Course: Physical Science

I. **Grade Level/Unit Number:** **9-12 Unit 2**

II: **Unit Title:** **Energy**

III. **Unit Length:** **15 days (based on 90 minutes per day)**

IV. **Major Unit Goal/ Learning Outcomes:**

Transfer of Energy

- Calculate kinetic energy: $KE = \frac{1}{2}mv^2$
- Predict change in kinetic energy when mass or velocity change in $KE = \frac{1}{2}mv^2$.
- Calculate gravitational potential energy: $PE = mgh = F_g h$
- Predict change in gravitational potential energy when mass or height change in $PE = mgh = F_g h$.
- Analyze and investigate the relationship among kinetic, potential, and other forms of energy to see that total energy is conserved.
- Analyze and investigate different forms of potential energy: gravitational, chemical, electrical, elastic and nuclear.
- Use conceptual analysis to investigate the characteristics of a substance-such as mass, specific heat capacity, and temperature-that affect its ability to absorb or release thermal energy. *(Students should only solve math problems with* $q = mC_p \Delta T$ *as an enrichment topic.)*

Thermodynamics

- Differentiate among conduction, convection, and radiation energy transfers.
- Investigate the interaction between substances of different temperatures.
- Explain why no machine can be 100% efficient.
- Differentiate between heat and temperature.

Waves

- Identify the basic characteristics of a transverse wave: trough, crest, amplitude, and wavelength.
- Identify the basic characteristics of a longitudinal (compressional) wave: amplitude, rarefaction, and compression.
- Recognize the relationship between period and frequency. Conceptual understanding of inverse relationship.
- Use the relationships among velocity, frequency, and wavelength to solve wave problems: $v_w = f\lambda$

- Explore the differences between compressional and transverse waves.
- Understand that a wave's energy is related to its amplitude.
- Investigate how the velocity of a sound wave varies through different mediums.
- Interpret the electromagnetic spectrum (use reference tables) to determine relationships among energy, frequency, and wavelength.
- Relate wave energies to possible health risks.

Radioactivity

- Compare and contrast the characteristics of alpha and beta particles and gamma rays.
- Compare and contrast the alpha, beta, and gamma decay processes.
- Compare and contrast the processes of fission and fusion.
- Describe various means of dealing with nuclear waste over time.

V. Content Objectives Included (with RBT Tabs):

Objective Number	Objective	RBT tag
3.01	Investigate and analyze storage of energy: • Kinetic energy • Potential energies: gravitational, chemical, electrical, elastic, nuclear • Thermal energy.	A1 A3 B4 C2
3.03	Investigate and analyze transfer of energy by heating: • Thermal energy flows from a higher to a lower temperature. • Energy will not spontaneously flow from a lower temperature to a higher temperature. • It is impossible to build a machine that does nothing but convert thermal energy into useful work.	A1 A3 B4 C2
3.04	Investigate and analyze the transfer of energy by waves: • General characteristics of waves: amplitude, frequency, period, wavelength, and velocity of propagation. • Mechanical waves. • Sound waves. • Electromagnetic waves (radiation).	A1 A2 A3 B4 C2

6.06	Describe and explain radioactivity and its practical application as an alternative energy source: • Alpha, beta, and gamma decay. • Fission. • Fusion. • Nuclear waste.	A1 A2 A3 B2 C2

VI. English Language Development Objectives (ELD) Included:
NC English Language Proficiency (ELP) Standard 4 (2008) for Limited English Proficiency Students (LEP)- English Language learners communicate information, ideas, and concepts necessary for academic success in the content area of science.

Suggestions for modified instruction and scaffolding for LEP students and/or students who need additional support are embedded in the unit plan and/or are added at the end of the corresponding section of the lessons. The amount of scaffolding needed will depend on the level of English proficiency of each LEP student. Therefore, novice level students will need more support with the language needed to understand and demonstrate the acquisition of concepts than intermediate or advanced students.

VII. Materials/Equipment Needed:

Activity	Materials
Newton's Cradle	A Newton Cradle
Pendulum Activity	String (long enough to tie between two table legs) Two or three metal washers
Tennis, Anyone?	Tennis ball Basketball Metric tape Timers
Poster Construction	Construction paper Markers (crayons/ colored pencils) Magazines for pictures Scissors Tape Rulers
Demonstration Thermal Energy	Goggles 2 Styrofoam cups (2 per group) Hot plate

<table>
<tr><td></td><td>Beaker
Small metal object
2 thermometers
Graduated cylinder
Cold water
Calculators</td></tr>
<tr><td>Transfer of Energy Lab</td><td>2 Styrofoam cups
Cold water
Warm water
2 thermometers
2 graduated cylinders</td></tr>
<tr><td>Thermal Energy Research</td><td>Resources or media center
Poster paper
Markers</td></tr>
<tr><td>Disposal of Nuclear Waste Lab</td><td><u>Per group</u>
4 NaOH pellets
4 jars with lids filled ¾ with water
Phenolphthalein solution
Plastic wrap
Twist tie
Aluminum foil
Modeling clay
Tweezers
<u>Per person</u>
Goggles
Latex gloves</td></tr>
<tr><td>Skittles Lab</td><td>Skittles (You may also use M&Ms or pennies.)
Cup
Paper towels</td></tr>
<tr><td>Playing with Play Dough</td><td>Play dough
Dominoes (if time permits)</td></tr>
<tr><td>Fission and Fusion</td><td>Video on fission and fusion and nuclear waste disposal</td></tr>
<tr><td>Who's Waving at You?</td><td>Shallow pan
Water
Rocks
Pebbles
Meter stick
Jump rope (or similar length of thin rope and thick rope)</td></tr>
<tr><td>It's A Slinky!</td><td>Slinky</td></tr>
</table>

	Meter sticks Timers Tape **Optional:** metal coil long enough to stretch across the room
What's That Sound?	Clear plastic container Water Tuning forks Resonance boxes
Your Favorite Song	Glass bottles Water Pencil
Doppler Effect Demonstration	Doppler Ball or Sound Emitting device Nerf ball Tape
How Bright is Your Light?	Flashlight Sheet of heavy (card stock) paper Scissors Ruler Mirrors
Mirror Activity	Plane, convex, & concave mirrors
Refraction Demonstration	Pencil Glass Water Goggles
What an Image!	Concave and convex lenses
Over the Rainbow	Prism (Light source- if not a sunny day)
Electromagnetic Waves	large block graph paper
Demonstration of Critical Angle and Total Internal Reflection	Laser (point light source) Block of glass Larger lenses

VIII. Detailed Content Description:
Please see the detailed content description for each objective in the Physical Science Support document. The link to this downloadable document is in the Physical Science Standard Course of Study at:

http://www.ncpublicschools.org/curriculum/science/scos/2004/26physical

IX. Unit Notes:

Overview of Unit Two:
This unit includes daily lessons and activities for the major topics of energy. Specific topics covered are: potential energy, kinetic energy, thermal energy, transfer of energy, general characteristics of waves, mechanical waves, sound waves, electromagnetic radiation, fission, fusion, nuclear waste, and alpha, beta and gamma decay. Specifically, students should be able to:

Transfer of energy

- Calculate kinetic energy: $KE = \frac{1}{2}mv^2$
- Predict change in kinetic energy when mass or velocity change in $KE = \frac{1}{2}mv^2$.
- Calculate gravitational potential energy: $PE = mgh = F_g h$
- Predict change in gravitational potential energy when mass or height change in $PE = mgh = F_g h$.
- Analyze and investigate the relationship among kinetic, potential, and other forms of energy to see that total energy is conserved.
- Analyze and investigate different forms of potential energy: gravitational, chemical, electrical, elastic and nuclear.
- Use conceptual analysis to investigate the characteristics of a substance-such as mass, specific heat capacity, and temperature-that affect its ability to absorb or release thermal energy. *(Students should only solve math problems with* $q = mC_p\Delta T$ *as an enrichment topic.)*

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Waves

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- Recognize the relationship between period and frequency. Conceptual understanding of inverse relationship.
- Use the relationships among velocity, frequency, and wavelength to solve wave problems: $v_w = f\lambda$
- Explore the differences between compressional and transverse waves.

- Understand that a wave's energy is related to its amplitude.
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- Relate wave energies to possible health risks.

Radioactivity

- Compare and contrast the characteristics of alpha and beta particles and gamma rays.
- Compare and contrast the alpha, beta, and gamma decay processes.
- Compare and contrast the processes of fission and fusion.
- Describe various means of dealing with nuclear waste over time.

In each unit, Goal 1 objectives which relate to the process of scientific investigation are included. In each of the units, students will be practicing the processes of science: observing, hypothesizing, collecting data, analyzing, and concluding. The Goal 1 Objectives are as follows:

1.01	Identify questions and problems that can be answered through scientific investigations.	B3
1.02	Design and conduct scientific investigations to answer questions about the physical world. • Create testable hypotheses. • Identify variables. • Use a control or comparison group when appropriate. • Select and use appropriate measurement tools. • Collect and record data. • Organize data into charts and graphs. • Analyze and interpret data. • Communicate findings.	RBT tag B6,A5
1.03	Formulate and revise scientific explanations and models using logic and evidence to: • Explain observations. • Make inferences and predictions. • Explain the relationship between evidence and explanation.	C5
1.04	Apply safety procedures in the laboratory and in field studies: • Recognize and avoid potential hazards. • Safely manipulate materials and equipment needed for scientific investigations.	C3
1.05	Analyze reports of scientific investigations of physical phenomena from an informed scientifically literate viewpoint including considerations of: • Appropriate sample. • Adequacy of experimental controls.	A4

	• Replication of findings. • Alternative interpretations of the data.	

Goal 1 objectives are an *integral* part of *each of the other goals*. In order to measure and investigate scientific phenomena, students must be given the opportunity to design and conduct their own investigations in a safe laboratory. Investigations may also be conducted using simulations. Specifically, students should be able to do the following:

- Develop questions for investigation from a given topic or problem.
- Distinguish and appropriately graph dependent and independent variables.
- Report and share investigation results with others.
- Discuss the best method of graphing/presenting particular data.
- Use technology resources such as graphing calculators and computers to analyze data.
- Use questions and models to determine the relationships between variables in investigations.
- Read and interpret Material Safety Data Sheets (MSDS).
- Read and analyze newspaper, journal, and on-line articles.

The unit plan below contains the activities that are suggested to meet the Standard Course of Study (SCOS) Goals for Unit Two. The guide includes activities, teacher notes on how to implement the activities, and resources relating to the activities which include language objectives for ESL (English as a Second Language) students. Teachers should also consult the Department of Public Instruction website for English as a Second Language at: http://www.ncpublicschools.org/curriculum/esl/ to find additional resources. If a teacher follows this curriculum (s)he will have addressed the goals and objectives of the SCOS. However, teachers may want to substitute other activities that teach the same concept. Teachers should also provide guided and independent practice from the textbook or other resource.

<u>Reference Tables:</u>
The North Carolina Physical Science Reference Tables were developed to provide essential information that should be used on a regular basis by students, therefore eliminating the need for memorization. It is suggested that a copy be provided to each student on the first day of instruction. A copy of the reference tables can be downloaded at the following URL:

http://www.ncpublicschools.org/docs/accountability/testing/eoc/PhysicalScience/physicalsciencereferencetable.pdf

<u>Essential Questions:</u>

Essential questions for this unit are included with the activities and embedded throughout the unit. Essential questions are those questions that lead to student understanding. Students should be able to answer these questions at the end of an activity. Teachers are advised to put these questions up in a prominent place in the classroom. The questions can be answered in a journal format as a closure.

Safety: Students should wear chemical splash goggles during any lab activity involving chemicals. This includes household substances. **It is extremely important for the safety and success of your students that you do ALL activities and labs prior to assigning them to students.** At the beginning of each lab, the teacher should address any specific safety concerns relating to the activity.

Modified Activities for LEP Students:
Those activities marked with a _⚐ have a modified version or notes designed to assist teachers in supporting students who are English language learners. Teachers should also consult the Department of Public Instruction website for English as a Second Language at: http://www.ncpublicschools.org/curriculum/esl/ to find additional resources.

Computer Based Activities:
Several of the recommended activities are computer based and require students to visit various internet sites and view animations of various biological processes. These animations require various players and plug-ins which may or may not already be installed on your computers. Additionally some districts have firewalls that block downloading these types of files. Before assigning these activities to students it is essential for the teacher to try them on the computers that the students will use and to consult with the technology or media specialist if there are issues. These animations also have sound. Teachers may wish to provide headphones if possible.

Suggested Websites:
Below is a list of suggested websites for various topics discussed in Unit Two.

Energy Form and Function – web lesson
http://www.sasinschool.com/ProductEntrance/Launch/launch.jsp?unit=449

Energy Lessons – list of internet sites
http://www.sasinschool.com/ProductEntrance/Launch/launch.jsp?unit=671

Kinetic (KE) and Potential Energy (PE)- Internet activity
http://www.sasinschool.com/ProductEntrance/Launch/launch.jsp?unit=1193

http://www.physicsclassroom.com/Class/energy/U5L1a.html

Simulations (in general)
http://phet.colorado.edu/new/simulations/

X. Global Content: Aligned with 21st Skills:

One of the goals of the unit plans is to provide strategies that will enable educators to develop the 21st Century skills for their students. As much as students need to master the NCSOS goals and objectives, they need to master the skills that develop problem solving strategies, as well as the creativity and innovative thinking skills that have become critical in today's increasingly interconnected workforce and society. The Partnership for 21st Century Skills website is provided below for more information about the skills and resources related to the 21st Century classroom.

http://www.21stcenturyskills.org/index.php?option=com_content&task=view&id=27&Itemid=120

NC SCS Physical Science	21st Century Skills	Activity
	Communication Skills	
Goal 1	Conveying thought or opinions effectively	• Pendulum Activity • Tennis, Anyone? • Poster construction • Transfer of Energy Lab • Thermal energy Transfer • Thermal Energy Research • Disposal of Nuclear Waste Lab • Skittles Lab • Who's Waving at You? • It's A Slinky!
Goal 1	When presenting information, distinguishing between relevant and irrelevant information	• Pendulum Activity • Poster construction • Transfer of Energy Lab • Thermal energy Transfer • Thermal Energy Research • Skittles Lab • Who's Waving at You? • It's A Slinky!
Goals 1-6	Explaining a concept to others	• Pendulum Activity • Poster construction • Transfer of Energy Lab • Thermal Energy Transfer • Thermal Energy Research • It's A Slinky!
	Interviewing others or being interviewed	
	Computer Knowledge	

Goals 1-6, esp. Goal 1	Using word-processing and database programs	• Thermal Energy Transfer • Thermal Energy Research
Goals 1-6, esp. Goal 1	Developing visual aides for presentations	• Transfer of Energy Lab • Poster construction • Thermal Energy Transfer • Thermal Energy Research
Goal 1	Using a computer for communication	• Thermal Energy Transfer • Thermal Energy Research
	Learning new software programs	
	Employability Skills	
Goals 1-6	Assuming responsibility for own learning	All activities
Goals 1-6, esp. Goal 1, 2.02, Goal 3, Goal 4, 5.03, 6.02, 6.05	Persisting until job is completed	All activities
Goals 1-6	Working independently	• Energy practice problems • Poster construction • Thermal energy Transfer • Thermal Energy Research • Disposal of Nuclear Waste Lab • Wave Velocity Practice Problems • How Bright is Your Light? • Mirror, Mirror, on the Wall • Your favorite Song
	Developing career interest/goals	• Thermal Energy Research
Goal 1	Responding to criticism or questions	• Transfer of Energy Lab • Thermal Energy Research
	Information-retrieval Skills	
Goal 1	Searching for information via the computer	• Thermal energy Transfer • Thermal Energy Research
Goal 1	Searching for print information	• Poster construction • Thermal energy Transfer • Thermal Energy Research
	Searching for information using community members	
	Language Skills - Reading	
Goal 1-6	Following written directions	Most of the activities can be presented as opportunities for students to follow written directions. The teacher will have to work with most students to develop this skill over time. The following activities are well suited to developing skills in following directions:

		• Pendulum Activity • Energy practice problems • Poster construction • Transfer of Energy Lab • Thermal Energy Transfer • Thermal Energy Research • Disposal of Nuclear Waste Lab • Skittles Lab • Wave Velocity Practice Problems • Who's Waving at You? • How Bright is Your Light? • It's A Slinky!
Goals 1-6	Identifying cause and effect relationships	• Pendulum Activity • Tennis, Anyone? • Poster construction • Transfer of Energy Lab • Thermal energy Transfer • Thermal Energy Research • Disposal of Nuclear Waste Lab • Skittles Lab • Who's Waving at You? • How Bright is Your Light? • It's A Slinky! • Mirror, Mirror, on the Wall • Your favorite Song
Goals 1-6	Summarizing main points after reading	• Poster construction • Transfer of Energy Lab • Thermal Energy Transfer • Thermal Energy Research
Goal 1	Locating and choosing appropriate reference materials	• Poster construction • Transfer of Energy Lab • Thermal Energy Transfer • Thermal Energy Research
Goals 1-6	Reading for personal learning	• Poster construction • Thermal Energy Transfer • Thermal Energy Research
	Language Skill - Writing	
Goals 1-6	Using language accurately	All the activities
Goals 1-6	Organizing and relating ideas when writing	All the activities
Goals 1-6, esp. Goal 1	Proofing and Editing	• Pendulum Activity • Poster construction • Transfer of Energy Lab • Thermal energy Transfer • Thermal Energy Research

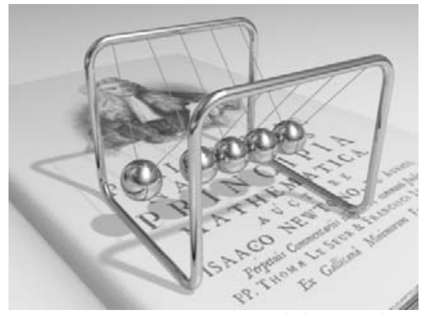
Goals 1-6, esp. Goal 1	Synthesizing information from several sources	• Poster construction • Thermal energy Transfer • Thermal Energy Research
Goal 1	Documenting sources	• Thermal Energy Transfer • Thermal Energy Research
	Developing an outline	
1.04	Writing to persuade or justify a position	• Transfer of Energy Lab • Thermal Energy Research
	Creating memos, letters, other forms of correspondence	• Transfer of Energy Lab • Thermal Energy Transfer
	Teamwork	
Goal 1, 2.02, Goal 3, Goal 4, 5.03, 6.02, 6.05	Taking initiative	• Pendulum Activity • Tennis, Anyone? • Energy practice problems • Poster construction • Transfer of Energy Lab • Thermal energy Transfer • Disposal of Nuclear Waste Lab • Skittles Lab • Wave Velocity Practice Problems • Who's Waving at You? • How Bright is Your Light? • It's A Slinky! • Mirror, Mirror, on the Wall • Your favorite Song
Goal 1, 2.02, Goal 3, Goal 4, 5.03, 6.02, 6.05	Working on a team	Most of the activities are designed to be done and discussed in teams. The following activities are well suited to developing team interdependence skills: • Pendulum Activity • Transfer of Energy Lab • Disposal of Nuclear Waste Lab • Skittles Lab • It's A Slinky! • Who's Waving at You? •
	Thinking/Problem-Solving Skills	
Goals 1-6	Identifying key problems or questions	• Pendulum Activity • Tennis, Anyone? • Energy practice problems • Poster construction • Transfer of Energy Lab • Thermal energy Transfer

		- Disposal of Nuclear Waste Lab - Skittles Lab - It's A Slinky! - Who's Waving at You? - How Bright is Your Light? - Mirror, Mirror, on the Wall - Your favorite Song
Goals 1-6	Evaluating results	- Pendulum Activity - Tennis, Anyone? - Energy practice problems - Poster construction - Transfer of Energy Lab - Thermal energy Transfer - Thermal Energy Research - Disposal of Nuclear Waste Lab - Skittles Lab - It's A Slinky! - Who's Waving at You? - How Bright is Your Light? - Mirror, Mirror, on the Wall - Your favorite Song
Goals 1-4, 5.02, 5.03, Goal 6	Developing strategies to address problems	- Pendulum Activity - Energy practice problems - Poster construction - Transfer of Energy Lab - Thermal energy Transfer - Thermal Energy Research - Disposal of Nuclear Waste Lab - Who's Waving at You? - It's A Slinky! - How Bright is Your Light?
Goal 1, 2.02, Goal 3, Goal 4, 5.03, 6.02, 6.05	Developing an action plan or timeline	- Pendulum Activity - Poster construction - Transfer of Energy Lab - Thermal energy Transfer - Thermal Energy Research - It's A Slinky!

Day 1

Language (ELP) Objectives for Limited English Proficient (LEP) Students:
- *Students will write a sentence to explain energy.*
- *Students will write a lab report and share their findings with the class.*

ENGAGE:



Newton's Cradle

Most find this (Newton's Cradle) very intriguing so it is easy to use as a lead-in to the concepts of potential energy, kinetic energy, and the conversion of one to the other.

Have Newton's cradle on your desk as students enter. Allow students to question what it is and how it works.

EXPLORE:

Pendulum Activity

Give each student a length of string and have them construct a double pendulum. The string should be long enough to tie between two table legs (as a support string across) and to hang two or three metal washers the same length down from the string, the same distance apart. Have students design an experiment to investigate how the motion of one washer affects the motion of the other(s).

> LEP Modifications:
> - Bring in examples of pendulums.
> - Demonstrate/Model to the class to give them a visual. Build the pendulum together.

By this point, students should be able to write lab reports which include: statement of purpose, hypothesis, design a test, perform a test, collection of data /making observations, and analysis of data. Have students do this. Allow flexibility, but give guidance as needed.

After students finish, have the different groups share what they tested, their results, and their conclusions.
To assess student lab work, you can use a yes/no checklist, a checklist with rating scale, or rubric.

Day 2:

> *Language (ELP) Objectives for Limited English Proficient (LEP) Students:*
> *- create and present posters about energy conversions.*

Discuss other examples of energy conversions such as a boulder falling from a cliff, a spring bouncing back and forth, etc. Include the concept of elastic potential energy here. Use this to lead into guided practice for the calculation of potential energy using the formula PE=mgh and actually calculate the values from the tests above.
You can also use this to initiate discussion of conservation of energy where KE=PE. Then use the kinetic energy formula, $KE=1/2m(v)^2$ to calculate the velocities of the objects as they hit the ground. Be sure to talk about the use of the joule for energy as well as for work.

LEP Modifications:
- *Show picture or use LCD projector to show a boulder falling from a cliff.*
- *Explain the definition of a boulder.*
- *Have students copy the formulas. Work problems together. Do not forget units.*

Tennis, Anyone?

Safety: objects can be thrown, stairs, height

Materials: tennis ball, basketball, metric tape, timers

Go to the football stadium or auditorium. (Be sure to check for availability). Ask for two volunteers and give each one a tennis ball. Have one student go to the top and another half way up. Measure the height of each. Give a countdown and have the students drop the tennis balls at the same time while the class observes whether they are moving at the same speed as they hit the ground. This can be calculated using the formula $v_f = 2d / t$. ($v_i = 0$)

LEP Modifications:
- *Take out a flip chart and have student volunteers' work out the problems.*

Ask the class if they think the results will change when using different masses. Give one of the students a basketball while the other keeps the tennis ball. Have them both go to the top. Again give a countdown and have the students drop the balls from the same height at the same time while the class observes to detect any changes. Speed can be calculated using the formula $v_f = 2d / t$. ($v_i = 0$)

Measure the masses of the objects used in steps 1 and 2. Guide the students to discuss the various factors involved (mass, height, and gravitational acceleration) and whether these factors changed from one "test" to the next. The students should come to the conclusion that mass and height make a difference while the gravitational acceleration stays the same. If they do not realize that the force is changing, you can calculate this using F=mg.

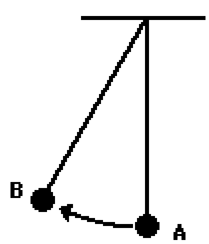
EXPLAIN:
Have students to complete the following problems and explain their answers to each other.

LEP Modifications: • *Write the formulas on the board. Have students take turns explaining what each variable in the formula means and what units it uses.* • *Complete some sample problems together.*

ENERGY PRACTICE PROBLEMS
Show all work.

1. Does an object have energy when it is not moving? Explain.

Use the following information and the diagram for questions 2 & 3.



A child is swinging on a swing. At the top of her swing (point B), she is 1.0m above rest position (point A). As she swings down, her speed increases only to decrease again as she moves upward.

2. At what point in her "swing" is her potential energy the greatest? Explain.

3. At what point in her swing is her kinetic energy the greatest? Explain.

4. A boy rides his bike at a speed of 5m/s. If his mass is 60kg, what is his kinetic energy?
5. An object has a mass of 50kg. At what height is the object if it has a potential energy of 250J?

EVALUATION:

Have students make a poster to illustrate what they have learned about kinetic and potential energies, including gravitational and elastic potential energies.
You can set your own criteria, but for example, you might ask them to include the following: definitions of each, pictures or diagrams to show examples of applications, as well as a description of why the picture does illustrate the energy type.
Be sure to point out what resources you will allow your students to use.
(Magazines may be obtained from the media center when they discard old ones.)

You can use a checklist assessment, rating scale assessment, or rubric.
Suggested for inclusion in the assessment are content (accuracy of information, completeness of information) and mechanics (neatness, attractiveness, grammar).

You may want to prepare an alternative or extension assignment as an "extra grade" for those who work more quickly than others. This could be a creative writing assignment in which the student writes a short story describing a ride at an amusement park in terms of what they have learned about motion and energy, especially as it relates to energy conversion between potential and kinetic energies. They can then share these at the end of the period or finish for homework and share with the class tomorrow.
If no one mentions that the most potential energy should be attained at the beginning of the roller coaster ride, be sure to talk about this.

Another aspect to include is how friction affects the motion/ energy. Talk about the heat generated through friction and use this as well as conservation of energy (First Law of Thermodynamics) as a lead-in to thermal energy.

Poster Construction

The poster activity is used to reinforce what students have learned.

Materials: construction paper, markers (crayons/ colored pencils), magazines for pictures, scissors, tape, rulers

Safety: Be careful with sharp scissors.

LEP Modifications:
- *Have students present their posters to the class.*
- *Each student must present some part of the poster.*

Day 3- Thermal Energy 

⚐Language (ELP) Objectives for Limited English Proficient (LEP) Students:

- *Students will orally explain thermal energy and heat transfer to their classmates.*
- *Students will write a paragraph explaining thermal energy and heat transfer.*

ENGAGE:

Hot Chocolate Anyone? It was a very cold night and the football game was just beginning when your little sister and her friend complain that their hands are cold. You decide to get them each a cup of hot chocolate. After a few minutes they notice that their hands are much warmer. When you buy a cup of hot chocolate at a football game on a cold night and keep it in your hands, does the cold from your hands cool the cup, or does the heat from the cup warm your hands?

- (Students might already know the answer, but it serves the purpose of "hook.")
- You could, perhaps, have hot chocolate for the students. ***(Caution: Be aware of food allergies of students.)***

Demonstration- Thermal Energy

Demonstration- Thermal Energy

To demonstrate the idea of heat transfer, heat a metal object in a water bath. While the object is heating, prepare a cup of cold water by measuring it in a graduated cylinder and then pouring it in a Styrofoam cup; then put a thermometer in the water. Have a student volunteer record the volume of water and its temperature on the board. Put the metal object into the cup of water. Have the student record the temperature of the water every 30s until it stops changing. Have the class graph the temperature changes vs. time. This allows the students to "see" that the water gains thermal energy. This is even more effective if you have access to either computer based labs or LabPros and probes so the students can see the graph in real time. (You can find labs through Vernier or The Science House at NCSU.

⚐LEP Modifications:

- *Provide students with graph paper and have them plot the date.*
- *Plot the first point together using an overhead projector.*

This demonstration reinforces heat transfer and introduces the concept of specific heat capacity. (A demonstration of specific heat is to put a plastic knife and a metal knife over a beaker of hot water. Put equal amounts of butter on each knife at the same time. The butter on the metal knife melts first because it has a lower specific heat capacity.) Have students read the text section related to thermal energy and heat transfer. Have them write a paragraph describing the two and then explain to their partners.

⚐LEP Modifications:

- *Have students work in pairs and read to each other.*
- *Have the pairs write a paragraph together.*
- *Have pairs exchange paragraph, use this as a peer review.*

For advanced or honors classes, you might include calculation of thermal energy using the formula $Q = mC \Delta T$. (Remember $D_{H2O} = m/V$, so for water you can use m=V.) Discuss the symbols and their meanings.

Materials: goggles, 2 Styrofoam cups (2 per group), hot plate, beaker, small metal object, 2 thermometers, graduated cylinder, cold water (you can have a pitcher of ice water on hand), calculators

Safety: Goggles and apron, closed shoes due to glass and **hot water (not hot enough to burn)**.

LEP Modifications:

- *Work some sample problems on the board.*
- *Have the students turn to their neighbor and explain how to complete the first practice problem.*
- *Have students finish the problems on their own.*

Thermal Energy Practice Problems

Show all work.

1. Gold has a specific heat of 0.130 J/g°C. Calculate the temperature change of the gold if 250J of heat are added to 85g of gold?

2. The temperature of 475g of water is cooled from 90°C to 25°C. If the specific heat of water is 4.18 J/g°C, how much heat has been removed?

3. An object has a mass of 50g. It gains 1,200J of heat. If the temperature of the object increases 40°C, what is the specific heat of the substance?

4. Two pieces of metal each have the same mass of 5.0g. The specific heat of one is 0.234 J/g°C and the specific heat of the other is 0.130 J/g°C. Which requires more heat to raise its temperature 60°C? Justify your answer.

Transfer of Energy Lab

Materials per group: 2 Styrofoam cups, cold water, warm water (If you don't have warm water, heat some in a beaker on a hot plate and put it in a thermos. **Make sure it is not**

hot enough to burn anyone.), 2 thermometers, 2 graduated cylinders

Safety: goggles, aprons, closed shoes, **warm water**, glass

Have students design a lab to show that two liquids at different temperatures will come to the same temperature. Tell them that they will have access to the following materials: 2 Styrofoam cups, cold water, warm water (If you don't have warm water, heat some in a beaker on a hot plate and put it in a thermos. **Make sure it is not hot enough to burn anyone**.), 2 thermometers, 2 graduated cylinders.

Due to safety concerns in this activity, be sure to have them write a plan to include the purpose, materials, hypothesis, and procedure which you check before they begin to assure that what they are doing is safe.
Students will need to prepare a data table for data collection and then use the data to construct and plot a graph showing the results. They will then be able to analyze the results.

For honors classes or as an extension you can also have them calculate heat lost and heat gained.

This process will most likely require the remainder of the class period as students discuss and refine their procedure. This will also give you time to check their procedures. The actual lab may need to wait until the next day.

LEP Modifications:

- *Designing your own lab takes time and patience for both teacher and students.*
- *Walk around and give advice and positive reinforcement.*
- *Give several examples of data collection forms.*
- *Provide graph paper and help students label the axis.*

LEP Modifications:

- *Have students present their lab report to the class.*
- *Make sure students use the following words or phrases in their presentations.*
    - *Heat loss, heat gained, transfer of energy by heating, energy flows from a higher temperature to a lower temperature.*

Day 5

Language (ELP) Objectives for Limited English Proficient (LEP) Students:
- Students will write and use vocabulary to prepare a booklet about the transfer of heat energy.

Thermal Energy Transfer

Materials: construction paper (or colored paper), rulers, scissors, stapler, markers (colored pencils or crayons)

Safety: Be careful with scissors.

Discuss the previous thermal energy labs/demonstrations and talk about the ways they have seen thermal energy transferred (by solids, by liquids).
Have students read the section on heat and thermal energy transfer in the text, or in other sources you may have, and let students prepare a booklet about what they have learned. The following should be included: thermal energy and temperature (with description and measure – both instrument and unit), 3 types of heat transfer, definitions/explanations of each, illustrations or examples of each (with diagram), Somewhere along the way make time to talk about land breezes and sea breezes incorporating the differences in specific heat between sand and water as well as convection currents. (Demonstrate convection currents by adding drops of food coloring to warm and cold water. This is more dramatic if you fill one bottle with cold water and fill another with warm water, put drops of food coloring in the warm bottle, and then invert the bottle of cold water onto the top of the bottle with hot water. The colored, warm water will rise into the cold water.)
You can also talk about cooking for relevance. For example, why food cooks faster in a glass baking dish than a metal one, or why it takes longer to bake two pies at the same time than one.

You can use a checklist assessment, rating scale assessment, or rubric.
Suggested for inclusion in the assessment are content (accuracy of information, completeness of information) and mechanics (neatness, attractiveness, grammar).

LEP Modifications:

- *Have students work in groups to prepare the booklet.*
- *Have students exchange their booklet with another group. Provide a checklist for groups to use when reading each others booklet.*

Day 6

Language (ELP) Objectives for Limited English Proficient (LEP) Students:

- *Students will research and create posters about heat engines.*

Thermal Energy Research
Since students have been studying thermal energy, ask them to list all the ways that we use thermal energy. At least one should pertain to using thermal energy to do work as in a heat engine.

Allow students to conduct research on heat engines. Topics would include: gasoline engines; diesel engines; 4, 6, & 8 cylinder engines; rotary engines, jet engines, etc. Students should include an explanation of how the engine works, diagram or picture of the engine, as well as the efficiency of the engine.

You could assign this as a written report, with poster, and then have the students report their findings to the class. You can go to the media center for research or bring resources to the room. Some may have resources at home they wish to use.

Materials: resources or media center, paper for posters, markers

Students will make their presentations the next day.

You can use a checklist assessment, rating scale assessment, or rubric. Suggested for inclusion in the assessment are content (accuracy of information, completeness of information) and mechanics (neatness, attractiveness, grammar).

LEP Modifications:

- *Posters work well with LEP students.*

Day 7

Language (ELP) Objectives for Limited English Proficient (LEP) Students:

- *Students will present their posters on heat engines.*
- *Students will listen to heat engine presentations.*

EXPLAIN:

Thermal Energy Research Presentations
Allow students to present their research to the class. You can use one checklist to assess content and another to assess things such as eye contact, clarity, etc. You can go to www.rubistar.com to compose a presentation rubric. When students present their information, be sure to stress that it is impossible to build a machine that does nothing but convert thermal energy into useful work. You can demonstrate that work can be completely converted into thermal energy by rubbing your hands together.

Day 8- Nuclear Energy

Language (ELP) Objectives for Limited English Proficient (LEP) Students:

- *Students will orally describe alpha, beta, and gamma rays.*

ENGAGE:

Concept of Half-Life Activity

How long does it take to walk from one side of the room to the other?

Have students (or one volunteer) stand along one wall. Ask them to walk half way to the other wall and then stop. Then ask them to walk half of the remaining distance to the wall. Continue doing this until they realize that if they continually walk one half of the remaining distance that they will never reach the other wall. Obviously this represents the concept of half-life. Another analogy is that you can never score a touchdown on a penalty with "half the distance to the goal" no matter how close the ball is to the goal at the time of the penalty.

Use this to introduce yet another type of energy that can be used to generate heat – nuclear energy.

Ask students what they know about nuclear energy or radiation. Some may mention nuclear power plants, nuclear weapons, or radiation therapy for cancer patients.
Use this as a lead in to discuss the three types of radiation: alpha, beta, and gamma.
Be sure to discuss what they are (mass and charge) as well as penetrating power.
You can use a decay chart to help show this as well as nuclear equations.
Somewhere in the discussion, relate back to the illustration at the beginning of the class to reinforce the concept of half-life. This will lead into the next activity.

LEP Modifications:

- *Some LEP students have little prior knowledge about nuclear energy.*
- *Show visuals of a power plant, atomic bombs, and cancer patients/radiation therapy.*
- *Explain that a when nucleus splits a large amount of energy is released and this energy is used in the above visuals you showed.*
- *Have students fold a piece of notebook paper into three.*
    - *Have students label the three parts of the paper alpha, beta, and gamma. Have students compare and contrast the 3 types of radiation.*

EXPLORE:

Through the Nuclear Waste Lab Activity, students will describe and explain radioactivity and its practical application as an alternative energy source including:

Alpha, beta, and gamma decay
Fission
Fusion
Nuclear Waste

Essential Question: What type of vessel best keeps nuclear waste from entering the environment?

Set up Nuclear Waste Lab
Intersperse the activities following the nuclear waste lab while waiting for it to "work."

Disposal of Nuclear Waste Lab

Teacher Notes:
This activity can easily be used as an inquiry activity- just let the students decide how to test each material.

Safety:

- NaOH pellets can be caustic. Make sure students wear goggles and gloves and ONLY touch the pellets with the tweezers.
- DO NOT put used pellets in the trash- dissolve & neutralize with an acid-check with pH paper and then dispose of the liquid.
- Be sure to include a copy of the MSDS for NaOH pellets. Review safety procedures.

Disposal of Nuclear Waste Activity

Problem
What type of vessel best keeps nuclear waste from entering the environment?

Purpose
To determine how to safely store nuclear waste

Materials

Per group
4 NaOH pellets
4 jars with lids filled ¾ with water
Phenolphthalein solution
Plastic wrap
Twist tie

Aluminum foil
Modeling clay
Tweezers
Per person
Goggles
Latex gloves

Procedure

1. Put 4 drops of phenolphthalein in each jar.
2. Using the tweezers, put one NaOH pellet in one of the jars. Put the lid on tightly. Label jar as CONTROL.
3. Using the tweezers and with gloves on, get another NAOH pellet and wrap it in aluminum foil. Try to make it water tight. Place it in a jar. Label and out a lid on the jar.
4. Wrap another pellet in plastic wrap using twist ties and another in clay and place each in a separate jar- label each jar and put the lid on tightly.
5. Observe each jar daily for three days. Look for signs of leaks. Record the information in the data table.

Analysis

1. What happened in the control jar?
2. Which type material would be best for the storage of nuclear waste? Why?

Data Table

Jar	Day 1	Day 2	Day 3
CONTROL			
ALUMINUM			
PLASTIC			
CLAY			

Instruct students to share their answers on the board.

LEP Modifications:

- *Complete this lab as a demonstration.*
- *Have the data table projected on the board.*
- *Have student volunteers to help with the lab and filling in the data table.*
- *Have students answer the analysis questions in complete sentences in their notebooks.*

ELABORATE:

Skittles Lab

This is lab is used to demonstrate half-life. (You can have students bring their own Skittles and they can eat them as they finish. Pennies or plain M&Ms can also be used.) Students will need approximately 100 Skittles.

Skittles Lab

Materials: Skittles, cup, paper towels

Have students construct a data table like the one below.

Spill number (half-life)	"s" up (atoms remaining)	"s" down (atoms decayed)
0	100	0

Procedure:

1) Place 100 skittles in a cup. This represents 100 atoms, or a certain mass, of a radioactive substance.

2) Put one paper towel toward one corner of the table. Students then spread paper towels on the center of the table and then dump the cup of skittles on the paper towels. Instruct the students to remove the skittles that have the "s" down. These represent atoms that have decayed. Count this number and place in the "s" down column. Put these on the paper towel in the corner and do not return them to the cup. Count the skittles that are "s" up and record this number in the "s" up column. These represent atoms that are still radioactive and are returned to the cup.

Students continue this process until all skittles are "s" down; in other words until all atoms have undergone radioactive decay.

At this point, students repeat the procedure using 60 Skittles. They will need to construct a separate data table, but will plot the points on the same graph.

There is another model of half-life that can be done with various markers. When they point one way, they have "decayed." If dropped into a box, they point to one side, or two, or three or all sides, they can demonstrate different rates of half-life.

Have students plot the data on a graph with atoms remaining on the y axis and half-lives on the x axis. Connect the points to form a continuous line or curve.

Have students answer questions similar to those below.

1) During which half-life did the most atoms decay ("s" down)?

2) How many skittles should have remained after three half-lives (“s” up)?
3) How close is this to your actual value?
4) According to your graph, how many half-lives did it take for half the atoms to decay?
5) How close is this to the actual value?
6) Does the half-life depend on how much of the sample you begin with?

Afterwards, in the post-lab discussion, talk about the fact that half of something is always something. Relate this back to the topic of nuclear waste.

LEP Modifications:

- *Review the vocabulary radioactive and radioactive decay.*
- *Have students take turns reading the directions to the class.*
- *Model expectations – Complete the first trail together as a class.*
- *Reinforce by writing on the board and having students copy, skittles down mean the decayed atoms and skittles up mean the atoms are still radioactive.*
- *Provide students with label graph paper.*

EXPLAIN:

Independent Practice on Radiation

Have students read sections in their texts or an online source regarding radioactivity, types of radiation, nuclear decay, and detection of radiation. As they read, they are to pick out main points and make a foldable. When finished, have students share information. Be sure to have them do a comparison of alpha, beta, and gamma radiation. This can be done by constructing a concept map.

Sample data may be as follows:

Radioactivity

■Radioactivity – process in which an unstable atomic nucleus emits charged particles and energy; release of radiation in form of particles and rays
–Discovered by Henri Becquerel; U salt, photo. Film
–Marie Curie – discovered radioactive element in uranium ore, named it Polonium
–Roentgen discovered X-rays
–greater difference b/t p^+ and n^o, the more unstable the nucleus
■Radioisotope – atom containing unstable nucleus
■Radiation – particles and energy released from radioactive nuclei

Types of Nuclear Radiation
■Alpha particle
–Helium nucleus; $_2He^4$

–Positive 2 charge
–Mass = 4 (2 protons, 2 neutrons)
–Can burn flesh
–Stopped by paper, cotton

■Beta particle
–Electron emitted from nucleus; $_{-1}e^{0}$
–Negative charge (1 electron)
–Mass = 0
–Stopped by 0.5cm Al

■Gamma
–High energy electromagnetic rays; short wave, high frequency
–Can pass through several cm of Pb, or 2-3 ft concrete
–Most damaging

Nuclides
▪A = mass number
▪Z = atomic number
▪N = number of neutrons
Specified nuclei with particular atomic number and mass
▪$^{14}_{6}C$

▪Mass number at top, atomic number at bottom

Nuclear Radiation
■Effects
–Background radiation – occurs naturally
–Can ionize atoms
–Can break bonds holding proteins and DNA together
■Detection
–Ionization (Geiger counter detects ions by electrical current, electroscope)
–Scintillation (flashes of light)
–Exposes photographic film (film badge) (Becquerel)

Nuclear Decay
■Nuclear decay – spontaneous change of an element into other isotopes or elements; unstable nucleus loses energy by emitting radiation
–Atoms of one element can change into atoms of another element
■Nuclear decay series – series of steps (nuclear reactions) by which an unstable, radioactive nucleus decays into a stable, nonradioactive nucleus

Nuclear Reactions / Equations
Alpha
▪α decay

▪(atomic # goes down by 2; mass down by 4)
▪$^{226}_{88}Ra$ ----> $^{222}_{86}Rn$ + $_{2}He^{4}$ + energy

▪*Beta*
▪ β Decay
▪(atomic # goes up by 1; mass stays same)
▪$^{14}_{6}C$ ----> $^{14}_{7}N$ + $_{-1}e^{0}$ + energy

▪*Gamma*
▪ γ Decay
▪152Dy* ----> 152Dy + γ

Half-Life
■Time required for ½ of the atoms in a radioactive sample to emit radiation and decay
■Unstable nuclei give off particles/energy to become stable
■Longer half-life, more nuclear stability
Half-life Example
Ex: N-13 emits beta radiation and decays to C-13 with a half-life of 10min. If the starting mass is 2g of N-13, how long is four half-lives, and how many grams of N-13 remain?

a. Half-life = 10min, no. of half-lives = 4
4 x 10min = 40 min

b. m = 2g, No. of half-lives = 4
2g / 2 = 1g; 1g / 2 = 0.5g; 0.5g / 2 = 0.25g;

0.25g / 2 = 0.125g

Radioactive Dating
■Carbon-14 dating
■An object's relative age is determined by comparing the object's carbon-14 levels with the carbon-14 levels in the atmosphere

LEP Modifications:
- *Have students create a concept map.*
- *Give the students the words, topic, and/or the above bullets on the board. Have students copy one vocabulary word or one of the above bullets on individual post-it-notes. You can color code the post-it notes to the different topics.*
- *Have students create their own concept map and share with the class.*

Nuclear Equations Practice

$^{214}_{84}Pb \rightarrow$ _______ + $^{4}_{2}He$

$^{222}_{86}Rn \rightarrow\, ^{218}_{84}Po$ + _______

$^{214}_{82}Pb \rightarrow\, ^{214}_{83}Bi$ + _______

$^{234}_{92}U \rightarrow$ _______ + $_{-1}e^{0}$

LEP Modifications:

- *Complete the first practice problem on the board explaining as you go.*
- *Have students complete the rest at their desk.*

Day 9

Language (ELP) Objectives for Limited English Proficient (LEP) Students:

- *Students will speak and listen to the explanation of fission and fusion to their neighbors.*

<u>Playing with Play Dough</u>

This is used to help develop understanding of fission and fusion.
Materials: play dough (You can find a recipe for this on the internet if you do not want to buy it.)

First, have students tell what they think fission and fusion are. If they don't get it, tell them that one involves splitting and one involves joining, and give them another chance.

Give each group (table) one ball of play dough and have them model fission and fusion. Use this as a point from which to introduce nuclear fission and fusion. You may also want to diagram this on the board for them.

If you have time, you can include chain reactions. These can be illustrated using dominoes. Set them up in a pattern so that when one is pushed, they all fall down. There are some good video clips of mousetraps and ping pong balls that also illustrate it very impressively and are more analogous to the process. One website is listed below http://www.physics.lsa.umich.edu/demolab/demo.asp?id=866

LEP Modifications:

- *Complete this activity using your overhead.*
- *Have the students draw illustrations in their notebooks.*
- *Then allow students to use the play dough to explain the concept of fission and fusion to their neighbors. This is a good reinforcement of vocabulary words and concepts.*

ELABORATE:

Fission and Fusion Video

Find a video or streaming to insert on the topics of nuclear power (fission and fusion) and nuclear waste disposal. You can try to find a video clip with a demo of a group of mousetraps set and then going off as a ball is dropped to set them off.

From the video(s) have students list and describe problems associated with nuclear waste disposal. You can take these up as a quiz grade (You could use some sort of checklist for assessment.) Be sure to discuss these together afterwards.

EVALUATE:

For closure, you can have the students use a double bubble map or Venn diagram to compare and contrast fusion and fission.

LEP Modifications:

- *Try to find a video that has close captions.*
- *Have students create Venn diagrams in pairs. Include visuals.*
- *Create a large size Venn diagram, have the pairs come up one at a time and add information from their own diagrams. Discuss along the way, have students add information to their own diagrams.*

Day 10

Language (ELP) Objectives for Limited English Proficient (LEP) Students:
- *Students will read, write, and speak about waves using vocabulary words while creating and presenting their posters.*

ENGAGE:

Use this activity (Who's Waving at You?) to introduce waves and wave properties. Ask students to raise their hands if they have been to the beach and observed the wave action. Explain to students that *a wave is a repeating disturbance or movement that transfers energy through matter or space*. For example, a pebble that is dropped into a pond will transfer its kinetic energy to the particles of water in the pond, forming a wave. Students will use a variety of materials to make and observe waves and their properties.

Who's Waving at You?

Materials: shallow pan (non-glass), water, rocks, pebbles, meter stick, jump rope or similar length of thin rope and thick rope

Safety: objects that can be thrown, possible water spills on the floor

Have pans prepared with 2-4cm of water in the bottom. (You can use inexpensive foil baking pans.) Students put these either on the floor or on their desks. Tell them to observe the water and wait until the water is perfectly calm to begin. The students are to drop the rock into the water. They then drop the pebble from the same height. Then repeat the procedure using a different height, either higher or lower. Share results with the class. They should be able to see that the rock and pebble provide energy to cause a vibration or disturbance in the wave (wave pulse). They should also be able to see that more energy will cause a larger disturbance. (You should relate this back to increased PE (potential energy) at a greater height.)

LEP Modifications:

- *Have a demonstration set up on teacher's desk so you can model instructions.*
- *You and the students drop a rock at the same time, ask students to say observations out loud to the class.*
- *Now drop the same rock from a different height, ask students to compare observations from the first rock and the second rock. Talk about how gravitational potential energy changed.*
- *Now drop a pebble (explain the definition of pebble), make observations and compare to previous dropped objects. How did size of the object effect their observations?*
- *Brain storm with students, what caused the water to ripple?*
- *Discuss how energy effected their observations.*

When this is cleaned up, give each group a jump rope or a similar length of rope. Have them tie one end to a chair leg or table leg. They first observe the rope at rest, then have them give the rope one shake (to observe a single pulse) and observe. They may also see that the pulse bounces back (reflection). Then the students will give the rope several shakes to observe a continuous wave. If students tie a thin rope (or maybe a shoe string) to a thick rope they can possibly detect a change in speed as the wave moves from one medium to the next.

LEP Modifications:

- *Complete these activities in front of the class room as a demonstration and have students take turns making and predicting observations.*

Have students read the accompanying section in their text to locate the correct terms for the things they just observed. Discuss as a class before moving to the next activity.

LEP Modifications:

- *Have students take turns reading the section in the textbook out loud. After each paragraph or topic, stop and ask students to help develop the notes that you will place on the board.*
- *Have students copy notes in their notebooks.*

LEP Modifications:

- *To reinforce vocabulary/topic have students design and present posters.*
- *Assign each student a vocabulary word and have the student design a poster explaining that vocabulary word. Include the word, definition, and illustration.*
- *Vocabulary words to reinforce (you can add others)*
    - *Crest, trough, amplitude, frequency, wavelength, compression, rarefaction, reflection, interference, transverse wave, compressional wave*

EXPLORE:

At this point, students should be ready to proceed to the "It's a Slinky" lab. You can use metal Slinkies; however, the plastic ones do not get tangled and stretched out of shape as badly as the metal slinkies. This activity is designed to allow them to see both transverse and compressional waves, as well as the "parts" of each. "It's a Slinky" lab is used to illustrate different waves and wave properties.

For inquiry, have the students make a list of wave characteristics that they can change and then determine ways to do this.

Students should see basic characteristics of waves such as crest, trough, compression, rarefaction, amplitude, and wavelength, as well as interactions such as reflection and interference. They should also see the direct relationship between energy and amplitude in addition to the inverse relationship between wavelength and frequency. Students may need to use their books or some sort of resource on the second part of this activity in which they have to use terminology to answer the questions.

LEP Modifications:

- *Have students copy and put in their notes the relationship between energy and amplitude.*
- *Explain and compare inversely related with directly related.*

Depending on the ability level of your class you could make a list of questions for them to answer. Take up these papers to use as assessment.

It's A Slinky!

Adapted from "Waves," NCSTA Journal, Fall, 1992

Materials: Slinkies, meter sticks, timers, tape (Optional- metal coil long enough to stretch across the room)

Safety: Metal Slinkies can slip out of the hand and pinch fingers.

Two students hold either end of a Slinky. They stretch it out enough to be able to see waves. As they perform various motions and investigations with the Slinky, they are to record what they do and what they observe.
Students begin by shaking the Slinky to the side to send a single wave pulse and then shake the Slinky from side to side for a series of waves (transverse). Next, students either pull back a section of coils and release or push the Slinky toward their partner to make a compressional wave (compressional/longitudinal). Again, they should make a single pulse as well as a series of waves.

(Students can stretch the metal coil across the room and shake it up and down to simulate surface waves.)

LEP Modifications:

- *Provide specific directions for the students to follow. Have the instructions written on paper and read them orally.*
- *Provide a data table for the students to fill in as they complete the activity.*
- *For example:*

Motion	*Observation*

- *Have students draw two of their observations and have them label the waves using their vocabulary words.*

Make sure the students understand that the waves formed in the rope and Slinky were mechanical waves, while the water waves were surface waves.

Day 11

Language (ELP) Objectives for Limited English Proficient (LEP) Students:

- *Students will write comparisons of vocabulary words (frequency, amplitude, pitch, wavelength, and intensity.*
- *Students will speak the wave velocity equations to another student.*

EXPLORE:

This activity (What's That Sound?) illustrates mechanical waves.

What's That Sound?

(Illustrate mechanical waves)

Materials: clear plastic container with water, tuning forks, resonance boxes

To demonstrate the fact that sound travels as waves, you can put a vibrating tuning fork onto the top of the water to see that waves begin in the water (It may splash out, so be prepared). To help students see that sound travels differently in different media, you can hit the tuning fork with the mallet and then touch the base of the fork to different materials. This will allow students to hear the difference.
Students may also be able to relate to the fact that they hear sounds differently in water than in air. Another point they may relate to is that on a hot summer night, sound travels faster over the lake than over land which is cooler. Use this as an opportunity to relate back to water's high specific heat capacity.

Students should strike different tuning forks to note the difference in pitch. If they don't notice the frequencies on the forks, be sure that they understand the direct relationship between frequency and pitch.

Illustrate resonance using the boxes. Relate this to how instruments produce sound. Another aspect of sound that can be investigated is pitch which is determined by frequency.

EXPLAIN:
Ask students to share their data with the class.

ELABORATE:

Your Favorite Song
This activity (Your Favorite Song) demonstrates the relationship between frequency and pitch.

Give each group several bottles of water, each bottle containing a different amount. Allow them to determine how to play a song, preferably one that everyone will recognize such as Mary Had a Little Lamb. Then give them time to play the songs for the class. Ask them to determine the relationship between the water in the bottle and the pitch. Did they "hit" the part of the bottle with water in it or did they hit the part of the bottle with air? Have them try this to see if it makes a difference. Then discuss again. Be sure to mention that the wavelength determines the frequency, the frequency determines the pitch, and amplitude determines intensity (loudness). Be sure that students know that sound waves are compressional, mechanical waves. You can most likely find a video clip showing the demonstration of a bell ringing in a bell jar, with a vacuum pump taking the air out so you no longer hear it. This change in sound can be a lead in to the Doppler Effect which is a different change in sound.

LEP Modifications:
- *Their songs are probably different from the songs you know. Try "Happy Birthday".*
- *Demonstrate first then let the students try.*
- *Use Venn diagrams to compare wavelength and frequency, frequency and pitch, and amplitude and intensity.*

Materials: glass bottles, water, pencil to use as mallet

Safety: Wear goggles when dealing with glass.

Demonstration- Doppler Effect

Materials: Doppler Ball or Sound Emitting device, Nerf ball, and tape

If you don't have a Doppler ball, purchase a sound emitting device from an electronics store. Cut a hole out of a Nerf ball, insert the device and secure with tape. Have two students toss the ball across the room and listen for any changes in sound. They should observe the pitch changes as the ball moves toward them and away from them. You can use this as an opportunity to relate to the technology of Doppler Radar. For more information, go to
http://edweb.sdsu.edu/doppler/pitch/dopplerball.htm

LEP Modifications:

- *Have students get into partners and draw a picture to present the changes in sound. Have them label high pitch, low pitch, high intensity, low intensity, high frequency, and low frequency.*

EVALUATE:
Instruct students to calculate the following problems regarding wave velocity. This can be done independently or as a group.

Wave Velocity Practice Problems

$$v_w = f\lambda$$

Show all work.

1. The frequency of a wave is 4Hz. If the wavelength is 2m, how fast are the waves moving?

2. The velocity of an ocean wave is 5m/s. The distance between two wave crests is 3m. What is the wave frequency?

3. A sound wave is traveling with a frequency of 880Hz. It has a wavelength of 0.75m. What is the speed of the sound wave?

4. Two people hold a rope at either end. One person moves his end of the rope at a frequency of 4.0Hz and a wavelength of 0.8m. At what speed does the wave travel through the rope?

LEP Modifications:

- *Put the equation for wave velocity on the board. Explain and label all the parts of the equation.*
- *Have students turn to their neighbor and explain the equation.*

Day 12

ENGAGE:
Use this activity (How Bright is Your Light?) to illustrate the relationship nature of light and diffraction.

How Bright is Your Light?

Materials per table: flashlight, sheet of heavy (card stock) paper, scissors, ruler, mirrors

Safety: scissors, glass, goggles, closed shoes

Have the students work with the flashlight and uncut paper to observe the light on the paper at different distances and record their observations. Students are to draw and cut a square hole from the sheet of paper, then measure and record the sizes of the sides. After you instruct students to turn on their flashlights, turn off the lights in the room. Then the students measure and record the sizes of the sides of the square of light on the floor.
When students compare and when you discuss in class, students should have observed that: light travels in straight lines. The light is brighter when closer to the paper (more intense) as well as the reverse, and that the light that traveled through the paper covers a larger area when it strikes another surface (diffraction).

LEP Modifications:

- *Provide students with written instructions. Have students read instructions out loud by taking turns.*
- *Provide students with a data table to fill out while making observations.*

Height from floor to paper/flashlight	*Size of light on floor*	*Brightness of light on the floor. (Scale 1 to 10)*	*Size of hole in paper*

- *Put chart on the overhead. Have students put their data on the chart. Discuss and compare results.*
- *Draw examples on the board to show that light travels in straight lines and intensity is related to brightness.*

Be sure to emphasize that light waves are electromagnetic as opposed to sound waves which are mechanical. Pictures of earth from space can be used to show that light travels through space but does not light space.

Mirror, Mirror, on the Wall

(Illustrate reflection by plane mirrors; use the convex and concave mirrors for enrichment.)

Materials: plane, convex, concave mirrors

Safety: if using glass mirrors, goggles and closed shoes

Pass out mirrors to let students observe and record the shapes of the mirrors and the differences in the images that are produced.
When the students compare and discuss in class, they should observe that the flat (plane) mirror produces a "normal" image, while curved in (concave) and curved out (convex) mirrors produce distorted images. Be sure to talk about the difference between real and virtual images, as well as how the distorted images change as you move the objects closer to and farther away from the curved mirrors. You can relate this to a House of Mirrors. Be sure to talk about specific practical uses for the different types of mirrors.

LEP Modifications:

- *Have students fill out a chart similar the one below.*

	Characteristics of Mirror	*Object reflected in mirror*	*Observations of the reflected object*
Concave Mirror			
Convex Mirror			

- *Have students share their observations.*
- *Discuss how images look in a car mirror.*

Materials: pencil, glass, water, goggles

Safety: goggles, closed shoes

You can lead from diffraction to refraction by using a pencil in a glass of water. When the pencil is at an angle in the glass, it appears broken due to the bending of the light waves. An example that most students relate to is that objects at the bottom of a pool are not where they appear to be.

LEP Modifications:

- *Have students draw their observations.*
- *Have pairs of students come up with a definition of refraction. Then as a whole class come up with a correct definition of refraction.*
- *Have students put this definition in their notebook.*

ELABORATE:

What an Image!

Materials: concave and convex lenses

Safety: if lenses are glass, goggles and closed shoes

Pass out lenses and have students observe and record the shapes of the lenses and the differences in the images that are produced.
When the students compare and discuss in class, they should observe that both types of lenses produce distorted images. Be sure to talk about the difference between real and virtual images, as well as how the distorted images change as you move the objects closer to and farther away from the curved lenses. Talk about specific practical uses for each type of lens.

Have students read the section on mirrors and lenses in the text, discuss with their partners, and then summarize some of the main points in a paragraph to be shared with the class.

LEP Modifications:

- *Give vocabulary words or statements that students should include in their paragraphs. Have them underline the words.*

Day 13

Language (ELP) Objectives for Limited English Proficient (LEP) Students:

- *Read and create a Venn diagram comparing transverse and longitudinal waves.*

Over the Rainbow

Prisms refract light and separates light into colors.

Materials per group: 1 prism (if not a sunny day then light source as well)

Safety: glass

Go outside with the prisms, or find a location within the school that has windows that allow light to come in. Allow students to work with the prisms to see that they break up (disperse) light into the colors of the rainbow (the spectrum). Have them record the colors in order and compare with other groups to see if there is a difference. Ask them why this happens. Hopefully someone will make the connection to refraction, if not then lead them to it. Discuss that the colors are refracted differently due to different frequencies. Ask which colors have the highest and lowest frequencies, then list them in order. If you have spectroscopes you can use those, too. At some point be sure to

include that frequency determines color and amplitude determines intensity (brightness).

LEP Modifications:
- *Have students draw and label their observations. Include vocabulary words and the colors that are observed. (ROYGBIV, refraction, highest frequency, and lowest frequency).*

If you are far enough from other classes while you are outside, you can demonstrate echoes as reflected waves if you have not already done so.

This is also a good time to stress the fact that light waves are transverse, electromagnetic waves.

LEP Modifications:
- *If time permits have the students create a Venn diagram to compare and contrast transverse waves and longitudinal waves.*

Electromagnetic Waves

The purpose of this activity is to practice related terms.

Materials: large block graph paper

Once students understand that light waves are electromagnetic, they may be able to relate that there are other electromagnetic waves that cannot be seen. Ask for some examples of these. Have students make a puzzle in which the waves are the terms and the "uses" or definitions are the clues. They could also make a chart showing this information as well as wavelength and frequency if the book does not show one.

Stress to students that electromagnetic waves have different frequencies but all travel at the speed of light. Point out again that wavelength and frequency are inversely proportional.

Distinguish between the speed of sound and speed of light using the delay between lightning and thunder as an example.

If you include total internal refraction, transition to total internal reflection using the example of fiber optic technology.

Demonstration of Critical Angle and Total Internal Reflection

This can be used as an enrichment activity if you have time.

Materials: laser (point light source), block of glass, larger lenses

Safety: Be sure that lasers are not directed at eyes.

You can a use a laser with a block of glass to show that light bends when it moves from air into glass. At the same time, you can show critical angle and total internal reflection. Relate to the transmission of information through optical fibers. Discuss other uses as well.

EVALUATE:

Instruct students to make a pamphlet illustrating the vocabulary terms addressed in this unit. Be sure to include a drawing or picture for illustration purposes. Instruct students to define the term in his/her own words.

LEP Modifications:

- *Students have been working on these vocabulary words throughout the unit.*
- *Review and reinforce vocabulary.*
    - *Flashcards*
    - *Games*
    - *Word wall*
    - *Create flow charts, bubble maps, or concepts maps using vocabulary words.*

Unit 2- Vocabulary List

energy
kinetic energy
potential energy
thermal energy
wave energy
nuclear energy
energy conversion
energy conservation
gravitational potential energy
elastic potential energy
nuclear potential energy
thermal energy
heat
thermodynamics
3 methods of heat transfer: convection, conduction, radiation
engines

efficiencies
radioactivity
nuclear energy
alpha decay
beta decay
gamma decay
nuclear fission
nuclear fusion
nuclear waste
waves
amplitude
frequency
period
wavelength
velocity
mechanical waves
electromagnetic waves
electromagnetic spectrum
sound waves
light waves
reflection
refraction
diffraction
Doppler effect

Sample Assessment Questions for Unit 2

Objective	RBT Tag	Question
3.01	B4	1) Two objects of equal mass fall from different heights. The object that falls from the greatest height would have the greatest ____. a. acceleration b. gravitational acceleration c. final velocity d. initial velocity
	A3 C2	2) Which of the following best explains why the first hill of a roller coaster is constructed to be the highest? a. As the height increases, the speed increases. b. As the height increases, the acceleration increases. c. Greater initial potential energy provides more kinetic energy for the remainder of the ride. d. Greater initial potential energy provides more power

		for the remainder of the ride.
3.03	A3 C2 B4	1) Which of the following best illustrates a spontaneous transfer of energy? a. A cup of hot tea in your hands transfers heat to your hands. b. Ice cools a glass of cola. c. A refrigerator does work to keep food cold. d. The air conditioner in a car cools the air in the car on a hot day. 2) Which of the following phase changes provides the cooling process during refrigeration? a. condensation c. melting b. freezing d. vaporization
3.04	B4 A2 A3 C2	1) Which of the following types of waves does not require a medium? a. light b. radio c. sound d. X-ray 2) Increasing the wavelength of a wave will most likely ___. a. decrease the amplitude of the wave b. increase the amplitude of the wave c. decrease the frequency of the wave d. increase the frequency of the wave
6.06	B2	1) Ships, submarines, and aircraft carriers that are at sea for a long time do not need to carry a large amount of fuel. Which of the following types of fuel would most likely meet this requirement? a. fossil fuels b. hydrogen c. uranium d. plutonium