: The amount of gravity pulling on that object**

Example: A 100 pound astronaut will weigh about 17 pounds on the moon and will be weightless in the space shuttle. The mass of the body (amount of matter) will remain the same.

.

**Misconceptions**

| ***Misconception*** | ***Fact-Truth*** |
|---|---|
| Gravity is a force that attracts objects to the surface of the earth. | People/objects fall into holes.<br>Cars roll down hills<br>Skiers fall down mountains<br>Objects sink in water |
| Weight and mass are the same thing | The mass of an object does not change, but changes in gravity will change the weight of the object |
| Friction only occurs between solids | Friction occurs between solids, liquids and gasses<br>Wind burnt face. (Friction between a solid & a gas)<br>Sailing, swimming (Friction between a solid and a liquid) |
| Constant speed needs constant force | Once in motion, an object will stay in motion unless acted upon by a force. Once a large snowball starts to roll, it is easier to keep it rolling. |
| Heavier objects fall faster | In the absence of air resistance, all objects, regardless of mass, will fall at the same rate |
| Objects in space need a force to keep it moving | There is no gravity or friction in space to affect motion. Once in motion, a space vehicle will continue to move at a constant speed without added force. Once in motion, a vehicle has the ability to continue moving forever. |

## ENERGY

**Energy: The ability to do work**

**Types of energy**: Kinetic & Potential

**Kinetic energy:** The energy of an object due to its motion (dependent upon mass & speed of object)

**Potential energy:** Two of the forms are the energy of position and stored energy

*Elastic potential energy*: energy stored in compressed or stretched material (elastic band, bow string, spring)

*Gravitational potential energy*: energy stored in an object because of its position above the ground (dependent upon mass & height of object)

**Conservation of Energy**

Energy can neither be created nor destroyed, but it can change form. The total amount of energy does not change.

Example: Mechanical energy can be reduced because of the heat produced by friction. Application of grease or oil can reduce the effects of friction on moving objects.

**Energy Transformation**

Energy can transform (change) from one form to another. Some energy may be transformed into heat, light or sound and some energy may be absorbed.

Example*: Roller coaster* – kinetic →potential →kinetic and back as car moves along track. Some energy is transformed by friction to heat & sound. Gravity, air resistance and mass of cars also affect energy.

*Eating an apple* – Solar energy → photosynthesis →potential energy (sugar) →picking (mechanical) →chewing (mechanical) → digestion (chemical) → running (mechanical) = heat loss (chemical).

**Energy Transfer**

Energy can be transferred from one object to another. An example of transfer is heat.

**Heat** can be transferred by convection, conduction & radiation

*Convection* – transfer of heat through air & liquids

Example: heating soup, furnace

*Conduction* – transfer due to contact, molecule to molecule

Example: A spoon becomes hot in a pot of soup, rubbing hands together

*Radiation* – transfer through space by electromagnetic waves (no molecules are needed)

Example: Astronauts communicate with Earth by radio waves.

Example: Sunlight reaches the Earth

## Forms and Sources of Energy

Energy may exist in many forms and originate from various sources. Some of the forms of energy also create energy, so they are listed in both categories. Example: Solar energy in the form of electromagnetic waves travel through space. Once the waves reach an object, they can change into heat, light or chemical energy.

| Forms of Energy | Sources of energy |
|---|---|
| **Mechanical**: Energy from the movement of an object | ***Mechanical:*** Work in an object due to its potential / kinetic energies |
| **Heat:** Energy movement due to conduction, convection, radiation, chemical reaction, or friction | ***Nuclear:*** Energy due to the breaking apart or combining of atoms |
| **Light:** Energy from the change in position of electrons. Chemical, mechanical or heat reactions produce light. | ***Chemica****l*: The breaking and forming of bonds create energy |
| **Solar**: Electromagnetic waves (heat, visible light, radiation, radio waves, infrared and ultraviolet radiation) | ***Solar***: Energy from the sun |
| **Electrical*:*** The movement of electrons, static and current | ***Water:*** Moving water through turbines creates mechanical energy |
| **Magnetic:** Attraction between objects due to the electromagnetic properties of materials | ***Geothermal*****:** Heat from within the earth ( hot water in the form of steam) |
| **Sound:** Energy waves produce by the compression of air molecules | ***Wind*****:** Spinning blades create movement in a generator which can create mechanical energy |
| **Fossil Fuel**: Petroleum, coal, and natural gas | ***Fossil Fuel*****:** Produced millions of years ago from plant and animal matter. Fossil fuels were formed by chemical change due to heat and pressure. |

Note: Not all of these forms are presented in the unit. *They are here for teacher information.*

**Misconceptions**

| ***Misconception*** | ***Fact-Truth*** |
|---|---|
| Energy is a 'thing;' fuel, food, or an ingredient | Calorie (unit of heat energy) The number of calories in food indicates the potential energy present. |
| Energy transformation involves one form of energy at a time | More than one form of energy can occur at the same time. Electrical energy can produce heat and light simultaneously. |
| Conservation of energy means the same as 'saving energy.' | Conservation explains that energy can change forms while the sum or amount of the energy remains constant. |
| Energy, force and work are the same thing | They are related, but different.<br>Work – ability to move an object<br>Energy – the ability to work<br>Force – the amount of the push or pull |
| Transfer and transform are the same | Energy transfer involves the movement of heat from one place to another.<br>Example: A burner on the stove heats a pan, which in turn fries an egg. (convection).<br>Example: The heat from a wood burning stove will move across a room.<br><br>Energy transformation encompasses a change in the form of energy.<br>Example: Playing a piano. Fingers depress a key (mechanical) which strike a string (mechanical) producing a sound wave.<br>Example: Burning a candle. Heat creates a chemical change which produces both light and heat energy. |

# DESIGN CHALLENGE ONE INQUIRY INVESTIGATION

This guide is a tool for helping you plan an inquiry activity. The prime factor is that your students get the opportunity to practice choosing their own question and planning and carrying out an investigation to find out what they can learn from investigating that question.

Approx. Time 9 days@60 min. each
Author: Christopher Stone, Wallingford Study Group – Summer 2004

| Related State Content Standard(s): | Related State Expected Performance(s): |
|---|---|
| 4.1 , 7.1 , *Scientific Inquiry*, *Scientific Literacy* | B8, B9, C14, B INQ. 1, B INQ. 2, and B INQ. 6 |
| **Related Enduring Understanding(s):** | **Related Essential Question(s):** |
| • Force can cause objects to move, change position or direction or stop.<br>• Energy provides the ability to do work.<br>• Designing and planning is a continual process that changes based on function and/or circumstance.<br>• Inquiry integrates process skills, critical thinking, and the application of scientific content to solve problems. | • How do forces govern motion? How are they used to predict motion?<br>• How do we use energy to do work in everyday life?<br>• How does asking and investigating questions about energy help me to understand it better? |
| What simple **content objectives**/goals do you want to accomplish with this investigation? (see district curriculum documents) | What simple **process skills** do you want to improve with this investigation? |
| K1 Conclude that push and pull are the basic forces that influence motion.<br><br>K2 Recognize that work is moving an object a certain distance.<br><br>K3 Analyze the effect of force on objects with different masses.<br><br>K4 Demonstrate some forces that resist motion, like friction, gravity, and air resistance.<br><br>K6 Explain the transfer of energy. | S1 Generate investigable and non-investigable questions.<br>S2 Observe objects and their motion and describe commonalities and differences among them.<br>S4 Predict the change in an object's motion when friction, gravity, or air resistance are applied, how a force changes an object's motion, how mass and size affect motion.<br>S5 Design a fair test to answer an investigable question.<br>S6 Revise plan based on observations/results.<br>S7 Collect and record data using appropriate tools, such as a metric ruler, timer, calculator.<br>S8 Organize appropriate and accurate measurements and observations using graphic organizers, charts/graphs, |

| | |
|---|---|
| | illustrations/diagrams, journaling.<br>S9 Draw conclusions based on data, observations, and/or findings.<br>S10 Communicate results or information in an appropriate manner using presentations, visuals, or simple reports. |

What phase of this investigation will you provide the most modeling/templates/mini-lessons/scaffolding for better skill development?

Phase 1 – Turning non-investigable questions into investigable questions
Phase 1 – Student journaling of observations
Phase 2 - Possible guided lessons: (These can be 10-15 minute discussions/guided activity/demonstration prior to investigation period)

- Museum walk and/or pair share
- Falling weight system
- Vehicle design
- Data collection methods
- Student journaling of observations

Phase 3 – Possible guided lessons: (These can be 20-30 minute guided lessons that focus on modeling)

- Museum walk and/or pair share
- Note taking from an oral presentation
- Writing a science notebook entry utilizing all phases of the writing process
- Recording observations, raising questions, or planning for process skill development

Materials/Resources:

Items as follows from STC Motion and Design Science Kit:

- Student buckets with materials (see page 28 of Motion and Design Teacher's Manual)
- Design Challenge One on chart paper (page 25 of Motion and Design Teacher's Manual)
- Chart paper
- Markers
- Rubber bands
- Large paper clips
- Small washers
- Large washers
- Fishing line
- Cardboard (8" x 11")

What kinds of investigations do you anticipate students designing?

- Students will investigate questions that will measure distance and time.
- Students will investigate questions that will examine the usefulness of materials such as rubber bands, falling weights (pulleys), and propellers as energy sources.

Sample questions that 5th grade students generated:

- How many centimeters can our vehicle move with one rubber band?
- How can the car move by using fishing line and weights? If so, how many

centimeters can it go?
- How can we make our car go without touching it, using four big and three small weights with fishing line? If so, how many centimeters will it travel?
- Which vehicle will go faster, a light vehicle or a heavy vehicle? How fast and how far will each vehicle go?

**PHASE 1 – Observing and Questioning**

## INQUIRY STARTERS

- What is the launching activity or **inquiry starter** for the investigation?
- What will be your **inquiry starter prompt**? How will you "invite" your audience to work with the materials?
- What **materials** will you use for the inquiry starters?
- How will you **elicit and collect or display student's questions**? Will they share questions orally? In writing?
- **Choosing investigation questions**: How will you help your students determine which questions they can choose from to investigate? How will you or the students form investigation groups?

| Time/ Materials | Task | Hints |
|---|---|---|
| **Day 1**<br><br>Page 25 of STC Teacher's Manual<br><br>**45 minutes**<br>Student Materials Bucket<br><br>Student Science Notebook<br><br>Chart Paper<br>Marker | **Design Challenge One: Part One, pg. 25 of Teacher's Manual**<br>Design and build a vehicle that will move at least 100 cm (39 in). Before students begin building, discuss how they will measure or determine whether their vehicles meet the requirements.<br><br>While exploring, require students to record their observations and any questions they have in their science notebook.<br><br>Through class discussion, the teacher will chart student observations and questions.<br><br>*Note: This is the initial activity for students as noted in the STC Motion | This lesson is designed for students to gain a comfort level with the materials.<br><br>Students should work in groups of two to three for this exploration period. |

| | | |
|---|---|---|
| | and Design Teacher's Manual. Days 2 through 9 are shifts made to this activity to turn this lesson into a full inquiry experience for students. | |
| **Day 2**<br><br>**45 minutes**<br><br>Student Materials Bucket<br><br>New Materials:<br><br>Rubber Bands<br>Paper Clips<br>Fishing Line<br>Small Washers<br>Large Washers<br><br>Student Science Notebook<br><br>Chart Paper<br>Marker | **Design Challenge: Part Two – Introducing New Phenomena**<br>Students will continue to explore with the new materials introduced: rubber bands and falling weight system materials (paper clips, fishing line, washers).<br><br>Students will continue to explore by designing and modifying a vehicle that will move at least 100 cm or 39 in. While exploring, require students to record their observations and questions in their science notebook.<br><br>Chart student observations and questions based upon their explorations. | Although students have completed their initial design challenge, this is an opportunity to explore with richer phenomena and make modifications to their existing design.<br><br>Students should work in their day1 groups of two to three for this exploration period.<br><br>While facilitating this exploration, encourage students to record their observations and questions in their science notebook.<br><br>**Assessment Note:** This is an opportunity for the teacher to formatively assess the ability of their students to write detailed observations and questions.<br><br>**Guided Lesson/Thinking Tool:** Writing Detailed Observations. The teacher will model writing detailed observations for the students through a "think aloud". See appendix 3 for "Observation Starters".<br><br>**Assessment Note:** Students may also need assistance to clearly identify the variable that is being tested.<br><br>**Guided Lesson/Thinking Tool:** A possible guided lesson on raising investigable questions may need to be taught. Discuss with students what variables can be tested.<br><br>Say to students, "When you do a fair test, you need to think about what variable you want to test, and which other variables are important not to |

| | | |
|---|---|---|
| | | change. For example, you may want to test the affect of rubber bands on a vehicle and how the rubber band affects the travel of the vehicle. What other variables do you want to keep the same during this investigation?<br><br>A sample question may be: *Would the vehicle we designed move further with more than one rubber band? If so, how many centimeters would it travel?* |
| **Day 3**<br><br>**45 minutes**<br><br>Student Science Notebook<br><br>Investigable Questions on Chart Paper or Sentence Strips | **Choosing An Investigable Question**<br>Possible procedures for choosing an investigable question:<br><br>1. The teacher may select one to two questions based upon student questions that best match the teacher goals and content objectives.<br><br>2. The students may select from multiple questions that are aligned with content goals and objectives. Students select questions for their investigation through a gallery walk.<br><br>Students will form their investigation groups based upon their interest. | The teacher may select questions raised that have been recorded on chart paper or the teacher may have students write questions on individual sentence strips. |

**PHASE 2 – Planning and Investigating**

## INVESTIGATION

- What **additional materials** will you introduce? How will you introduce additional materials participants can use to study the phenomena?
- How will you manage/organize materials, set up and clean up?
- How will you support the groups in **planning** their investigation? Will you provide criteria or planning sheets?
- How will you facilitate during the investigation?

| Time/ Materials | Task | Hints |
|---|---|---|

| | | |
|---|---|---|
| **Day 4**<br><br>**60 minutes**<br><br>**Student Plans**<br>**Student Science Notebook** | Share with students the expectations of this investigation.<br><br>Brainstorm criteria for an effective plan with students.<br><br>Students will generate a plan in their science journals that will help them find answers to the question that they have selected for this investigation. Each group should generate a collaborative plan, however, each member of the group should record their plan in their science journal.<br><br>Students will peer conference to get advice on how they can make their plan stronger.<br><br>Teachers should collect plans for review and approval based upon criteria. | See appendix 1 for "Expectations for Lesson One".<br><br>Based upon criteria developed, teacher should generate a brief plan outline. Some sample criteria is student selected question, materials, prediction, steps (including data collection), and conclusion. Students may decide to include diagrams or illustrations to support their plan.<br><br>**Assessment Note:** This is an opportunity to formatively assess student planning.<br><br>**Guided Lesson/Thinking Tool/Mini-lesson:** Based upon teacher formative assessment, the teacher may need to provide a guided lesson for students to improve planning. See appendix 2 for "Planning An Investigation" template. |
| **Days 5 and 6**<br><br>**2 work periods @ 60 minutes**<br><br>Student Selected Materials<br><br>Student Plan<br><br>Student Science Notebook<br><br>Chart Paper<br><br>Markers | Students will investigate their question selected based upon their plan they developed. As students start their investigation, revisions may need to be made to their original plan.<br><br>Students record observations and collect data during investigation.<br><br>Teacher will facilitate the investigations by asking appropriate questions aligned with content objectives.<br><br>Teacher will facilitate with reminders to record observations and collected data.<br><br>At the end of each work period, provide students with the opportunity to reflect individually about what they have learned during their investigation. Below their observations and data | Students should record their observations and collect their data in their science journal.<br><br>**Possible guided lesson/thinking tool from Motion and Design Teacher's Manual:**<br>• Data Collection Methods (Lesson 4)<br>• Using Rubber Bands (Lesson 7)<br>• Using a Falling Weight System (Lesson 4)<br><br>**Materials Management Hint:** Have students keep their materials in a central location. Label the bucket or shoebox that students are using with their names.<br>The student investigation should end on day two at the 30 minute mark of the work time to allow students the opportunity to plan for their sharing time. See appendix 4 for "Preparing to |

| | | |
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| | collection, students will draw a line. Below the line, students will record what they have learned. You may refer to this as their "Line of Learning."<br><br>Brainstorm with students a variety of ways to share. Allow investigation groups 10-15 minutes to plan for sharing. | Share" template. |

**PHASE 3 – Interpreting Results and Communicating**

## SHARING RESULTS AND PROCESSING FOR MEANING

- How will investigation groups present what they have learned from their investigations? (visual, oral presentation, combination, etc.) How will you decide the order of the presentations? (by similar questions, content goals, random, etc.)
- How will the facilitator synthesize the knowledge and findings of the participants for the group?

| Time/ Materials | Task | Hints |
|---|---|---|
| **Day 7**<br><br>**45 minutes**<br><br>Student Visuals<br><br>Teacher Synthesis Notes<br><br>Student Science Notebook | Students will share their findings through their presentation.<br><br>Each group will have 3-5 minutes to share their findings.<br><br>Encourage students to take notes during the presentations in their science notebook. | Teacher should have the "Big Ideas or Important Concepts for Synthesis" - see Appendix 5. This appendix can be used for the teacher to take notes while students are presenting their findings.<br><br>**Assessment Note:** The teacher may formatively assess student note taking skills during oral presentations. This may lead to a guided lesson on note taking.<br><br>**Guided Lesson/Thinking Tool:** Model note taking on the overhead, during a student presentation. The teacher may create a graphic organizer to assist students in note taking. |
| **Day 8**<br><br>**45 minutes**<br><br>Student Science | Immediately following student presentations, students will summarize (write and draw) their learning in their science notebook. | See appendix 6 for "Reflection Question".<br><br>**Assessment Note:** The initial writing prompt found in appendix 6 may come before or after teacher synthesis. |

| | | |
|---|---|---|
| Notebook | | Instructing students to reflect prior to teacher synthesis is an excellent way to formatively assess student knowledge. Teacher will collect and read student science notebooks as a formative assessment.<br><br>**Guided Lesson/Thinking Tool:** Model writing a science notebook journal entry through a "Think Aloud" to provide students insight into a writer's craft. |
| **Day 9**<br><br>**20 minutes**<br><br>Teacher Synthesis Notes and Overhead<br><br>Student Science Notebook | Teacher will synthesize the concepts learned using the "Big Ideas or Important Concepts for Synthesis" as a guide - see appendix 5<br><br>Students will record each synthesis concept in their science notebook. | While facilitating the synthesis, teacher should refer to student models and presentations to create student ownership for the concepts learned<br><br>The teacher should reveal one synthesis concept at a time on the overhead or chart paper.<br><br>Provide notes to students with special needs. |
| **Day 9**<br><br>**30 -50 minutes**<br><br>Student Science Notebook | Immediately following teacher synthesis, students will revise their journal (write and draw) based upon what they have learned about this investigation following the teacher synthesis. (See appendix 6)<br><br>**Assessment Note:** Teacher will collect the student science notebooks for summative assessment. (See appendixes 7 and 9 for sample rubrics) | Students can share their science notebook entry with a partner (from their investigation group) or with the whole group.<br>**Assessment Note:** Based upon the assessment of student entries, the teacher may decide to teach the following guided lessons prior to the next investigation: recording observations, raising questions, planning, note taking from an oral presentation or summarizing through writing.<br><br>See appendix 8 (Student Survey) and appendix 9 (Sample Science Notebook/Journal Assessment) for additional assessment ideas. |

## Expectations For Investigation

Design Challenge One Inquiry Investigation

*Appendix 1*

- Generate a detailed plan that you and your group members will follow prior to investigating your question.
- Record any changes made to your plan during your investigation.
- Sketch or illustrate your vehicle.
- Keep a record of your investigation through written observations.
- Keep a record of your investigation by creating a data collection method.
- Support your findings with reasons.
- Share your findings as a way to teach other students.

# Planning An Investigation

Design Challenge Inquiry Investigation

*Appendix 2*

## Investigation Question:

_____

_____

_____

## Materials Needed for the Investigation:

_____

_____

_____

## My first step will be to

_____

_____

_____

## My next step(s) will be

_____

_____

_____

## Changes I made to my plan are

_____

_____

_____

Source: Exploratorium, Increasing Inquiry in Kits and Hands-On Curricula, 2004

# Observation Starters

Design Challenge Inquiry Investigation

*Appendix 3*

Think of the five senses

- What kind of information does your five senses tell you? Size, shape, color, lines, texture, smell, weight, patterns, sound, behavior
- I observed…….
- I noticed…….

Connect it with what you know.

- It reminds me of _____ because _____.

Observe and record cause and effect

- When I _____, it _____.

Note any changes

- It changed after _____, and now it _____.

Be curious and full of wonder.

- I am curious about _____.
- I wonder what would happen if _____.
- I wonder what would happen if _____.

*Source: Seattle's K-5 Inquiry Based Science Program, Betsy Rupp Fulwiller, March 2002*

# Preparing to Share Results

Design Challenge One Inquiry Investigation

*Appendix 4*

**What was your question?**

_____
_____
_____

**What variable did you test and how did you test it?**

_____
_____
_____

**What did you find out?**

_____
_____
_____

**We think this happened because**

_____
_____
_____

**Prepare to share your investigation and results with the class. Consider what you think would be an effective way to communicate your results (by talking, making a poster, a chart or graph, etc.)**

Source: Exploratorium, Increasing Inquiry in Kits and Hands-On Curricula, 2004

## Big Ideas or Important Concepts for Synthesis

Design Challenge One Inquiry Investigation

*Appendix 5*

- Force causes objects to move, change position, change direction or stop.
- Energy provides the ability to do work.
- There are multiple sources of energy.
- There is a transfer of energy when a vehicle moves.
- Science inquiry is a way to critically solve problems.

## Reflection Question

Design Challenge One Inquiry Investigation

*Appendix 6*

Based upon your personal investigation and what you have learned from others during our share session, summarize what you have learned during our first investigation.

Write a well-written summary of your experience in your science notebook.

In addition, you may include any pictures, diagrams, or data tables that explain what you have learned during your first investigation.

## Revising My Reflection

Design Challenge One Inquiry Investigation

Based upon what you have learned during the teacher's synthesis, revise your science notebook entry.

You may include any new ideas in words or by using picture or diagrams.

# Written Communication Rubric

Design Challenge One Inquiry Investigation

*Appendix 7*

| | 3 | 2 | 1 |
|---|---|---|---|
| **Written Communication** | • The written response provides a thorough, complete explanation to the question.<br>• Includes accurate detail<br>• Correctly uses science words when writing<br>• Conclusions are thorough and supported by specific observations | • The written response provides a partial explanation to the question<br>• Most of the detail is accurate<br>• Uses correct science words most of the time<br>• Conclusions are not accurate or are not supported by observations | • The written response does not answer the question<br>• A few of the details are accurate<br>• Uses little to no science words<br>• Conclusions are not related to the observations |


| | 3 | 2 | 1 |
|---|---|---|---|
| **Written Communication** | • The written response provides a thorough, complete explanation to the question.<br>• Includes accurate detail<br>• Correctly uses science words when writing<br>• Conclusions are thorough and supported by specific observations | • The written response provides a partial explanation to the question<br>• Most of the detail is accurate<br>• Uses correct science words most of the time<br>• Conclusions are not accurate or are not supported by observations | • The written response does not answer the question<br>• A few of the details are accurate<br>• Uses little to no science words<br>• Conclusions are not related to the observations |

| | 3 | 2 | 1 |
|---|---|---|---|
| **Written Communication** | • The written response provides a thorough, complete explanation to the question.<br>• Includes accurate detail<br>• Correctly uses science words when writing<br>• Conclusions are thorough and supported by specific observations | • The written response provides a partial explanation to the question<br>• Most of the detail is accurate<br>• Uses correct science words most of the time<br>• Conclusions are not accurate or are not supported by observations | • The written response does not answer the question<br>• A few of the details are accurate<br>• Uses little to no science words<br>• Conclusions are not related to the observations |

# Student Survey

Design Challenge One Inquiry Investigation

*Appendix 8*

Science Unit: _____

Name: _____ Date: _____

**Assessment Scale**

**1. Work in Progress 2. Meets Expectations 3. Exceeds Expectations**

| I used these skills …. | | | |
|---|---|---|---|
| **1. I worked well with my partner (s) and respected all materials.** | | | |
| **2. I raised questions to be investigated.** | | | |
| **3. I predicted the outcomes of my experiments.** | | | |
| **4. I formed a hypothesis (explanation) based upon my observations.** | | | |
| **5. I planned my investigation with my partner.** | | | |
| **6. I used the skill of observation (see, touch, smell, or sound) often during my experiments.** | | | |
| **7. I used my best discussion skills to communicate my observations and results.** | | | |
| **8. I used my best writing skills to communicate my observations and results.** | | | |
| I completed these activities…… | | | |
| **1. I explored with materials to help me raise questions.** | | | |
| **2. I carried out my investigation with my partner.** | | | |
| **3. I kept careful record of my learning in my science notebook by using scientific words, pictures, and charts.** | | | |
| **4. I evaluated my learning by asking the question, "What did I learn through about this topic?"** | | | |
| **5. I appropriately used science material.** | | | |
| **6. I connected my learning through literature related to my topic.** | | | |

| | | | |
|---|---|---|---|
| **7. I connected my learning through mathematics related to my topic.** | | | |
| **8. I connected my learning through research (library and web sites) related to my topic.** | | | |

**Teacher's Comments:**

**Student's Comments:**

**1. The best thing about this unit was**

**2. One thing that I learned during this was**

**3. Something that motivated me was**

# Sample Science Notebook/Journal Assessment

*Appendix 9*

**Name:**
**Topic: Energize Me**
**Date:**

*Assessment Scale*
1-Work in Progress
2- Meets Expectations
3 – Exceeds Expectations

| ***Process*** | **Rating** |
|---|---|
| 1. Organized Notebook | |
| 2. Managed time wisely throughout the unit | |
| 3. Communicated efforts with teacher throughout the unit | |
| 4. Participated during class discussions | |
| 5. Worked independently during unit | |
| 6. Worked cooperatively with others during unit | |
| 7. Portfolio demonstrates knowledge learned during unit. | |

**Total Points: _____/21=_____%**

Teacher's Comments:

Student's Comments:

Parent's Signature: _____
Parent's Comments: _____

This signed grade sheet, portfolio folder, and science journal are due by _____.

*Student Survey*
*Science Assessment Rubric*

**3**

Organized with all aspects and is on task
Science notebook and folder is organized
Organized workspace
Respects all science materials
Respects partners and compromises when necessary
Follows directions carefully
Uses elaboration in all areas of writing, speaking and mathematics
(Examples: Observations and making connections)
Always participates in big and small groups
Has all parts of a plan and follows the entire plan during investigation

**2**

Doesn't include many details in observations and written responses
Some elaboration is included in written responses
Follows parts of a plan for an investigation
Does only what is expected
Five to ten observations are written
Some directions are followed
Investigation is not well organized
Fools around sometimes
Respects most science materials
Some questions are raised for investigations
Makes one or two predictions during the investigations
Makes some personal connections
Participates sometimes in class discussions
Works okay with partners

**1**

Rarely follows directions
Rarely listens to others
Some or no parts of the plan are followed
Observations are repeated
Few details included in writing
Rarely completes tasks
Doesn't participate in class discussions
Demonstrates little self-control
Doesn't choose partners wisely for investigations
Doesn't respect others and science material
Rarely comprises with partner/partners

# FOR SAIL INQUIRY INVESTIGATION

Authors: Sandra Justin, Ph.D. UCONN
Christopher J. Stone, Fifth Grade Teacher, Wallingford Public Schools

Date: August 2004 (Initial plan generated during Wallingford Summer Study Group)
November 2004 (Revisions as a result of piloting and TOSA Lesson Study Model)

Approx. Time: 6 class periods

**Students will design a vehicle that uses a sail for motion. While exploring this challenge, students will raise questions for further investigation. This lesson can be designed as open inquiry, guided inquiry or as a challenge activity, depending on available time and the interest of the students**

| Related State Content Standard(s): | Related State Expected Performance(s): |
|---|---|
| 4.1 The position and motion of objects can be changed by pushing and pulling.<br><br>***<br><br>7.1 Energy provides the ability to do work and it can exit in many forms.<br><br>***<br><br>3.4 Earth materials provide resources for all living things, but these resources are limited and should be conserved. | B8. Describe the effects of pushes and pulls on the motion of objects.<br>B9. Describe the effect of the mass of an object on its motion.<br>***<br>C 14. Describe how different types of stored (potential) energy can be used to make objects move.<br>***<br>B 7. Describe how Earth materials can be conserved by reducing the quantities used, and by reusing and recycling materials rather than discarding them. |
| **Related Enduring Understanding(s):** | **Related Essential Question(s):** |
| ▪ The size of the change in an object's motion is related to the strength of the push or pull.<br>▪ The more massive an object is, the less effect a given force will have on its motion.<br>▪ Work is the process of making objects move through the application of force.<br>▪ Energy can be stored in many forms and can be transformed into the energy of motion. | ▪ What evidence do we have that energy can be changed?<br>▪ How do forces govern motion?<br>▪ How does new information change ideas? |

| | |
|---|---|
| ▪ Decisions made by individuals can impact the global supply of many resources. | |
| What simple **CONTENT OBJECTIVES**/goals do you want to accomplish with this investigation? (see district curriculum documents) | What simple **PROCESS SKILLS** do you want to improve with this investigation? |
| K1 Conclude that push and pull are the basic forces that influence motion.<br>K2 Recognize that work is moving an object a certain distance.<br>K3 Analyze the effect of force on objects with different masses.<br>K4 Demonstrate some forces that resist motion, like friction, gravity, and air resistance.<br>K6 Explain that energy can be transformed. | S1 Generate investigable and non-investigable questions.<br>S4 Predict<br>S5 Design a fair test to answer an investigable question.<br>S6 Revise a plan based on observations/ results.<br>S7 Collect and record data using appropriate tools.<br>S8 Communicate results or information in an appropriate manner.<br>S9 Organize appropriate and accurate observations using: graphic organizers, charts/graphs, diagrams/illustrations, and journaling. |
| What phase of this investigation will you provide the most modeling/templates/mini-lessons/scaffolding for better skill development? | |
| Generating investigable questions<br>Designing a 'fair test'<br>Reinforcing presentation skills | |
| Materials/Resources: | |
| K'nex pieces (primary materials)<br>Resources included in Motion & Design Kit<br>Assorted materials for sails (paper, fabric, plastic, screen) Students may provide additional, appropriate materials from home.<br>3 fans (small, medium, and large diameters)<br>2 long tables to be used with large fan<br>Masking tape — Index Cards<br>Post-it notes — Scissors<br>Staplers — String<br>Centimeter measuring tapes — Stopwatches<br>Scale for weight — Science notebooks<br>Motion and Design student activity books<br>Open space to be used with small and medium fans | |
| What kinds of investigations do you anticipate students designing? | |
| Students will have the opportunity to test variables which may include:<br>• Shape of the sail | |

- Size of the sail
- Sail material
- Position of sail on vehicle
- Number of sails on vehicle

Other variables to explore and/or identify:

- Size and shape of vehicle (measuring the length and width)
- Energy source (fan)
    - diameter of fan
    - position of fan and air stream
    - strength of air stream

**Possible sample questions from students:**

1. How far can the vehicle travel using a small fan?
2. Which type of fan (small, medium or large) will make my vehicle go further?
3. What will happen if we put all materials on our vehicle? I wonder how weight will affect speed?
4. How do different types of sails affect the way the car moves? (size, shape, position, **or** # of sails)
5. What material works best?
6. Would a heavy vehicle go as fast or as far as a light vehicle?
7. What kind of sail would go a farther distance?
8. Would our car travel as far on land as on water?
9. Which sail works best, fabric or cardboard?

**PHASE 1 – Observing and Questioning**

## INQUIRY STARTERS

- What is the launching activity or **inquiry starter** for the investigation?
- What will be your **inquiry starter prompt**? How will you "invite" your audience to work with the materials?
- What **materials** will you use for the inquiry starters?
- How will you **elicit and collect or display student's questions**? Will they share questions orally? In writing?
- **Choosing investigation questions**: How will you help your students determine which questions they can choose from to investigate? How will you or the students form investigation groups?

| Time/ Materials | Task | Hints |
|---|---|---|
| **Day 1**<br>60 min.<br><br>Chart paper<br>Science notebooks<br>Student Buckets<br>Measuring Tapes<br>Precut Sails in Plastic and Fabrics<br>Precut Cardboard (included in motion and design kit)<br>Three rolls of string<br>3 rolls of masking tape<br>Small Fan<br>Medium Fan<br>Large Fan | Setting the context – Design Challenge<br><br>On chart paper the teacher should write:<br>**Use the K'NEX materials to design a vehicle with a sail that will be able to travel at least 40 centimeters.**<br><br>**While completing your design challenge, record things you notice and things that you are still wondering about.** | This inquiry is a continuation of the Motion & Forces unit.<br><br>Emphasis is on the charting of what you notice and what you are wondering as a way to develop a 'fair test'. |
| **Day 2**<br>30 min.<br>Large index cards<br><br>Science notebooks | Students will record at least three wonderings (questions) that they would like to investigate further.<br><br>On chart paper the teacher should write the following:<br>**Record questions that you would like to investigate further. Record 1 to 2** | Review characteristics of an investigable question:<br><br>Independent variables: Review use and characteristics of vehicles. Students will suggest the following: materials (like cardboard, plastic, felt, screen), type of car, size of sail, and |

| | | |
|---|---|---|
| Planning Template | **questions. Record each question on a separate index card.** | fan type.<br><br>Dependent variables: Review things to measure during the investigation. Students will suggest distance, speed, angle.<br><br>Encourage students to have characteristics of each in an investigable question. **To conduct a 'fair test' students should only test one independent variable at a time.** |
| | Students will post their questions on index cards by theme.<br><br>Students identify a question they wish to investigate. Students write their name on 2-3 'post-its' and place their 'post-its' on different index cards/questions they would like to investigate.<br><br>Teacher forms investigation groups. | Themes to consider are:<br>1. Size and shape of sail<br>2. Sail material<br>3. Position of sail<br>4. Fan type<br>5. Weight (of vehicle or sail)<br>6. Other<br><br>The teacher may want to use a student checklist to easily group students.<br><br>It may be helpful to give each question a number. It is easier to refer to a question by its number instead of the whole question.<br><br>When grouping students, read the question number and reread the question to the class to help reinforce the breadth and depth of the questions being investigated.<br><br>A question may be investigated by more than one group. |

**PHASE 2 – Planning and Investigating**

**INVESTIGATION**

- What **additional materials** will you introduce? How will you introduce additional materials participants can use to study the phenomena?
- How will you manage/organize materials, set up and clean up?
- How will you support the groups in **planning** their investigation? Will you provide criteria or planning sheets?
- How will you facilitate during the investigation?

| Time/ Materials | Task | Hints |
|---|---|---|
| **Day 2 (cont.)**<br>30-50 min.<br>Science notebook | Once students have selected their question for investigation, students should generate a plan to investigate their question. On chart paper, the teacher should write the following:<br><br>**Generate a plan to investigate your question. Your plan should include all of the important elements of our planning template. Each group member should have a plan recorded in their science notebook.**<br><br>**Optional (if time allows)**<br>Students will pair share with another group. Each group member will record a positive comment and a comment for improvement on a 'post-it'. The reader will stick the 'post-it' on the author's plan. Comments could include:<br>1. I noticed you were measuring ….<br>2. One improvement I would suggest is …<br><br>The teacher will collect all plans for review before starting the investigation. | Review 'fair test' criteria.<br><br>Students can peer review plan and effectiveness of proposed data table(s).<br><br>If students have not previously used a planning template the teacher may want to lead a discussion on what the elements of an effective plan are.<br>-The teacher will chart these characteristics as students share their ideas.<br>-After students have suggested their characteristics, the teacher will say:<br>"I am now going to provide you with a planning template that has been used by students. You will notice that some or all of your suggestions are in this planning template. I would like you and your group members to revise your plan according to the characteristics of this planning template."<br>-Students will revise their plans. |
| **Day 3**<br>50 min.<br>Science notebook | Students conduct investigations. | Monitor for data collection strategies.<br><br>Monitor for recording of observations. |

| | | |
|---|---|---|
| **Day 4**<br>60 min.<br>Science notebook<br><br>Materials for investigation | Students continue investigations. | Possible Mini-lessons:<br>**1.Data Collection**<br>Say to students, "At this point in the unit we have conducted investigations in which we have used data collectors. Take one minute and look through your science notebook to recall some of those data collectors." After students have reviewed their notebook, chart responses from students.<br><br>**2.Observations**<br>Say to students, "At this point in the unit we have recorded our observations in several investigations. Take one minute and look through your science notebook to recall some ways that we have recorded our observations. After students have reviewed their notebook, elicit responses that match "Observation Starters".<br><br>When students have completed their investigations, they may begin preparing for their presentations. |

**PHASE 3 – Interpreting Results and Communicating**

**SHARING RESULTS AND PROCESSING FOR MEANING**

- How will investigation groups present what they have learned from their investigations? (visual, oral presentation, combination, etc.) How will you decide the order of the presentations? (by similar questions, content goals, random, etc.)
- How will the facilitator synthesize the knowledge and findings of the participants for the group?

| Time/ Materials | Task | Hints |
|---|---|---|
| **Day 5**<br>5 minutes<br>Chart paper<br>Science | Brainstorm and chart criteria for effective presentations.<br><br>Brainstorm and chart criteria for an | Some suggestions to include in their presentation are: question, prediction, plan, observations, data and conclusion. |

| | | |
|---|---|---|
| notebook | attentive audience. | |
| **Day 5**<br>20 minutes<br><br>Science notebooks<br>Chart paper | Students prepare presentations. | Students decide on presentation that will best showcase their investigation.<br>Presentation options, may include:<br>Demonstration of car<br>Poster<br>Diagrams & graph<br><br>Students should record their question on construction paper or sentence strip so the class can view the question when taking notes. |
| **Day 5**<br>30 minutes<br><br>Science notebooks | Students present results to class.<br><br>Students take notes on each oral presentation<br>Possible Formats:<br>Option 1:<br>Column 1 – Group members<br>Column 2 – Question<br>Column 3 – What the group learned<br><br>Option 2: (may be used for the first time with your class to allow for a steady flow through the presentations)<br>Column 1 – Group members<br>Column 2 – What the group learned | Allow approximately 3 minutes per student presentation. |
| **Day 6**<br>20 minutes<br><br>Chart paper<br>Science notebooks | Facilitate a synthesis that summarizes the main findings. The facilitator will focus on the following concepts (see appendix 1 & 2):<br>▪ Simple machines are used to do work.<br>▪ The energy used is a push.<br>▪ Energy provides the ability to do work.<br>▪ Scientific inquiry is a way to critically think and solve problems. | The teacher should take notes during the presentation to help with the synthesis. The teacher should record these concepts on four separate papers. As students present record the group members and concepts learned in appropriate categories. (See appendix 1 and 2) |
| **Day 6**<br>20 minutes<br><br>Chart paper | Students will complete the following reflection assignment (see appendix 3):<br>**Draw and label a car that uses the best features you observed in class.** | **Optional Pre-write activity:** Prior to students creating their design, generate a list of words with students that apply to this follow up. This may provide |

| | | |
|---|---|---|
| Science notebooks | **Consider the following:**<br>▪ **vehicle design**<br>▪ **shape of sail**<br>▪ **sail material**<br>▪ **fan choice**<br><br>**Write a short summary explaining your choices.** | students with a word bank to use while creating their diagram and writing their summary.<br><br>See appendices 4, 5 & 6 for additional assessment ideas. |
| Independent Follow up<br><br>Science notebooks<br><br>Motion and Design Student Activity Book Glossary<br><br>Dictionary | **Vocabulary Reinforcement**<br>As a follow up, have students add the following words to their science notebook: energy, motion, force, push, sail, design, and simple machine.<br><br>Have students define each word, use each word in a sentence and draw a picture of each word. | Words can be added or deleted based upon teacher choice and time. |

## Big Ideas or Important Concepts for Synthesis

For Sail Inquiry Investigation

*Appendix 1*

- Simple machines are used to do work.
- The energy used is a push.
- Energy provides the ability to do work.
- Scientific inquiry is a way to critically think and solve problems.

# Teacher's Synthesis - Facilitation Guide

For Sail Inquiry Investigation

*Appendix 2*

**Below are some "guiding questions" that may be helpful during your synthesis. These questions are designed to "draw out the big ideas" from the students during their sharing session.**

- Why do you think that happened?
- What can you say you learned from your investigation? Or What is one thing you have learned from this investigation?
- What fan(s) (size, power) did you use? Why?
- Did you always use the same fan? What fan did you use? Why?
- Can you demonstrate that for us with your vehicle?
- Do you think that if you change the design of your vehicle, would it have changed your results? How so? And why?
- When did you decide to do that? (such as revisions to your plan) – During your investigation or during your initial planning session?
- How did you revise your plan during your investigation? Why?
- Do you think that weight might have been a factor in your design? Why?
- Based on your investigation, what "features" do you recommend to make the vehicle travel the furthest?
- We learned that from other groups too, both of you found out that …….

**The following sub-concepts may help students better understand the important ideas. You as the teacher may want to emphasize the following bullets during your synthesis by referencing student presentations.**

**It is recommended that the teacher takes notes to reinforce concepts and to address misconceptions. The bullets below may help you when taking notes.**

**<u>Simple machines are used to do work.</u>**

- You designed a simple machine based on the wheel/axle.
- The vehicle moves as a result of work.

**<u>The energy used is a push.</u>**

- The fan was the energy source.

- The fan moves the air which pushes against the sail.
- The size of the fan is related to the amount of energy produced and affects how the vehicle moves.
- The placement or angle of the fan affects movement.
- The weight of the vehicle also impacts how far the vehicle moves. The heavier vehicle the more energy that is needed to push the vehicle an equal distance.
- The size, shape and material of the sail will affect its motion.

**Energy provides the ability to do work.**

- When your vehicles moved forward – this is work. The fan was the energy source. The moving air provided a push.

**Scientific inquiry is a way to critically think and solve problems.**

- During your investigation you followed a process that involved raising questions, predicting, developing and following a plan, collecting observations and data, making conclusions and sharing your findings with your class.
- Many groups found it important to make revisions during their investigation. Scientists also make revisions during their experiments when it is needed.
- Stop, think about what you see, and then continue to work. Sometimes we get caught up in the "fun" of the investigation. But it is important to stop and think during our investigation to avoid careless errors that would make our data less accurate.

# Reflection Question and Rubric

For Sail Inquiry Investigation

*Appendix 3*

Draw and label a ***car*** that uses the best features you observed in class.

Consider the following:

- vehicle design
- shape of sail
- sail material
- fan choice and position

Explain your choices.

**Sail Inquiry**
**Diagram Rubric**

**2 –** Labels on all important pieces, direction of force, position of energy source, and direction of vehicle

**1 –** Some labels missing on important pieces and energy sources.

**0 –** No labels

## Student Reflection Question - Alternative Assessment Idea

For Sail Inquiry Investigation

*Appendix 4*

Draw and label a ***water vehicle*** that uses the best features you observed in class.

Consider the following:

- vehicle design
- shape of sail
- sail material
- fan choice and position

Explain your choices.

**Sail Inquiry**
**Diagram Rubric**

**2 –** Labels on all important pieces, direction of force, position of energy source, and direction of vehicle

**1 –** Some labels missing on important pieces and energy sources.

**0 –** No labels

# Sample Sail Concept Quiz

## For Sail Inquiry Investigation

*Appendix 5*

1. We used _____ energy as the force to push our vehicles in the sail inquiries.

2. Extra weight on the vehicle slowed the speed down. What is the force that opposes motion called?

3. What happens when no black tires were on the vehicle? _____

   _____

   Why? _____

   _____

4. When testing cardboard, felt, and zebra fabric, which materials made a better sail?

   _____ Why? _____

   _____

5. When using the small fan, groups found that their vehicle went slower than when using the large fan. Explain why this happened? _____

   _____

   _____

6. Some groups found that when using the **medium fan** their vehicle went **faster** then when using the **large** fan. Describe two variables that might have caused this to happen.

   _____

   _____

   _____

   _____

7. When one group changed the design of their vehicle, they discovered that it went faster. How did they change it? _____

   _____

   _____

# Sample Sail Performance Quiz

For Sail Inquiry Investigation

*Appendix 6*

**Directions**: You will rotate through three stations and answer the following questions that correspond with the station number.

1.
Using the provided sail vehicle, investigate it's movement with the two different sized fans at this station. Describe your observations and explain why this happened.

2. Using the provided fan, test the 2 vehicles (same design) that have two different size sails attached to them. Describe your observations and explain why this happened.

3. Investigate placing different amounts of weights on the vehicles. How do different amount of weights affect the motion of the car? Describe your observations and explain why this happened.

# I N S T I T U T E · F O R · I N Q U I R Y
# A DESCRIPTION OF INQUIRY

*Appendix A*



At the *Exploratorium Institute for Inquiry* our work in science education is deeply rooted in the belief that human beings are natural inquirers and that inquiry is at the heart of all learning. The work that we do with educators is designed to give them an opportunity to personally experience the process of learning science through inquiry. Our hope is that this experience will stimulate their thinking about how to create classrooms that are supportive environments for children's inquiry.

Inquiry is an approach to learning that involves a process of exploring the natural or material world, that leads to asking questions and making discoveries in the search for new understandings. Inquiry, as it relates to science education, should mirror as closely as possible the enterprise of doing real science.

**The inquiry process is driven** by one's own curiosity, wonder, interest or passion to understand an observation or solve a problem.

**The process begins** when the learner notices something that intrigues, surprises, or stimulates a question—something that is new, or something that may not make sense in relationship to the learner's previous experience or current understanding.

**The next step** is to take action—through continued observing, raising questions, making predictions, testing hypotheses and creating theories and conceptual models.

**The learner must find** her or his own pathway through this process. It is rarely a linear progression, but rather more of a back and forth, or cyclical, series of events.

**As the process unfolds,** more observations and questions emerge, giving occasion for deeper interaction and relationship with the phenomena—and greater potential for further development of understanding.

**Along the way,** the inquirer collects and records data, makes representations of results and explanations, and draws upon other resources such as books, videos and the expertise or insights of others.

**Making meaning from the experience** requires reflection, conversations and comparison of findings with others, interpretation of data and observations, and the application of new conceptions to other contexts. All of this serves to help the learner construct new mental frameworks of the world.

**Teaching science using the inquiry process** requires a fundamental reexamination of the relationship between the teacher and the learner whereby the teacher becomes a facilitator or guide for the learner's own process of discovery and creating understanding of the world.

# Map of IFI Inquiry Structure

(3 Phases of Inquiry Diagram)

*Appendix B*