1. Lesson Plan for Heat Vs Temperature

Prior Knowledge: Students have studied kinetic energy in their kinematics unit

Objective:
To observe and explain differences between temperature and heat

Engage:

1. Teacher swabs rubbing alcohol on the students' back of hand.
    a. "What do you observe about the alcohol?"
    b. "Is the alcohol colder than the air? How can we test that?"
    c. "Why do you think that the alcohol feels cool?" If the class has already studied vaporization, the teacher might continue the discussion comparing water and alcohol.

Explore:

1. 4 containers of small materials with differing head conduction rates are placed at each table.
    a. "Predict the temperature of each container. How do you think each will feel if you place your hand in them?"
    b. Students design an experiment and create a data table to test their hypothesis.

Explain

1. Discuss the data with the class. Through inquiry questions, allow students to differentiate between temperature and heat. Questions can include:
    a. "Why do some materials feel cooler? How could we test that hypothesis?"
    b. "How does your brain determine hot and cold?

Elaborate

1. Students read the introduction and procedure for Measurement of Heat Transfer. They write their hypothesis before collecting data
2. Discuss the data with the class. Use the discussion questions to develop an understanding of the 1^{st} Law of Thermodynamics.

Evaluate

1. Students answer the following written prompt as an exit ticket
   "When your mama tells you to close the refrigerator door and not let all the "cold" out, what is not scientific about that demand? (warning do NOT tell her that)" Draw a diagram of the thermal energy and the movement of heat energy before and after you opened the refrigerator.

Student Pages

Measurement of Heat Transfer

The first law of thermodynamics says that heat added into a system changes into an equal amount of some other energy. It is based on the law that says energy cannot be created or destroyed. It can only change forms. You can understand the law of thermodynamics if you understand a car engine. Gasoline is burned. The energy in its bonds is released. That energy causes the gases in the combustion chamber to explode. The explosion forces a piston to move. The piston does work. The heat energy put into the engine equals the increase of temperature inside the engine plus the work that the piston did.

This next activity is a simpler way to show the law of conservation of energy. You will measure the amount of heat lost by hot water and the amount of heat gained by cool water. You will mix different amounts of hot and cold water together to determine their final temperature. First write an objective and a hypothesis. Next collect your materials: one 50 mL graduated cylinder, one foam cup, one thermometer, and one spoon. Put 60 mL of hot water in your cup. Measure the temperature and record in your data table. Quickly add 60 mL of cold water. Stir the water gently until the temperature remains steady and then record in your table. Repeat the experiment with 30 mL of hot water and 60 mL of cold water.

Write a lab report with an objective, hypothesis, and procedure.

Fill in the data table:

Volume		Starting Temperature		Final Temp.	Temp. Rise	Temp. Drop
cool water	hot water	cool water	hot water	mixture	cool water	hot water

Answer the following questions in your conclusion:

1. When you mixed equal volumes of hot and cold water, what happened to the temperature? How did the temperature rise of the cool water and temperature drop of the hot water compare?

2. Was the result what you expected? What does this tell you about energy transfer in this activity?

3. When you mixed only 30 mL of hot water with 60 mL of cool water, how did the temperature rise of the cool water and the temperature drop of the hot water compare? How would you explain your results?

2. Heat Insulation

Objective: to collect and analyze data on the heat conduction rate of different materials and read interpret an article to collect evidence to support their models

Engage

1. Teacher displays a picture of an igloo made from ice and asks the class, "how do igloos keep people warm?" Students write their ideas after discussing with a partner.
2. Class discusses igloos and other examples of heat transmission in everyday life. Concept of insulation is discussed.

Explore

1. Parameters for Heat Insulation, is discussed with the class. Teacher connects the objective of next activity, heat box, to this engineering challenge. Class is shown available materials and asked to test those materials' ability to insulate.
2. Class collects and shares data.

Explain:

1. Students review reading: "Heat Conduction and Transfer". In teacher directed instruction, class reviews how to calculate heat transfer coefficient. Students complete problems in pairs.
2. Class discusses results of data including

a. What materials acted as the best insulator? What qualities did they have?
b. What other things may have affected the results? Could we control for them better?
c. Students work in groups to develop a method to determine the heat transfer coefficient for their box.

3. Class reads and discusses article on how things work: Heat Insulation
   http://www.explainthatstuff.com/heatinsulation.html

Students read the article independently for the first time, circling key terms, numbering paragraphs, and focusing on graphics.

In groups of four, student reread the article each for a different purpose.

a) *What does the article tell you about what would make the best insulation for your box?*
b) *How is heat insulation used in everyday life?*
c) *How does heat insulation work?*
d) *What can you learn about key terms and ideas about heat from the article?*

Students fill out graphic organizer of information and evidence and location in text. As a group of four, students share their findings. The class then discusses whether the article met each of the purposes.

Elaborate

1. Students design a second container using the article, class data and discussion.
2. After making their second model, they test it.

Evaluate

1. Citing evidence for their claim: students analyze all the data collected and make a claim. They use a graphic organizer to support their claim with evidence and reasoning.

Student Pages:

Making the Best Heat Insulation Challenge

How do igloos keep people warm?

Insulation reduces the rate of entropy. It keeps the heat energy from conducting or spreading out. However though igloos demonstrate that air is an excellent insulator, no substance prevents heat conduction completely. It can just slow conduction or the rate of entropy. This next activity will help you understand conduction and insulation better.

Make an insulating container that can hold a 150 mL beaker of water with the materials provided. When you are ready, send a team member to collect 100 mL of boiling water. Record your start time. Wait 15 minutes and return your beaker for an official final temperature reading.

1. Record your own results and the class' results in a table. Include a column for group, start temperature, final temperature, change in temperature, loss of joules, heat conduction rate, and description. (To calculate how much heat was lost, multiply the change in temperature by the amount of water used. To calculate heat conduction rate, divide the joules by the change in time)

Data Table

Group	Start temp	Final temp	Change in temp	Loss of joules	Heat conduction rate	Description

Answer the analysis questions in a paragraph.

2. Why did some containers lose less heat than others?

3. Which materials provided the best insulation?

*4. Which materials **conducted** heat best?*

Student Pages:

Heat Conduction and Transfer

Since heat always flows from a region of higher temperature to a region of lower temperature, the conduction of heat through walls and windows is a major source of unwanted heat loss and gain. To reduce the heat flow through a wall, the space within the wall is filled with materials such as fiberglass wool, plastic foam, or shavings. Such materials are referred to as **insulation**. Insulation is a misnomer, for these materials are actually conductors of heat. Only a perfect vacuum prevents heat conduction.

Experiments show that heat transfer through a wall is in direct proportion to the temperature difference between the inside and outside of a wall surface. A heat transfer coefficient is defined for a square meter of wall area. For example, if a wall transfers energy at the rate of 1 W for every square meter of area, when the outside is 1°C colder than the inside, we say its heat transfer coefficient is 1 W/m^2•°C. The symbol is U.

Heat Transfer Coefficient, U

The heat transfer coefficient is the rate of heat flow through a 1 square meter surface when the difference between the outside and the inside is 1°C.

2. What is insulation? What could you use for insulation in your solar heater?

3. Explain heat transfer coefficient in your own words. How might you calculate the heat coefficient of your box?

Example

Find the heat conduction rate in W through a ceiling with a heat transfer coefficient of 0.20 W/m^2•°C when the outdoor temperature is 40°C lower than the indoor temperature. The ceiling is 10 m wide and 12 m long.

Problems

1. A house has an insulated ceiling 12 m long and 8 m wide with a heat transfer coefficient of 0.40 W/m^2•°C. What will be the total heat transfer rate through the ceiling in W when the inside temperature is 20°C and the outside temperature is -30°C? _____________ W

2. A concrete basement wall has a 60 m perimeter and a 2.3 m height. Its U value is 2.43 W/m^2•°C. If the inside temperature is 15°C and the outside temperature is -2°C, what is the heat transfer rate in W? ___________W

3. Review the data collected for your own box. Develop a model for determining the heat transfer coefficient for your project. Below your calculation explain how you determined that value.

Tackling Informational Texts: Reading for a Purpose

Use the website: http://www.explainthatstuff.com/heatinsulation.html. Read the article independently for the first time. As you read, circle key terms, number paragraphs, and focus on graphics.

Informational texts can be read for different purposes. In groups of four, delegate one of the following four purposes to each member. Read the article for a second time focusing on the purpose you have been assigned.

1. *Engineering design: What does the article tell you about what would make the best insulation for your box?*
2. *Examples: How is heat insulation used in everyday life?*
3. *Scientific Explanation: How does heat insulation work?*
4. *Key terms and ideas: What can you learn about key terms and ideas about heat from the article?*

Fill out graphic organizer for your purpose. Share your findings with your group, adding to your graphic organizer for the other three purposes.

Purpose	Information	Location in Text
Engineering Design		
Examples **Scientific Explanation**		
Key terms and Ideas		

Do you think that the author of the article met your purpose? Why or why not?

Design Improvements

Discuss the data and the information from the article in your group. Redesign your box to reduce the heat conduction rate. Retest your box. Then use all the evidence and information collected to make a claim regarding the design of a heat insulation box.

Observations:

Evidence to support your claim:

Evidence

How it supports claim

Claim

3. Heat Box

Objective: to design a model that demonstrates the three methods of heat flow

Engage:

1. *https://www.youtube.com/watch?v=bnZQgp6srF4*

Watch YouTube on frying an egg on the sidewalk. Ask students to discuss in pairs how heat was transferred from the sun to the egg.

Explore:

1. Review the three methods of heat transmission. Give multiple examples in everyday life.
2. Discuss the parameters of their box and the rubric for grading
3. Allow students planning time in groups to design models. In their plans students must show how their model will demonstrate each kind of heat flow. Groups must get approval for their plans, their choice of materials, and how they will test their models.
4. Students build and test their models.

Explain & Elaborate

1. Students develop an explanation for their models that includes analysis of data, scaled drawings, and explanations of the three methods of heat flow and how they are applied to model.

Evaluate

1. Students design plans for an improved model and a specific explanation for those improvements.

Student Pages:

Three Methods of Heat Transmission

Since everything in the universe is either matter or energy, understanding energy is critical to our understanding of science. One of the most important concepts in science is that for the most part, **energy cannot be created or destroyed. However it can be converted from one type of energy to another type (the Law of Conservation of Energy).**

In this section we will learn how molecular movement can be transmitted (moved to a new place). Heat energy can be transmitted in three ways: **radiation**, **convection**, and **conduction**. Conduction of heat is when the atoms and free electrons bump into other atoms and free electrons causing them to start moving, such as when your chair is warmed by your butt. Convection is when the heated atoms and molecules move from one place to another, such as when warm air rises. Radiation is movement of radiant energy. An electromagnetic wave is the means that heat moves through outer space. The sun heats the earth through radiation.

We are all very well acquainted with conduction through everyday life. Heat a pan on the stove. Does the pan get hot? This is conduction. The heat energy from the stove causes the molecules in the pan to move faster. The pan's molecules on the bottom move more first. They bump into the pan molecules on the sides, causing them to move faster. Finally the top of the pan heats up through conduction.

Some things conduct heat well. They contain atoms such as metals that have free electrons to transmit the heat. Other things are "insulators". They are poor conductors and do not take in heat easily. Ever wonder how igloos can keep people warm? The snow that makes up the igloo contains a lot of air in their crystals. Air and things that hold pockets of air are good insulators. The air does not contain a lot of free electrons to carry the energy. The heat from the people's bodies cannot leave the igloo easily.

1. Use the above reading to fill in the chart. What are the three ways heat can be transmitted? Draw a picture of each and describe them. Include an everyday example and how it applies to your heat box.

Heat Transmission	**Description**	**Picture**	**Example**	**Application to your heat box**
Conduction				
Convection				
Radiation				

2. What is the law of conservation of energy?

3. If energy cannot be created or destroyed, why do we need to conserve energy?

4. A student stated that people could live without the sun. They could heat their homes with oil or gas to keep warm, and grow the plants they need with electric lamps. What is wrong with the student's hypothesis?

A) Plants need light to live. B) People would not be able to see in the dark.

C) The earth would quickly run out of oil, gas and other fuels to heat the homes and grow the plants.

D) Animals get their energy from plants.

Explain your choice using the law of conservation of energy:

Essential Question: How is energy transferred?

To demonstrate our understanding of energy, we will build a model that shows how energy is transferred.

Heat Box Project Based Learning

Request for Proposal

Driving Question: *How do we design a working model that demonstrates and explains three methods of heat transfer: radiation, conduction, convection?*

Model Parameters and Rubric

1. Teams of three to four students
2. Each group must construct a working model that demonstrates the three methods of heat transference using water. The engineers choose the theme and purpose of the model as well as the amount of water to be heated.
3. Each team will orally present their model and analysis to the judges. Judges will grade based on creativity, craftsmanship, scientific understanding, and how well the model demonstrates the three methods of heat transference
4. All of the items used in the model will be provided by the teacher.

Presentation

The teams must provide a written and an oral explanation of their model that includes the following:

I. answer to driving question that describes how the model demonstrates the 3 methods of heat transference

II. scaled drawing and measurements of plan

III. analysis of heat flow including the three methods of heat transmittance, the first law of thermodynamics, and any data collected from lab experiments conducted in class

IV. Suggested improvements to model

Preliminary Planning

1. *List scientific topics that you will need to research in order to answer the driving question.*

2. *Make notes on parameters and rubric.*

3. *Which materials will you use and how will you use them?*

4. *List notes regarding the presentation.*

5. *How will the model demonstrate each type of heat flow?*

Radiation	**Conduction**	**Convection**

Rubric for Project

4

- Creative model and use of materials that integrates project objectives of all three methods of heat flow
- project is neat, well crafted, detailed, and shows careful planning
- Presentation is clear and dynamic with all members demonstrating a clear understanding of the three methods of heat transference, insulation, and heat calculation; scientific concepts applied to model; driving question thoroughly and clearly answered; has a complete and detailed written analysis with neat scaled and labeled drawings

3

- Model integrates project objectives of two methods of heat flow well
- project is well crafted, showing evidence of preplanning
- all members contribute and demonstrate an understanding of heat transference and insulation; heat calculation attempted; driving question is answered and applied to engineering; has a complete written analysis and neat labeled drawings

2

- Model includes one method of heat flow
- project is complete
- 1 member does most of the oral presentation, 3 methods of heat transference and insulation correctly defined and partially applied, briefly answers driving question; has some written analysis and drawings

1

- Model is complete but does not demonstrate heat flow
- project is partially complete
- oral presentation mentions 3 methods of heat transference and insulation, one member contributes

6. Read the rubric. Make a thinking map of the three sections of evaluation: engineering goals, craftsmanship, and oral presentation. Under each section explain the difference between a project rated "3" and "4".

Analysis *(individual)*

1. Include a picture of your preliminary and final plans. Scale your drawings.
2. Explain the three methods of heat transmittance: radiation, conduction, convection. How do the three methods apply to your model?
3. What is insulation? How did you or could you use insulation in your project?
4. It takes one calorie of heat energy to raise one milliliter of water by one degree Centigrade of temperature. How much water did you heat in your heat box? What was the temperature change? How many calories did you need to do it?
5. Include a picture and explanation of improvements

7. Make a checklist of the parts you need to complete the analysis.

4. Heat Engines: **Heat Engine Cups**

Objective: To investigate the function and purpose of heat engines (conversion of heat to work)

Engage

1. Students are shown video clips of functioning heat engines
    a. A putt putt boat
    b. Sterling Heat Engine

Explore

1. Teacher provides materials to do the heat engine cup activity.
2. Students construct ("cookie cutter") heating cup activity.
3. Students explain how their models work **(CER)**.

Explain

1. Student teacher discussion using students' explanations from Explore piece.
2. Students read about heat engines and thermodynamics.
3. Students organize and take notes on the articles to formulate a working knowledge of heat engine and thermodynamic theory.
    a. http://www.thefreedictionary.com/heat+engine
    b. http://www.sparknotes.com/testprep/books/sat2/physics/chapter12section4.rhtml
    c. http://www.taftan.com/thermodynamics/HENGINE.HTM
    d. http://auto.howstuffworks.com/stirling-engine.htm
    e. http://physics.bu.edu/~duffy/py105/Heatengines.html
4. Pictorial modeling of heat engine as small groups/whole class "follow the energy"
    a. Students model of thermal energy transfer from varying temperature reservoirs.
    b. A system to convert thermal energy to mechanical energy. "the engine"
    c. Students submit an illustration identifying and purpose of each component

Elaborate

1. Using prior knowledge, students will make a claim on a way they can improve the efficiency and/or work output of their heat engine.
2. Students will make a claim of one modification they can make to the heat engine model from the explore piece.
    a. Possible modifications (however students may have others!)
        i. More candles (adding heat)
        ii. Colder ambient air
        iii. Modifications to flaps, cup to improve design.
3. Students will design and test their modification and provide evidence and reasoning in explaining whether their modification improved or hindered efficiency and/or work output
4. No calculations are necessary as this can be done by simple observations.

Evaluate

1. Evaluation of students is performed informally and formally throughout the lesson design.

2. Evaluation on laboratory exercises are not performed as “right/wrong” rather students’ evaluation criteria should be on use of the CER model in development and refinement of prior knowledge. Evidence from investigations should support or refute their claims and be used to redefine their misconceptions.

5. Culminating Activity – Putt Putt Boat

Objective:

Engage students in real world problem solving by performing design iterations using science to support decision making.

Provide real world application of conversions of energy from one form to another

Engage

1. Show examples of two different putt putt boats performing.
   a. Explain parameters of engineering challenge. Students will use this model as a launching point. They will make a modification that they will then design on their own boat. They will experiment to see if their modification improved the work production of their boat.

   http://www.youtube.com/watch?v=JOE3qIslu24

Explore

Engineering design and implementation (iterative process)

1. Students are given the blueprints for both the boat and heat engine.

http://www.youtube.com/watch?v=0ki9Kta8g14
http://www.sciencetoymaker.org/boat/asembCartonl.html

2. Students analyze the design and come up with several possible improvements to the design to increase the work
3. Students select one of the design modifications to implement in their project.
4. Students design their blueprints for their steam engine and boat, implementing their **one** design modification.
5. Students check blueprints with the teacher. (Students need approval before moving on).
6. Students build their boats/ heat engines
   a. Students check for leaks in their engine by submerging in water and blowing air through the straws.
   b. Students check for buoyancy of boat and leaks in boats
   c. Students assemble the boat/engine combination and check for buoyancy and leaks.

Experimental procedure to determine Work

1. Students are asked to determine a way to find the work of their putt putt boat using work equations they know throughout the year.
   a. $W=F*d$
   b. $W= Q_h - Q_c$

c. W= ΔKE
d. P = W/t

2. Students should design a lab procedure using one of these equations.

Explain

1. Teacher discusses with students their lab procedure.
2. Teacher provides questions to students to make them think about their process
3. Teacher and students develop a procedure using work-kinetic energy theorem. **(Through trial and error other equations have been attempted but not successful in determining work).**
4. Teacher scaffolds anything else students need assistance with from the explore portion.

Elaborate

1. Students present their claim (modification of initial design and its influence)
2. Perform an experiment to find evidence to support/refute their claim.
    a. Students will need to determine the work output of their boat.
    b. They will compare their work output of their boat to that of the class model to determine if their design modification improved the work output.

Evaluate

1. Students will prepare a lab report that includes the following:
    a. Determination of work
    b. Explanation of a heat engine applied to their model
    c. Explanation of energy transfer
    d. Reasoning for acceptance or dismissal of their design modification.

Additional websites

1. www.sciencetoymaker.org/**boat**/

This link has a bunch of information and VERY detailed instructions including some of the science behind Putt Putt boats: http://www.sciencetoymaker.org/boat/howBoatWorksl.html

2. This website shows how to make Putt Putt boats without epoxy. https://www.youtube.com/watch?v=0ki9Kta8g14

3. This website explains the instructions in Spanish

https://www.youtube.com/watch?v=nBLLAWKZ-6Q

4. This last website shows a Putt Putt racing track https://www.youtube.com/watch?v=sFRi_As96iU

Student Pages:

Putt Putt Boats

1. Draw a picture of the Putt Putt prototype. Describe the boat's design.

2. List possible changes that you could make to the Putt Putt Prototype to improve its performance:

3. Describe the change that your group will make to the prototype design. Be as specific as possible.

4. Review the blueprints for the prototype. Draw your design and obtain approval from your teacher.

   Teacher signature:

5. After building your Putt Putt boat, check to see that the boat floats. Build a sail for your boat. Get a hand fan from your teacher and place it on your boat where the candle will go. "*Imagine you sailing on a boat where there was no wind. You have a large fan on the boat. Which way do you face the fan, toward the sail or away from the sail? Why?"*
   Write your hypothesis:

   Fill in the observation table.

Procedure	**Results**
Fan placed on the boat toward the sail	
Fan placed on the boat way from the sail	
Fan kept in hand but faced toward the sail	

   Explanation of results:

Boat Analysis

Include the following for your portfolio entry:

1. Cover sheet

2. Preliminary Plan: Large, neat, proportionate. Use a ruler and a sharp pencil. Label parts. Include measurements. Explain how your plan differs from the prototype. SUBMIT PRIOR TO BUILD.

3. Final Drawing: Large, neat, to scale. Use a ruler and a sharp pencil. Label parts. Include measurements. Discuss changes and reason for changes from preliminary plan.

4. Data and Work calculations: determine the work and show data used for calculations.

5. Discussion--use the following guide questions to discuss your boat in a paragraph format.

a) Explain energy transfer. Apply your explanation to the boat.

b) Define heat engines. Apply your definition to your boat.

c) Use your data and work calculation to accept or dismiss the design modification

Improvements--how could you improve your boat and why would those improvements be advantageous? Be specific and include drawings.

Grading Rubric

4	*Discussion questions* thoroughly and clearly explain energy transfers and heat engines with concepts applied to boat correctly. *Data and work calculations* are thoroughly and clearly explained and demonstrated. *Improvements* are specific and show rationale using science. *Preliminary and final drawings* are neat, labeled, large, scaled, and proportionate using a ruler. Overall *presentation* is neat, typed, and includes a coversheet.
3	*Discussion questions* explain energy transfers and heat engines with some applications to boat. *Data and work calculations* are explained and demonstrated. *Improvements* include scientific reasons. *Preliminary and final drawings* are neat, labeled, and proportionate using a ruler. Overall *presentation* is neat and includes a coversheet.
2	*Discussion questions* answered, some *data and work calculations* are attempted, at least one *improvement* and reason, *Preliminary and final drawings* are completed, presentation is neat
1	Report includes *discussion questions*, one *improvement, drawings* and some *data*

Connections to CCSS:
Finding Evidence to Support Arguments

Engage Putt Putt Race

1. Race the prototype boat and one of the student boats. Use the race to discuss what model "is better" and the evidence for that decision.

Explore

2. Students compare their model with the prototype. Students design a poster that explains their model: what was the modification; effect of modification on performance; explanation of success or failure of modification on performance.
3. Students complete a gallery walk of posters and Putt putt boats to fill in a T-chart with modification, evidence, and reasoning

Explain

4. Students make a claim about the design of the models. They can choose either their own model or the prototype based on their claim. Students explain how does this model support their claim and which model supports the claim better and why. They collect evidence to defend their model. The thinking map will scaffold their argument and allow students to outline and organize their explanation.

Elaborate

5. Students learn how to write an argument defining their design claim; ways/evidence that model supports this claim as well as qualifications-- ways the model does not support the design claim; in conclusion they explain how to test these claims.

Evaluate

6. Students peer critique the other group's work: what was designed well; poorly; how they could have designed better.
7. Students write a self-reflection. Students learn how to peer critique and how to use their peer critiques to understand their own model better.

Scientific Models and Arguments

I. Argument/ Claim: *Make a claim about the engineering design of the two boats. (Think about what you changed in the prototype). Choose the boat that best represents this claim.*

II. Evidence to support your claim:

Evidence

How it supports claim

Claim

III. Qualification: *What are some problems with this boat design?*

Limitation

Why it does not support claim

Claim

IV. Counterargument: *Examine the second model. How is this model an effective design? Compare it to the first model. How is the first model a better design?*

Claim

Evidence

Counterargument

V. Conclusion: *How could you test these models? How would this test help prove or disprove your claim?*

Essay

Write an essay using your prewriting chart to structure your writing. Use your claim as a thesis. Then use your multi-flow maps to support your claim. Be sure to include a counterargument. In your conclusion, explain how to test your model. Give details as to how the test can be used to support or refute your claim.

Writing Rubric

4	Complete and detailed prewriting chart, evidence and limitations explained and counter-argued, method to test model demonstrates clear understanding of claim. Essay has a defined structure with clear thesis statement, supporting paragraphs that discuss both models, evidence and limitations, and a strong non-repetitive conclusion that explains how to test model. There are limited spelling and grammatical errors.
3	Complete prewriting chart citing evidence from both of both models, and method to test model, some research of additional information, and application of teaching experience. Essay shows structure with thesis statement, supporting paragraphs, and a conclusion. Spelling and grammar are mostly correct.
2	Prewriting charts have argument and evidence from one model. Student states method for testing models. Essay has two or three of the following components: thesis statement, supporting paragraphs, and a conclusion.
1	Prewriting charts are partially completed with a claim and some evidence. Essay is written about the models.

Teacher Pages:
Sample Work-Kinetic Energy Theorem (putt putt analysis)

Work = ΔKE

$Work=12mvf2-12mvi2$

$Vavg=\Delta X\Delta t$

Assuming the boat reaches max velocity quickly. Final velocity = average velocity after initial acceleration.

$Vavg=Vfinal$

$Work=12mvavg2-12mvi2$; $Vi=0$

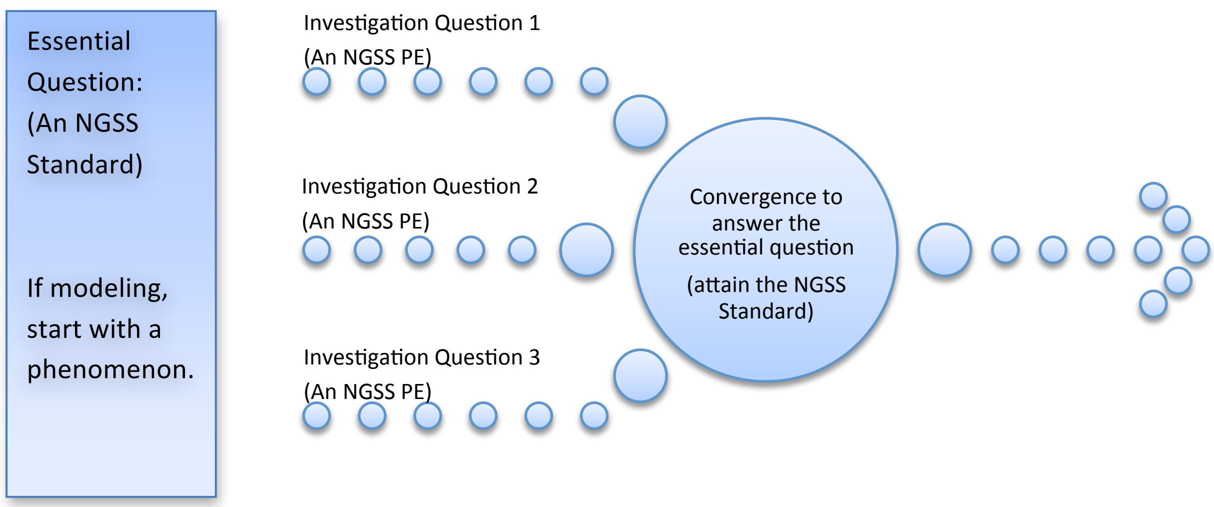
Example of blueprints boat and Engine

Current CA Science Standards on Heat

3. Energy cannot be created or destroyed although in many processes energy is transferred to the environment as heat. As a basis for understanding this concept:

a. *Students know heat flow and work are two forms of energy transfer between systems.*
b. *Students know that the work done by a heat engine that is working in a cycle is the difference between the heat flow into the engine at high temperature and the heat flow out at a lower temperature (first law of thermodynamics) and that this is an example of the law of conservation of energy.*
c. *Students know the internal energy of an object includes the energy of random motion of the object's atoms and molecules, often referred to as thermal energy. The greater the temperature of the object, the greater the energy of motion of the atoms and molecules that make up the object.*
d. *Students know that most processes tend to decrease the order of a system over time and that energy levels are eventually distributed uniformly.*
e. *Students know that entropy is a quantity that measures the order or disorder of a system and that this quantity is larger for a more disordered system. (needs additional lessons)*

Understanding by Design



Within the unit, two ideals for Investigation Questions…

5E – and/or- **POE (CER)**