8TH GRADE CURRICULUM

8TH GRADE CURRICULUM OUTLINE
TRANSPORTATION MODULE

Lesson I: 8th Grade
Transportation: American Driving Habits
- Brainstorming session on average U.S. driving, U.S. energy use, global energy use, and CO_2 emissions from automobiles
- Word map brainstorming exercise
- Interpret published statistics through calculations

Lesson 2: 8th Grade
Amercian Driving Habits Explored: Why Do We Drive?
- Compile class graphs exploring personal transportation habits]
- Determine patterns in the data
- Write a short essay interpreting the class data (making inferences)

Lesson 3: 8th Grade
How Communities are Organized
- From local to global–community organization and transportation options

Lesson 4: 8th Grade
Life-cycle Costs: Learning to Consider the Hidden Costs of Technology
Alternative Fuel Technologies: the Pros and Cons of Ethanol
- Read the Chapter "Bike and Car" from *Stuff: The Secret Lives of Everyday Things* by John C. Ryan and Alan Thein Durning
- Discuss ethanol

Lesson 5: 8th Grade
Hybrid Vehicles: a growing alternative
- U.S. energy use
- Discussion of hybrid vehicles within the U.S. auto market **Basic Automobile Structure:**

World Transportation Use
- Direct and Indirect energy use of various modes of transportation
- World implications of different modes of transportation–focus on India and China

Lesson 6: 8th Grade
Chassis, Wheels, Gears, Engine
- Quick lesson of basic parts of a car: diagrams
- De-mystifying how a car works

Lesson 7: 8th Grade
Photovoltaics: How Do Solar Cells Work & Solar Cell Experimentation
- Basic lesson on how solar cells work
- Discuss different solar cell technology available today
- Hands' on experiments with the solar cells and engines

- Design Journal notes–descriptive ideas, experiments, designs, messes & successes

Lesson 8: 8th Grade

Design Lego Racers using Lego Designer Program

- Using Lego Designer create multiple rough construction ideas for racer designs
- Design Journal notes–descriptive ideas, best designs, pros and cons of different designs

Lesson 9: 8th Grade

Build Solar Cars

- Based on design experimentations from Lego Designer, begin building racers with actual parts

Lesson 10: 8th Grade

Test Drives & Design Refinement: Changing Gear Ratios, Solar Cell Placement, etc.

- Experiment with changing the angle of the solar cell in order to make the car move in different directions or at different speeds (goal: how to maximize or reduce output of solar cell)
- Continue writing and drawing outcomes in Design Journal

Race Day

Lesson 1: 8th grade
Transportation: American Driving Habits

Lesson Overview: Exploring U.S. automobile impacts.
Lesson Concept: Develop numeracy skills related to U.S. population and driving habits and be able to perform back-of-the-envelope calculations to aid statistical understanding.

Materials:
- Note-taking journals
- Pencils
- Erasers
- Student Hand-out: Average U.S. Driving Habits

Standards:
- English:
  - IX.11.MS.1 (Inquiry and Research: Define and investigate important issues and problems using a variety of resources).
- Science:
  - I.1.MS.1 (Construct new Scientific and personal Knowledge: Generate scientific questions about the world based on observation).
  - II.1.MS.3 (Reflect on the Nature, Adequacy and Connections Across Scientific Knowledge: Show how common themes of science, mathematics, and technology apply in real-world contexts).
- Social Studies:
  - II.3.MS.4 (Geographic Perspective: Describe the major economic and political connections between the United States and different world regions and explain their causes and consequences).
  - II.5.MS.1 (Geographic Perspective: Describe how social and scientific changes in regions may have global consequences).
  - IV.2.MS.4 (Economic Perspective: Examine the historical and contemporary role an industry has played and continues to play in a community).
  - VI.1.MS.3 (Public Discourse and Decision Making: Explain how culture and experiences shape positions that people take on an issue).

Timeline: 1 class period (50 - 60 minutes) depending on the length of each presentation

Class Structure: large class brainstorming, small group calculation exercises

Assessment Strategy: Pre-module Assessment Questions #1, 2, & 3
EEK! Daily Assessment

Lesson 1: 8th grade
Transportation: American Driving Habits

Lesson Overview: Exploring U.S. automobile impacts.
Lesson Concept: Develop numeracy-skills related to U.S. population and driving habits and be able to perform calculations to aid statistical understanding.

Materials:
- Note-taking journals
- Pencils
- Erasers
- Student Hand-out: Average U.S. Driving Habits

CLASS EXERCISES:

I. Introducing the Module

The first three lessons of this module will weave together two significant points of inquiry:
- the student's personal decision-making surrounding transportation, and
- the impacts these personal decisions may have globally.

This lesson focuses on interpreting statistics and performing calculations with specific data sets. These concepts were introduced in the 7th grade Transportation Curriculum in Lesson 10. In order to provide contiguous curricular structure, this lesson is a direct review of that information.

II. Class Brainstorming Session

In order to gauge the students' knowledge, begin the lesson with a brainstorming session. You may want to create a word map based on the students' responses. Below is a list of questions to facilitate the brainstorming session. (***Please note, some of the statistics may have changed given the sourcing is from 2002 – present. Please refer to the Energy Information Administration website for the most current data–eia.doe.gov***)

FACILITATION QUESTIONS

General (population and energy use) questions

1. Approximately, what is the U.S. population? (3,000,000,000–census.gov 2006)
2. What is the approximate world population? (6.5 billion–census.gov 2006)
3. What is the approximate world energy consumption? (397 quadrillion Btu (1 Btu is about the amount of energy in one wooden match.)–need.org 2002)
4. What is the approximate total U.S. energy consumption? (97.3 quadrillion Btu–need.org 2002)

Specific Transportation-related questions

5. About how many passenger cars per person account of all of the cars in the United States today? 1 per person? Less than 1 per person? More than 1 per person? (1.3 vehicles / person–need.org, 2002)
6. Roughly how many miles does the average American drive per year? (15,000–aaa.org)

7. Approximately how many gallons of gasoline is consumed every day in the United States? (approximately 400 million gallons / day–eia.doe.gov 2006)
8. What are the average CO_2 emissions per gallon of gasoline? (22.2 lbs./gallon–sierraclub.org)
9. What is the approximate gas mileage of the average U.S. car? (20 mpg–eia.doe.gov)
10. What is the average cost of a gallon of gasoline in the United States? ($2.40–2006 average)

III. Comparing Class Responses with the Published Statistics

Once the students have agreed on their answers to the questions (and you have written them down on the board), share the published statistics (in red after each question) with them. If there are grave discrepancies between their ideas and the published statistics, discuss how / why they came up with their answers.

Write the published statistics next to the class brainstorming responses on the word map (or other method for compiling the information that you are using).

IV. Question Set: interpreting statistics

Working in small groups, have the students answer the following questions based on the published statistics from III.

CALCULATION QUESTIONS

1. What percentage of the world population lives in the United States?
2. What percentage of world energy does the United States consumer each year?
3. How many passenger vehicles are there in the United States?
4. About how many gallons of gasoline does each person living in the United States consume per day. Please refer to the total population of the United States, not just people of legal driving age.
5. What are the average gasoline CO_2 emissions in the United States per day? Per year?
6. How many CO_2 emissions could be reduced if the average U.S. car fuel economy was increased by 10 mpg?
7. How much money does the average American spend on gasoline per year?

Student Hand-out: Average U.S. Driving Habits / Calculations

CALCULATION QUESTIONS

1. What percentage of the world population lives in the United States?

2. What percentage of world energy does the United States consumer each year?

3. How many passenger vehicles are there in the United States?

4. About how many gallons of gasoline does each person living in the United States consume per day. Please refer to the total population of the United States, not just people of legal driving age.

5. What are the average gasoline CO_2 emissions in the United States per day? Per year?

6. How many CO_2 emissions could be reduced if the average U.S. car fuel economy was increased by 10 mpg?

7. How much money does the average American spend on gasoline per year?

Lesson 2: 8th grade
Amercian Driving Habits Explored: Why Do We Drive?

Lesson Overview: Explore the students' opinions and ideas about their personal (families) driving habits.

Lesson Concept: Become aware of personal decision-making and corresponding potential global effects.

Materials:
- Note-taking journals
- Pencils
- Erasers
- Large graph paper (18 x 24) for brainstorming exercises
- Markers

Standards:
- English:
  - IX.11.MS.1 (Inquiry and Research: Define and investigate important issues and problems using a variety of resources).
- Science:
  - I.1.MS.1 (Construct new Scientific and personal Knowledge: Generate scientific questions about the world based on observation).
  - II.1.MS.3 (Reflect on the Nature, Adequacy and Connections Across Scientific Knowledge: Show how common themes of science, mathematics, and technology apply in real-world contexts).
- Social Studies:
  - II.3.MS.4 (Geographic Perspective: Describe the major economic and political connections between the United States and different world regions and explain their causes and consequences).
  - II.5.MS.1 (Geographic Perspective: Describe how social and scientific changes in regions may have global consequences).
  - IV.2.MS.4 (Economic Perspective: Examine the historical and contemporary role an industry has played and continues to play in a community).
  - VI.1.MS.3 (Public Discourse and Decision Making: Explain how culture and experiences shape positions that people take on an issue).

Timeline: 2 - 3 class periods (50 - 60 minutes) depending on the length of each presentation

Class Structure: large class discussion, small group project

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #1
General Assessment Strategy #2

Lesson 2: 8th grade
Amercian Driving Habits Explored: Why Do We Drive?

Lesson Overview:	Explore the students' opinions and ideas about their personal (families) driving habits.
Lesson Concept:	Become aware of personal decision-making and potential rationale for decision-making–taking responsibility for actions.

Materials:
- Note-taking journals
- Pencils
- Erasers
- Large graph paper (18 x 24) for brainstorming exercises
- Markers

CLASS EXERCISES

I. Personal Transit

After reviewing the outcomes of Lesson 1's calculations, ask the students the question: Why might Americans drive so much? Ask them to consider their personal, or their families' transportation habits.

Create class graphs based on the answers to the following questions:
- How often do you drive in a car? On average how many trips per day?
  - 1x or less per day,
  - 2x/day,
  - 3x/day,
  - 4x/day,
  - 5x/day,
  - 6+x/day
- When you travel in a car, what is the average distance you travel for a one-way trip?
  - >1 mile
  - >2 miles
  - >3 miles
  - >4 miles
  - 5 - 10 miles
  - 15 – 20 miles
  - 20 + miles
- How often do you take public transit?
  - Every day
  - 5-6 days / week
  - 3-4 days / week
  - 1-2 days / week
  - 2-3 times / month
  - 1x / month
  - not very often
  - I can't remember the last time I took public transit

- Do you own a bike / scooter (non-motorized) / skateboard?
  - Yes
  - No
- How often do you ride your bike / scooter (non-motorized) / skateboard?
  - Every day
  - 5-6 days / week
  - 3-4 days / week
  - 1-2 days / week
  - 2-3 times / month
  - 1x / month
  - not very often
  - only when it's warm outside
  - I can't remember the last time I rode it
- How often do you walk to your destinations?
  - Every day
  - 5-6 days / week
  - 3-4 days / week
  - 1-2 days / week
  - 2-3 times / month
  - 1x / month
  - not very often
  - only when it's warm outside
  - only when it's not raining outside
  - I don't walk
- What is the farthest you have walked to go somewhere?
  - 1 -2 blocks
  - ½ mile
  - about 1 mile
  - between 1-2 miles
  - 2-3 miles
  - 3-4 miles
  - 5+ miles
- Usually, how do you get to school?
  - Driven
  - Walk
  - Ride the bus
  - Ride bike / scooter / skateboard
  - Other

II. Compiling the Information

After the class has created simple line graphs compiling the class totals to the information, discuss the results.

- What are the patterns?

III. Interpreting the Patterns

Have the students write a brief synopsis (3-5 paragraphs) describing the class data and providing the following information:

- Describe the potential rationales for the patterns they detected.
- Write brief *viewpoint synopses* making suggestions to
  - o improve what they perceive as the negative patterns, and;
  - o increase what they see as the positive patterns.
- Provide ideas on why Americans might drive so much.

IV. Statistical Analysis of the Patterns

A. Based on their class data line graphs, have the students roughly determine how many gallons of gasoline they collectively use for driving per week.

B. After the students have agreed on a rough approximation for gasoline use, have the students calculate the approximate total class CO_2 emissions based on the their transportation use.

C. Please refer to the statistics from Lesson 1– average CO_2 emissions per gallon of gasoline is 22.2 lbs./ gallon (sierraclub.org)

Lesson 3: 8th grade
How Communities are Organized

Lesson Overview: Create neighborhood maps to determine local transportation options.
Lesson Concept: Understand different community organization strategies and how that relates to community transportation options.

Materials:
- Note-taking journals
- Pencils
- Erasers
- Large graph paper (18 x 24) for mapping project
- Markers
- Student Hand-out: Best Neighborhood Improvement Ideas
- Optional video: *Taken for A Ride*

Standards:
- English:
  - IX.11.MS.1 (Inquiry and Research: Define and investigate important issues and problems using a variety of resources).
- Science:
  - I.1.MS.1 (Construct new Scientific and personal Knowledge: Generate scientific questions about the world based on observation).
  - II.1.MS.3 (Reflect on the Nature, Adequacy and Connections Across Scientific Knowledge: Show how common themes of science, mathematics, and technology apply in real-world contexts).
- Social Studies:
  - II.3.MS.4 (Geographic Perspective: Describe the major economic and political connections between the United States and different world regions and explain their causes and consequences).
  - II.5.MS.1 (Geographic Perspective: Describe how social and scientific changes in regions may have global consequences).
  - IV.2.MS.4 (Economic Perspective: Examine the historical and contemporary role an industry has played and continues to play in a community).
  - VI.1.MS.3 (Public Discourse and Decision Making: Explain how culture and experiences shape positions that people take on an issue).

Timeline: 2 - 3 class periods (50 - 60 minutes) depending on the length of each presentation

Class Structure: large class discussion, small group project

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #1
General Assessment Strategy #3

Lesson 3: 8th grade
How Communities are Organized

Lesson Overview: Create neighborhood maps to determine local transportation options.
Lesson Concept: Understand how communities are organized relates directly to community transportation options.

Materials:
- Note-taking journals
- Pencils
- Erasers
- Large graph paper (18 x 24) for mapping project
- Student Hand-out: Best Neighborhood Improvement Ideas
- Optional video: *Taken for A Ride*

CLASS EXERCISES

†††**Teacher's Note**: Before you begin this lesson, briefly discuss what the class has learned based on their personal transportation habits learned in Lesson 2. Then, suggest that personal transportation habits tend to develop based on the choices available and the perceived ease of these choices. †††

I. Mapping Your Neighborhood
Working in small groups, have the students either map their own neighborhood (if they live near one another) or map the neighborhood surrounding the school. Depending on the neighborhood density, choose either ½ mile or 1 mile radius.

Have the student investigate and map the following:
- Is the area completely residential?
- Are there stores close by?
- What kinds of stores, i.e. what products do they carry?
- How close is the nearest grocery store?
- How close is the nearest gas station?
- How many gas stations are located with the 1-mile radius?
- Is there public transit available in the neighborhood? If yes, what type? Does it operate on a reliable schedule?
- If there is not public transit available in the neighborhood, how far is the closest public transit stop?
- Is there a library in the neighborhood? If no, how far away is it?
- Is there a Neighborhood Center in the neighborhood? (A safe place where kids can hang out, get help with homework, play sports, etc.).

II. Improving Your Neighborhood

Continuing to work in small groups, have the students brainstorm how they would improve their neighborhoods. Below is a set of Facilitation Questions to jumpstart this conversation.

> ***Teacher's Note: Transportation issues are a part of a larger issue–creating **sustainable communities**. Many ideas may arise that seem to have little to do, at first glance, with transportation issues, such as safe parks, open space, or better neighborhood stores. But, these issues are in fact very important. If more people feel comfortable and safe in their neighborhood, chances are they will walk, ride a bike, or take public transit (if that is an option) more often.
>
> Therefore, encourage all neighborhood improvement ideas that seem positive.***

BEST NEIGHBORHOOD IMPROVEMENT IDEAS–FACILITATION QUESTIONS

1. Looking at the map of your neighborhood, what do you believe would be the best improvement to the neighborhood?

2. If you could either add or change a store in the neighborhood, how would you change it? Would you carry different items–if, yes, be specific. Would you be open different hours?

3. What would encourage you and your family to drive less? Could there be anything added to the neighborhood that would make driving less feasible?

4. If you don't currently walk or ride a bike, why not? Could anything be changed in the neighborhood so you would walk and ride a bike more?

5. Decide on what you believe would be the Three Best Neighborhood Improvements and add them to your original neighborhood map.

Improving the Neighborhood Map

Once the small groups have decided on their three (3) Best Neighborhood Improvements, have them add them to the original neighborhood maps. Encourage the students to use a specific, bright color to mark the additions, so it is obvious, upon observation, what their Improvement ideas are.

Completing the Neighborhood Map

Below is a Checklist of the minimum items for the completed neighborhood maps:

- Legend
- Original detailed information (houses, sidewalks, roads, stores, parks, schools, libraries, gas stations, etc.)
- 3 Best Neighborhood Improvements

III. Optional Video: *Taken for A Ride*

This video discusses how General Motors systematically destroyed the United States public transit system by replacing rail with buses. This video raises excellent questions for discussion and debate.

Student Hand-out

BEST NEIGHBORHOOD IMPROVEMENT IDEAS–FACILITATION QUESTIONS

1. Looking at the map of your neighborhood, what do you believe would be the best improvement to the neighborhood?

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3. What would encourage you and your family to drive less? Could there be anything added to the neighborhood that would make driving less feasible?

4. If you don't currently walk or ride a bike, why not? Could anything be changed in the neighborhood so you would walk and ride a bike more?

5. Decide on what you believe would be the Three Best Neighborhood Improvements and add them to your original neighborhood map.

COMPLETING THE NEIGHBORHOOD MAP

Below is a Checklist of the minimum items for the completed neighborhood maps:

- Legend
- Original detailed information (houses, sidewalks, roads, stores, parks, schools, libraries, gas stations, etc.)
- 3 Best Neighborhood Improvements

Lesson 4: 8th grade
Life-cycle Costs: Learning to Consider the Hidden Costs of Technology

Lesson Overview: Read a short book chapter on the production and use of making a bike (and car).

Lesson Concept: Taking into account the life-cycle costs of a technology. Please note, this book chapter does not take into account disposal, so therefore, it is not a total life-cycle analysis.

Materials:
- *Stuff: The Secret Lives of Everyday Things*
- Note-taking journals
- Pencils
- Erasers

Standards:
- English:
  - IX.11.MS.1 (Inquiry and Research: Define and investigate important issues and problems using a variety of resources).
- Science:
  - I.1.MS.1 (Construct new Scientific and personal Knowledge: Generate scientific questions about the world based on observation).
  - II.1.MS.3 (Reflect on the Nature, Adequacy and Connections Across Scientific Knowledge: Show how common themes of science, mathematics, and technology apply in real-world contexts).
- Social Studies:
  - II.3.MS.4 (Geographic Perspective: Describe the major economic and political connections between the United States and different world regions and explain their causes and consequences).
  - II.5.MS.1 (Geographic Perspective: Describe how social and scientific changes in regions may have global consequences).
  - IV.2.MS.4 (Economic Perspective: Examine the historical and contemporary role an industry has played and continues to play in a community).
  - VI.1.MS.3 (Public Discourse and Decision Making: Explain how culture and experiences shape positions that people take on an issue).

Timeline: 2 - 3 class periods (50 - 60 minutes) depending on the length of each presentation

Class Structure: large class discussion, small group project

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #2
General Assessment Strategy #3

Lesson 4: 8th grade
Life-cycle Costs: Learning to Consider the Hidden Costs of Technology

Lesson Overview: Read a short book chapter on the production and use of making a bike (and car). Then engage in small group debate over the pros and cons of ethanol.

Lesson Concept: Taking into account the life-cycle costs of a technology. Please note, this book chapter does not take into account disposal, so therefore, it is not a total life-cycle analysis.

Materials:

- *Stuff: The Secret Lives of Everyday Things*
- Student Hand-out: Ethanol Discussion–pros and cons
- Note-taking journals
- Pencils
- Erasers

CLASS EXERCISES

I. Reading *Stuff: The Secret Lives of Everyday Things*

The short chapter "Bike (and Car)" on pages 33 – 42 provide an easy to read account of some of the costs associated with making a bike. Oftentimes, we only consider the "sticker price" of an item. But, there are significant costs to consider that consumers may not be aware of such as:

- Production costs
- Transportation of goods
- Worker pay, working conditions, and rights
- Production waste and disposal
- Effects on the environment

II. Class Discussion

Facilitate class discussion based on the following questions:

- Were you surprised by what you read in "Bike (and Car)"? Why or why not?
- When you purchase things do you look to see where it is made?

Then, turn the discussion to: how a new technology may, at first glance, seem like a great idea, but on further investigation (as you learn more about it), there may be "hidden" costs that you didn't at first consider.

III. Small Group Brainstorming Exercise: Ethanol Discussion–Pros and Cons

Ethanol is a particularly interesting topic to discuss given that much of the United States ethanol production is in the agrarian areas of states such as Minnesota, Illinois, Michigan, etc. There is currently (2006) widespread debate about the efficacy of ethanol production. If possible, provide additional resources for the students' to read about the pros and cons of ethanol.

- In small groups, have the students read Ethanol Discussion–Pros and Cons.
- Divide the class into two groups: pro and con
- Have each group create a short argument based on extrapolated ideas from their reading.
- After a 15 minute debates (either full class or 1:1 small group ratios), have the groups change position.
- Debate their new position.

Ethanol Discussion–Pros and Cons

Getty images from www.forbes.com

What is ethanol?
Ethanol is a clear, colorless alcohol fuel made from fermenting the sugars or starches in grains. In the United States corn is the main ingredient used for making ethanol. Currently, Brazil claims the world's highest ethanol production producing the fuel from sugar cane and sugar beets.

How is ethanol used?
Ethanol is typically used as a gasoline additive by blending small quantities (up to 20%) of ethanol with gasoline. The energy content of ethanol is approximately two-thirds that of gasoline by volume. Therefore, since ethanol is less energy dense, it takes more ethanol to travel the same distance than if you were using gasoline.

Do you need a special vehicle to use ethanol?
All reciprocating engine vehicles can use ethanol blends in small quantities. These blends are denoted as E15 or E20 depending on the amount of ethanol blended in the gasoline. With modifications, engines can run on E85.

What are the pros for using ethanol?
Ethanol burns more completely than gasoline therefore reducing emissions. It can be used as a blend to boost the octane of the gasoline to prevent engine knocking, and it increases the gasoline's lubricity. Since ethanol can be completely produced in the United States, it has the potential to add to local economies, particularly in agricultural areas, and help reduce oil importation.

What are the cons for using ethanol?
If you a vehicle that uses E85, the price at the pump of E85 varies across the country. Data on E85 prices across the country collected by the DOE (Department of Energy) show that in the Midwest–where much of the United States' ethanol is produced) sells for approximately 30 cents less than gasoline. But, in the mid-Atlantic states, ethanol was 44 cents higher than the gasoline and on the West Coast, nearly 35 cents more per gallon than conventional gasoline.

Also, as mentioned earlier, ethanol contains less energy than gasoline. Therefore, if using E85, your fuel economy will be reduced by 20% – 30%.

What are the costs associated with ethanol production?
Corn has been the main biomass feedstock in the U.S. due to its abundance and low price. But, this low price is deceptive given it has been greatly subsidized by the U.S. government. Furthermore, there isn't enough land to grow the amount of corn needed to greatly reduce the United States dependence on foreign oil imports.

But, what about reducing greenhouse gas emissions by switching to ethanol?
Some say that by using E85, the net CO_2 emissions would be almost zero because the crops used to make the ethanol absorb CO_2 from the atmosphere when they are growing. This CO_2 is then put back into the atmosphere when ethanol is burned in an automobile engine, and then re-absorbed by the newly growing feedstock (crops).

But, what this argument does not take into account is the cultivation and production of ethanol. For example, modern farming equipment used to plant and harvest corn relies heavily on diesel-powered machines. Distilling ethanol is also an energy-intensive process that often uses electricity generated from coal. Transporting the final produce oftentimes relies on transport burning diesel (trucks) or coal (trains). Also, growing corn relies on using large amounts of fertilizer, pesticide, and water.

Are there better solutions than corn to make ethanol from?
According to researchers at the University of California at Berkeley, if ethanol feedstocks were changed to switchgrass and other cellulose based plants, overall greenhouse emissions would be reduced.

Switchgrass is a crop currently grown by some U.S. farmers to control erosion on idle fields. It requires no fertilizer, pesticide, or additional water after germination. The UC Berkeley researchers project a potential 88% reduction in greenhouse gas emissions if technological advances make it possible to make ethanol from materials like switchgrass, scrap wood, wood fiber, or pulp.

Photo: National Renewable Energy Lab

Lesson 5: 8th grade
Consumer Choices: Making a Difference

Lesson Overview: Exploring reinforcing and balancing feedback loops.
Lesson Concept: Linking causes and effects by understanding feedback loops and the difference between reinforcing and balancing feedback and their potential effects.

Materials:
- Note-taking journals
- Feedback Loop Exercises
- Pencils
- Erasers

Standards:
- English:
  - IX.11.MS.1 (Inquiry and Research: Define and investigate important issues and problems using a variety of resources).
- Science:
  - I.1.MS.1 (Construct new Scientific and personal Knowledge: Generate scientific questions about the world based on observation).
  - II.1.MS.3 (Reflect on the Nature, Adequacy and Connections Across Scientific Knowledge: Show how common themes of science, mathematics, and technology apply in real-world contexts).
- Social Studies:
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  - IV.2.MS.4 (Economic Perspective: Examine the historical and contemporary role an industry has played and continues to play in a community).
  - VI.1.MS.3 (Public Discourse and Decision Making: Explain how culture and experiences shape positions that people take on an issue).

Timeline: 2 - 3 class periods (50 - 60 minutes) depending on the length of each presentation

Class Structure: large class discussion, small group project

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #2
General Assessment Strategy #3

Lesson 5: 8th grade
Consumer Choices: Making a Difference

Lesson Overview: Exploring reinforcing and balancing feedback loops.

Lesson Concept: Linking causes and effects by understanding feedback loops and the difference between reinforcing and balancing feedback and their potential effects.

Materials:

- Note-taking journals
- Feedback Loop Exercises
- Pencils
- Erasers

Background Information

We have a responsibility to make wiser decisions about our daily energy use. We also have a responsibility to embrace the understanding that our personal energy-use decisions have a ripple effect throughout the world. But, the first step is to raise awareness and education about energy issues. Then, we must learn how to navigate making complex decisions in the face of competing, and oftentimes, conflicting desires and goals.

CLASS EXERCISES

I. Brainstorming Session Using Feedback Loops

This lesson requires synthetic thinking and an understanding of cause and effect. Given that this is an introduction to feedback loops, they will be introduced as simple models without explaining amplification or weighting.

Background Information

In general, when analyzing complex problems, one strategy is to determine what causes outcomes to be balancing or reinforcing.

One example to describe this idea, is the following story:

There is a small child crying in the supermarket because they want some candy. The parent tells the child they cannot have the candy. (The crying increases). The child then grabs a bag of candy off the shelf. In response, the parent takes the bag of candy away from the child and scolds the child. (The crying increases even more). As both, the child and the parent become increasingly frustrated, the child's crying becomes stronger and the parent's frustration becomes stronger.

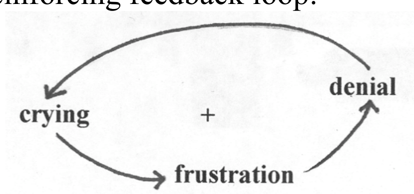
This is an example of a reinforcing feedback loop. There is an initial cause (the child wants candy), then a response (the child cries), and then a reinforcing behavior to the response (the parent denies the child candy). The frustration of the parent and child then begin to reinforce one another and escalate the situation.

The situation will not be resolved (the child stop crying) until a different method is taken–diversion about something else by the parent, the parent does not engage in an emotional power struggle with the child, the child decides they no longer want the candy, etc. In other words, all of those tactics would then become balancing to the situation–cause a different result or course of action to the situation.

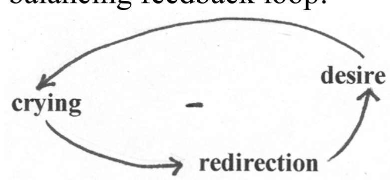
When we draw feedback loops, balancing is indicated with a minus (-) and reinforcing with a plus (+):

Balancing -
Reinforcing +

An example of how to draw a reinforcing feedback loop:



An example of how to draw a balancing feedback loop:



A. Living Loops Class Exercise

This group exercise is taken (and slightly modified) from *The Systems Thinking Playbook Volume III* by Linda Booth Sweeney and Dennis Meadows. This exercise, *Living Loops*, can be found on pages 58 – 75.

The Living Loops exercise helps "participants understand the differences between open and closed chains of causation–when there is no feedback and when there is. It also illustrates, in a physical way, the kinds of behaviors that reinforcing and balancing behaviors loops create." This exercise also "encourages participants to hypothesize about the impact of simple change in the sign of a link or loop, and then to test their hypotheses. This activity is a smiple, effective, and engaging way to physically, mentally, and emotionally experience the two building blocks of system behavior. All learners–but particularly those who learn best through physical experience–can benefit from Living Loops." (p. 59)

Tools for the Exercise

- An even number of participants (at least 6): if there are students remaining, they will act as the note-takers and write down their observations
- Enough space in the room so all of the participants can stand shoulder to shoulder in a straight line

- 3x5 index cards (1 for every participant): divide the cards into 2 equal stacks–write a + (plus sign) on 1 stack of cards and write a – (minus sign) on the other stack of cards
- tape
- a small light weight ball

Setting up the Exercise

- Shuffle all of the index cards together
- Tape 1 card to each participant
- The person at the end of the line (far left side) holds the ball
- Explain that their left hand is the action hand and their right hand is the passive hand. This means that their right hand moves in the same direction as the left hand of the person next to them (on their right).
- Explain that the index cards indicate what type of motion they will do in the exercise: everyone with a + sign will do the same motion with their left hand that they did with their right. Everyone with a – sign, their left hand will do the opposite motion of their right hand.
- For example:
    - All of the students are standing in a straight line shoulder to shoulder
    - Begin at the right side of the line (facing forward to your right)
    - The first person has a + sign (for example), they will then move both hands up 4" above their waist
    - The person next to them (on their left) has a + sign also, so their right and left hand both move up 4" above their waist
    - The next person (the 3rd person in the line) has a – sign, so their right hand moves up but their left hand moves down
    - And so on. . .
    - Once the motion reaches the end of the line, the ball will either move up or down depending on the last person's sign

Object of the Exercise

To see how long it will take for the ball to reach the floor. Go through the line as many times as necessary for the ball to reach the floor.

Questions for the Class:

- How long did it take?
- What would happen if the signs were changed?
- Can the students brainstorm a way to get the ball to the floor more quickly?

B. Reinforcing Closed Loop Exercise

Now, try a variation of the exercise. Change all of the signs to a +. Then, have everyone in the line form a circle. The person at the former end of the line who is holding the ball is still holding the ball in their left hand. The former 1st person in the line now raises their hand. See what happens around the circle.

Ask the class what is happening? What might happen if the signs were changed to everyone wearing the – sign? How long would it take for the ball to reach the floor?

Debriefing

When the same action continues, this is a reinforcing action–it reinforces the behavior (action). When there is a change, this a called a balancing action because the action is changed. Now, the broader question is their can be both positve and negative reinforcing actions as well as positive and negative balancing actions.

C. Brainstorming Reinforcing and Balancing Actions

Have the class brainstorm 1 (one) scenario with 4 (four) different potential outcomes based on whether there are positive or negative reinforcing actions or positive or negative balancing actions. *But, there needs to be clear consensus on what constitutes "positive outcomes" and "negative outcomes."*

Below is a potential exercise based on global warming:

Reinforcing and Balancing Class Exercise on Global Warming
This final exercise is an opportunity for the class to work together and extrapolate the basic information they have read about global warming.

Once the students have a basic working knowledge of the causes and effects of global warming, introduce the idea of feedback loop diagrams to the class. Essentially, this is a strategy for organizing information that involves different effects that different strategies or information may have on an initial problem.

This is a particularly useful strategy for discussing dynamic situations / problems that have multiple consequences and / or multiple causes–which are most real-world problems.

Given that different groups of students may be more or less versed on the causes and effects of global warming, you may want the students to delve further into global warming research given that the above information is a very quick overview of the issues. One suggestion would be to show the class the *An Inconvenient Truth* DVD. This film is an excellent overview to the issues (historically and at hand) and delves into extrapolating scientific information on global warming to hypothesize future global trends.

Question:

- **What is the relationship between a change in the earth's temperature, snow and ice cover, and driving automobiles?**

Diagrams:

- Create diagrams of feedback loops that are reinforcing (both positive and negative outcomes), and;

Create diagrams of feedback loops that are balancing (both positive and negative outcomes).

Lesson 6: 8th grade
Hybrid Vehicles: a growing alternative

Lesson Overview: In-depth discussion of hybrid technology.
Lesson Concept: Reducing our energy demands and changing our relationship with the automobile remain critical–now and for the future well being of the world and it's inhabitants.

Materials:
- Note-taking journals
- Pencils
- Erasers

Standards:
- English:
  - IX.11.MS.1 (Inquiry and Research: Define and investigate important issues and problems using a variety of resources).
- Science:
  - I.1.MS.1 (Construct new Scientific and personal Knowledge: Generate scientific questions about the world based on observation).
  - II.1.MS.3 (Reflect on the Nature, Adequacy and Connections Across Scientific Knowledge: Show how common themes of science, mathematics, and technology apply in real-world contexts).
- Social Studies:
  - II.3.MS.4 (Geographic Perspective: Describe the major economic and political connections between the United States and different world regions and explain their causes and consequences).
  - II.5.MS.1 (Geographic Perspective: Describe how social and scientific changes in regions may have global consequences).
  - IV.2.MS.4 (Economic Perspective: Examine the historical and contemporary role an industry has played and continues to play in a community).
  - VI.1.MS.3 (Public Discourse and Decision Making: Explain how culture and experiences shape positions that people take on an issue).

Timeline: 2 - 3 class periods (50 - 60 minutes) depending on the length of each presentation

Class Structure: large class discussion, small group project

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #1
General Assessment Strategy #3

Lesson 6: 8th grade
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Materials:
- Note-taking journals
- Pencils
- Erasers

CLASS EXERCISES

I. Reducing Energy Demands
Read the Primer–American in the Spotlight: Energy Demands and Transportation.

II. Global Energy Consumption
Calculate percentages of global energy use for India and China compared with the United States. Discuss the potential effects of China and India increasing their passenger car driving.

III. Hybrid Vehicles
Discuss the Primer and watch the video clips from the website resources.

America in the Spotlight: Energy Demands and Transportation
a primer

THE NUTS AND BOLTS

In general Americans consume a lot of energy–about 1/4 of the world's total energy resources. The average American consumes six times more energy than the world average. We use energy everyday to heat, light, and cool rooms, for manufacturing, entertainment, and transportation.

Representative Countries & Energy Usage, 2002

Country	Population in millions	Energy consumption in quadrillion Btu's
China	1295	43.2
India	1050	14.0
United States	288	97.4
Brazil	176	8.6
Pakistan	150	1.8
Russia	144	27.5
Bangladesh	144	0.6
Japan	128	22.0
Nigeria	121	0.9
Mexico	102	6.6
Germany	82	14.3
France	60	11.0
United Kingdom	59	9.6
Italy	57	7.6
South Korea	47	8.4
Canada	31	13.1

This chart is from the Energy Information Administration website (eia.doe.gov)

OUR AUTOMOBILE ADDICTION

Even though Americans make up less than 5%of the world's population, we own 1/3 of the world's automobiles. According to the EIA, the transportation sector of the U.S. economy accounts for over 1/4 of its energy consumption. Furthermore, the average American uses 500 gallons of gasoline every year and the average vehicle is driven approximately 15,000 miles per year. The United States currently consumes 25% of the world's petroleum total. Also, the average American vehicle's fuel economy is 20 mpg; cars and light trucks account for 40% of U.S. oil consumption and emit 20% of the nation's CO_2 emissions. To put it simply, Americans drive a lot. (These statistics are from the EIA, 2006, website).

Why does it matter that Americans drive a lot?
Exhaust pollutants. Gasoline has been the fuel of choice because it is an energy dense fuel source–which means it takes only a small amount to cause a large reaction. But, the combustion reaction inside of an automobile engine is not perfect and creates large amounts of toxic emissions. These emissions or exhaust pollutants, specifically CO_2, NO_X, and CO, are some of the direct causes of the warming of planet and drastic increases in airborne pollution.

For the first time in history, people are the direct cause of the warming of the planet. This unprecedented event is upsetting the balance of nature causing climatic shifts that, even thus far, have proven to be disastrous for all life. The current rate of habitat loss, increase in storm severity, increase in pollution induced illnesses, and the increase in death, and malformation of those living in areas that are exposed to polluted foods, land, and water is intensifying at an alarming rate around the globe.

> Global warming solutions will not succeed unless automobile emissions are controlled. According to Sierra Club research, "**if U.S. autos were a separate country, they would be the world's fifth largest global warming polluter**." Recall, also, that the United States accounts for 5% of the global population and accounts for using 25% of the world's resources. That places us as the world leader in per-capita energy use.

What can be done?
Given these statistics, the single most effective thing Americans can do is reduce their energy demands. Drive less, and walk, bike, carpool, and public transit more. And when we do drive, drive more fuel efficient, lower emission vehicles. In a nutshell, the most important actions we can take to curb global warming are

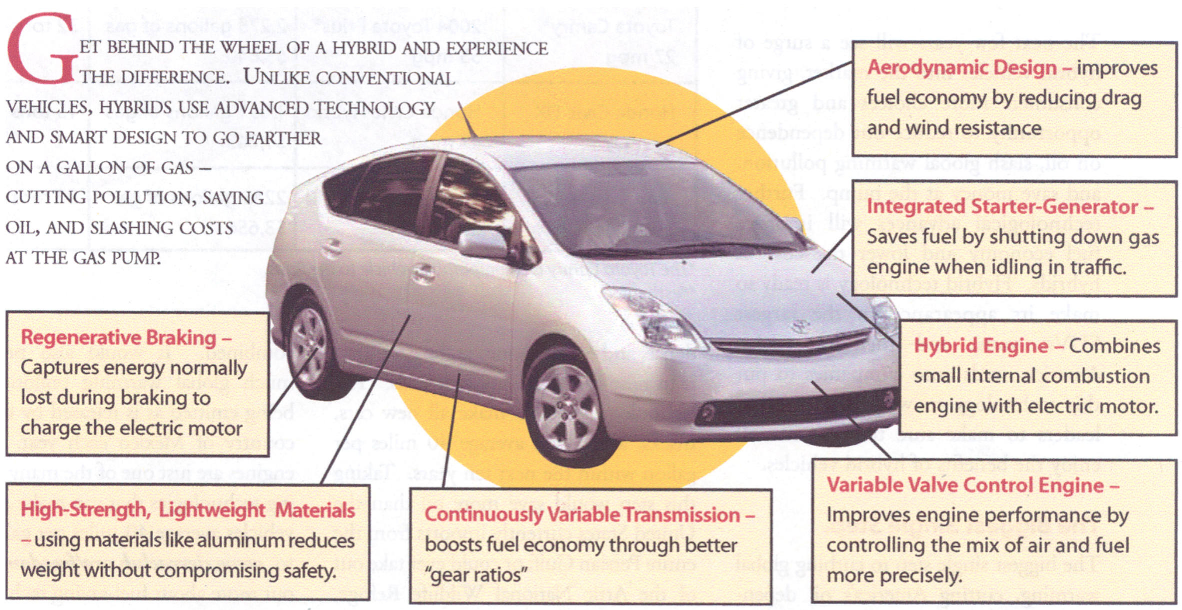
- decrease our energy use, and
- consume energy more efficiently.

THE CONSUMER AUTOMOBILE MARKET–INCREASING OPTIONS

More people in the United States are becoming interested in fuel-efficient vehicles and weighing that consideration–higher mpg–prior to making new car purchases. The automobile industry is responding to the consumer demand and to the mounting scientific evidence that automobiles play a major role in global warming and that globally we are using non-renewable resources at an alarming rate.

Consumers can now purchase hybrid vehicles, and in some areas of the country use biodiesel or ethanol to fuel their vehicles. Below is a cursory look at hybrid technology, ethanol, biodiesel–and a few of the benefits and drawbacks of each new technology.

Hybrid Technology



the above graphic was created by the Sierra Club for their internally developed *Hybrid Cars–Driving Solutions* flyer. The flyer in its entirety can be downloaded from www.sierraclub.org

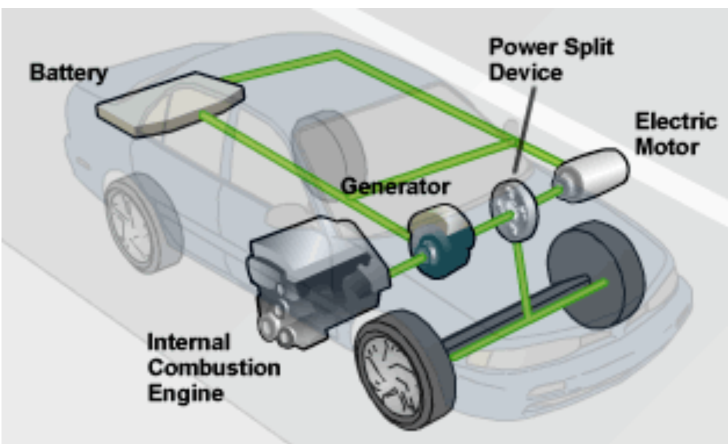
The Concept: How do Hybrids work?

Hybrid vehicles combine an electric-drive motor and an efficient gasoline engine to create a vehicle that gets better-than-average U.S. fuel economy plus reduced emissions.

Please see the following website for a 3-d illustration to view the different parts of a hybrid car. www.howstuffworks.com/hybrid-car.htm

Do hybrids have to be plugged in to recharge?

No. Even though hybrids use electric motors that draw power from a battery, they never have to be plugged in. The battery is recharged from two sources: a generator powered by the internal combustion engine and through reclaiming the energy that is normally wasted when the brakes are used.



This image is from www.fueleconomy.gov/feg/hybridtech.shtml. This is an excellent resource providing flash animation of this diagram illustrating how a hybrid engine works.

How do hybrids reclaim normally wasted energy from using the brakes?
This technique is called regenerative braking. This is how it works: hybrids use a combination of an electric motor and an electric generator. A generator is a motor ran in reverse. In the hybrid system, when you step on the brakes, instead of the friction (inertia) converting into heat–which is what happens in non-hybrid vehicles–they connect the generator to the battery that charges the electric motor.

How is the gasoline engine more efficient?
The gasoline engine can be smaller in a hybrid than in a non-hybrid vehicle because the electric-drive motor assists in acceleration. (**Remember, the electric motor is being charged each time the brakes are pressed).

Hybrids: better gas mileage / fewer emissions

There are several hybrids currently available from different automobile companies (Toyota, Honda, Ford, Mercury, and Lexus). Given the continued increase in gasoline prices coupled with an increase in consumer awareness and concern over energy issues, there may be an increase in hybrid vehicles into the automobile market.

The Sierra Club has compiled the chart below to compare three hybrid vehicles and the equivalent all-gasoline vehicles. This information can be found in the Sierra Club's publication: *Hybrid Cars–Driving Solutions*.

Hybrid / All Gasoline Comparison Chart

Traditional Vehicles	Hybrid Vehicles	Lifetime Fuel Savings	Emissions Prevented
Toyota Camry 27 mpg*	Toyota Prius 55 mpg*	2,275 gallons of gas $3,640	32 tons CO_2
Honda Civic DX 33 mpg*	Honda Civic Hybrid 47 mpg*	1,091 gallons of gas $1,745	15 tons CO_2
Ford Escape XLT 22 mpg*	Ford Escape Hybrid 37 mpg*	2285 gallons of gas $3,656	32 tons CO_2

*estimated mpg

Lesson 7: 8th grade
Engine, Transmission, Brakes, and Steering

Lesson Overview: Demystifying how a car moves.
Lesson Concept: An overview explaining how energy is transferred to propel an automobile.

Materials:
- Note-taking journals
- Pencils
- Erasers

Standards:
- English:
  - IX.11.MS.1 (Inquiry and Research: Define and investigate important issues and problems using a variety of resources).
- Science:
  - I.1.MS.1 (Construct new Scientific and personal Knowledge: Generate scientific questions about the world based on observation).
  - II.1.MS.3 (Reflect on the Nature, Adequacy and Connections Across Scientific Knowledge: Show how common themes of science, mathematics, and technology apply in real-world contexts).
- Social Studies:
  - II.3.MS.4 (Geographic Perspective: Describe the major economic and political connections between the United States and different world regions and explain their causes and consequences).
  - II.5.MS.1 (Geographic Perspective: Describe how social and scientific changes in regions may have global consequences).
  - IV.2.MS.4 (Economic Perspective: Examine the historical and contemporary role an industry has played and continues to play in a community).
  - VI.1.MS.3 (Public Discourse and Decision Making: Explain how culture and experiences shape positions that people take on an issue).

Timeline: 2 - 3 class periods (50 - 60 minutes) depending on the length of each presentation

Class Structure: large class discussion, small group project

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #1
General Assessment Strategy #3

Lesson 7: 8th grade
Engine, Transmission, Brakes, and Steering

Lesson Overview: Demystifying how a car moves.
Lesson Concept: An overview explaining how energy is transferred to propel an automobile.

Materials:
- Note-taking journals
- Pencils
- Erasers

BACKGROUND INFORMATION
Most of us do not consider how a car moves other than stepping on the gas pedal in order to move forward or backward or stepping on the brake pedal in order to stop. Given that the majority of Americans take for granted the phenomenon of moving approximately 4,000 lbs down a road, this lesson provides a brief overview of the basic components necessary to move a modern automobile.

If students do not have a working understanding of combustion and 4-cycle engines, please refer to the 7th grade curriculum, Lesson 8.

CLASS EXERCISES
I. Moving Mass: assessing student prior knowledge
Organize the class into small groups of 2 – 4 students. Then ask them to discuss the following questions and write down their answers in their class journals.

On average, provide 5 minutes per question. This is a quick assessment tool to gain information on what the different levels of the students' prior knowledge.

Question #1: What do you believe is the average weight of an American car today? (The average weight of an American car is 4,000 lbs.)

Question #2: Describe the basic components of a car.

Question #3: In as much detail as possible (including drawings and illustrations), describe how a car moves.

II. Discussion: assessing student prior knowledge
Discuss the small groups conclusions. If there are differing responses, write them on the board or a large piece of paper.

III. Small group project: Illustrating the reading–From Engine to Braking: An overview of the basic components of a car
In small groups, ask the students to read the overview, *From the Engine to Braking: An overview of the basic components of a car*. Then ask the small groups to synthesize the reading material into either one (1) composite drawing, or a series of drawings illustrating how the energy of gasoline is converted into motion.

From the Engine to Braking: An overview of the basic components of a car

illustration from www.khulsey.com/demo_howto_car.html

Something to sit in

Open the door. Sit down. Turn the key in the ignition. Start the car. Take a drive. A modern car is built from many components. But, we first begin our explanation by asking, "Before we start the engine, what are the different parts that create the 'body' of the car?"

The frame, the wheels, the tires, and all of the equipment that holds these parts together are referred to as the running gear. The wheels are attached to the frame by the suspension system–axles, control and support arms, shock absorbers, and springs.

Starting the engine

Now we are ready to start the car. The starting system consists of an electric starter motor and a starter solenoid. When the key is turned in the ignition, it activates the starter solenoid to power the starter motor. The starter motor spins the engine a few revolutions so that the combustion process can begin. Given that it takes a large amount of energy to spin a cold engine, modern cars use a 12-volt electrical system that can handle large amounts of current. The starter solenoid is essentially a large electronic switch that can handle these large amounts of current. (How Stuff Works: How Car Engines Work by Marshall Brain)

Keeping the engine running (the following text has been excerpted from www.millville.org)

Now that the car is successfully running, what keeps it going? The engine.

> The engine is the powerhouse of the automobile. Modern gasoline-powered automobiles almost exclusively have internal combustion engines. The engine consists of the main block. The block houses at least four cylindrical combustion chambers (depending on how many combustion chambers there are equals how many cylinders the car has–4-cylinder, 6-cylinder, 8-cylinder, etc.) where a piston slides up and down. There are two valves in the top of each cylinder–an intake valve and an exhaust valve–which are opened and closed at the proper time by cams on the camshaft.
>
> The camshaft is geared to the crankshaft at the bottom of the engine. The pistons are attached to the crankshaft by what are called connecting rods.

The crankshaft transforms the up-and-down motion of the piston in the cylinder into rotary motion. The four-stroke engine operates as follows: The cycle is a four-stroke process. One stroke equals each time the piston moves up or down. During the first stroke, the piston moves down and the intake valve opens, drawing in a volatile mixture of gasoline and air in through the intake manifold from the carburetor. The second stroke, or the compression stroke, is when the intake valve closes, and the piston moves up, compressing the air-fuel mixture in the top of the chamber. In the next stroke, the power stroke, the gasoline-air mixture is ignited by the spark plug at the top of the engine just as the piston reaches its highest position and the gas is compressed the most. When the air-fuel mixture is ignited, the sudden, violent expansion drives the piston downward, turning the crankshaft. In the fourth stroke, the piston moves back up and the exhaust valve opens, pushing the exhaust fumes and unburned gasoline out of the exhaust valve and out through the exhaust manifold to the muffler and catalytic converter. The piston starts the process all over again. In a multi-cylinder engine, the pistons and their respective valves are carefully timed so that the crankshaft is turned continuously and smoothly.

The engine is cooled by a jacket around the piston through which water–usually mixed with antifreeze–is pumped by a small pump driven by the crankshaft or camshaft. The water is also pumped through the radiator where it is cooled by the air rushing through it.

The engine is lubricated by the use of oil. The oil is kept in the oil pan at the very bottom of the engine. The oil is pumped up through to the crankshaft bearings and through drilled holes in the crankpins. (The pistons are connected to the crankshaft via the crankpins). In some systems, the oil also lubricates the connecting rods and the walls of the cylinder.

Transferring the energy from the engine to the wheels
The transmission system allows the engine and wheels to turn at different speeds. The transmission system transfers the power produced by the turning of the crankshaft all the way out to the tires on the road. There are two types of transmissions: automatic and manual. In each type of transmission the energy is transferred from the engine to the end of the crankshaft. At the end of the crankshaft is the flywheel. The flywheel is connected to the clutch and the clutch is the mechanism that facilitates changing gears. Also, the energy from the transmission is transferred to the drive shaft and universal joints to the rear or front differential. From the differential the energy is transferred to the axles.

Steering the vehicle
The steering system consists of a steering wheel mounted on a column and attached to a steering tube inside the column. This column is connected (at the other end) to the steering gear. Most modern cars have power steering in which a hydraulic system is used to reduce the driver's effort needed to turn the steering wheel.

The steering system allows the driver to turn the front and back wheels. This enables steering while the car is moving.

Stopping and slowing down

The braking system facilitates stopping and slowing the vehicle. The brake system usually consists of a foot brake pedal and an emergency brake. When depressed, the foot brake pedal engages the braking hydraulic system to put pressure on all four wheels of the car. Depending on the amount of pressure applied to the brake pedal, the amount of friction applied to the wheels will vary resulting in either slowing or stopping the car.

In a nutshell

Essentially the key is turned in the ignition to create a spark that when perfectly timed will ignite the energy dense gasoline and begin the combustion process. The energy from the engine is transferred via the transmission out to the wheels of the car. There are interconnected systems to steer and slow / stop the vehicle.

Lesson 8: 8th grade
Design Lego Racers using Lego Digital Designer Program

Lesson Overview: Designing a car built of Lego using a free, downloadable design program.
Lesson Concept: Gain 3-dimensional, relational understanding: provide easy to use to tools to help facilitate the students' ability to turn and "see" objects 3-dimensionally in their mind.

Materials:
- Computers
- Download Lego Digital Designer program (free)

Standards:
- English:
  - IX.11.MS.1 (Inquiry and Research: Define and investigate important issues and problems using a variety of resources).
- Science:
  - I.1.MS.1 (Construct new Scientific and personal Knowledge: Generate scientific questions about the world based on observation).
  - II.1.MS.3 (Reflect on the Nature, Adequacy and Connections Across Scientific Knowledge: Show how common themes of science, mathematics, and technology apply in real-world contexts).
- Social Studies:
  - II.3.MS.4 (Geographic Perspective: Describe the major economic and political connections between the United States and different world regions and explain their causes and consequences).
  - II.5.MS.1 (Geographic Perspective: Describe how social and scientific changes in regions may have global consequences).
  - IV.2.MS.4 (Economic Perspective: Examine the historical and contemporary role an industry has played and continues to play in a community).
  - VI.1.MS.3 (Public Discourse and Decision Making: Explain how culture and experiences shape positions that people take on an issue).

Timeline: 3 - 5 class periods (50 - 60 minutes) depending on the amount of computer access or teaming with the computer lab educator to team teach this part of the curriculum.

Class Structure: small group design and building project

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #3
General Assessment Strategy #4

Lesson 8: 8th grade
Design Lego Racers using Lego Digital Designer Program

Lesson Overview: Designing a car built of Lego using a free, downloadable design program.
Lesson Concept: Gain 3-dimensional, relational understanding: provide easy to use to tools to help facilitate the students' ability to rotate and "see" objects 3-dimensionally in their mind.

Materials:
- Computers
- Download Lego Digital Designer program (free)

BACKGROUND INFORMATION

Lego Digital Designer is a free, downloadable computer program. This program has been created for individuals to create their own Lego designs, and then, purchase them. In order to use the program, there is no purchase necessary. The program is akin to a CAD pre-cursor: laid out on 3-d grid, the user has the ability to turn the object they are building in 3-dimensions and build an object (brick by brick) using a variety of Lego parts (bricks and connectors).

The program is very user friendly. All projects can be saved, filed and accessed later. Internet access is necessary in order to used Lego Digital Designer Program.

CLASS EXERCISES

I. Introducing the Model Solar Car Building Project

The first step is to introduce the final project–building a model car that will run on solar power. The significance of this hands'-on project is multi-fold:

- Test out designs using familiar, accessible and easily re-constructed materials (Lego)
- Develop working understandings of the inter-related parts of a vehicle
- Create and test hypotheses
- Develop working understandings of how a solar panel works
- Develop 3-dimensional "sight" in their mind
- Facilitate successful small group experiences
- Foster healthy competition

You may want to first have the students draw their model cars on paper, but we suggest beginning directly with the Lego Digital Designer program so the students will have the most amount of time working with a 3-dimensional object visualized on the computer.

II. Designing, Building, and Refining Model Solar Cars

Step #1: Introduce final project: building model solar car using Lego
Step #2: Divide the class into small groups of 2 – 4 students
Step #3; Download Lego Digital Designer onto all of the computers
Step #4: Begin building model cars on the computer
Step #5: Agree on model solar car design and print out brick list
Step #6: Build model solar cars using real (not virtual) Lego parts
Step #7: Test out how well the model solar car glides
Step #8: Refine model solar car as necessary either with or without computer assistance
Step #9: Finalize model solar car design
Step #10: Design where solar panel and motor will be attached
Step #11: Refine, re-design as necessary
Step #12: Prepare to add the solar panel and motor

Lesson 9: 8th grade
Adding the Solar Panel to the Model Cars

Lesson Overview: Adding the solar panel to the model car.
Lesson Concept: Gain a basic understanding of how a solar panel works.

Materials:

- Lego parts
- Completed car designs or a model prototype
- Solar panels

Standards:

- English:
  - IX.11.MS.1 (Inquiry and Research: Define and investigate important issues and problems using a variety of resources).
- Science:
  - I.1.MS.1 (Construct new Scientific and Personal Knowledge: Generate scientific questions about the world based on observation).
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Class Structure: small group design and building project

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #1
General Assessment Strategy #4

Lesson 9: 8th grade
Adding the Solar Panel

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Lesson Concept: Gain a basic understanding of how a solar panel works.

Materials:
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- Completed car designs or a model prototype
- Solar panels

I. Demystifying solar panels: how do they work
Read and discuss the questions in the PV Primer.

II. Mounting the solar panel to the model LEGO car
Please see the website resources in Lesson 10 for additional resources in how to mount the solar panels.

PV Primer: a brief explanation of how solar panels work

12 kW photovoltaic (PV) array at Western Michigan University, Kalamazoo MI
photo courtesy of Dr. Harold Glasser

What is a solar cell?
A solar cell is a device that directly converts the energy in light (electromagnetic energy) into electrical energy. Once used almost exclusively in space, they are now used to provide electrical energy for calculators, street lights, emergency road signs, businesses, and homes.

How does a solar cell work?
The most basic answer is the following. Photovoltaic cells are made of materials called semiconductors–most commonly silicon. When the light strikes the cell, a certain portion of the light is absorbed within the silicon and the electrical energy of the light is transferred to the semiconductor material. The electrical energy knocks electrons loose allowing them to move freely. This flow of electrons is a current. By placing metal contacts on the top and bottom of the semiconductor material, the current can be drawn off and used.

There are also ultra-thin layers of different types of silicon sandwiched together within one photovoltaic cell. This creates an electrical field and forces the electrical current to flow in one specific direction.

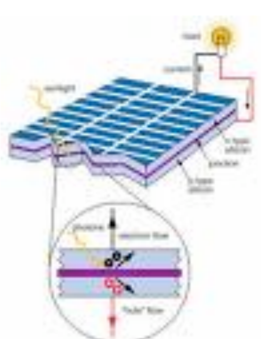

image from www.corrosion-doctors.org/Solar/cells.htm

How long have solar cells been used?

The term photovoltaic comes from the Greek “phos” which means “light” combined with “volt” in honor of Alessandro Volta who is considered a pioneer in studying electricity.

The first modern photovoltaic cells were made in the late 1950s. Throughout the 1950s and 1960s, solar cells were used primarily to provide electricity for earth-orbiting satellites. In the 1970s, improvements in quality, performance, and manufacturing were implemented and pv cells began being used in a wide variety of circumstances–powering remote land stations, navigational signals, and telecommunication equipment in critical, low power settings. In the late 1980s, photovoltaic became a popular source of power for consumer electronics.

After the energy crisis of the 1970s, efforts to develop pv systems that could power homes and commercial buildings began in earnest. Today, the pv industry is growing and photovoltaic technology is becoming more advanced while creating a higher output of energy.

Lesson 10: 8th grade
Testing and Refining the Solar Car Design

Lesson Overview: Test and refine the completed model solar car.
Lesson Concept: Successfully complete the model solar car building project and have a fun, safe race day.

Materials:
- Completed model solar cars
- A designated race way

Standards:

Science:
  - II.1.MS.3 (Reflect on the Nature, Adequacy and Connections Across Scientific Knowledge: Show how common themes of science, mathematics, and technology apply in real-world contexts).

- Social Studies:
  - II.5.MS.1 (Geographic Perspective: Describe how social and scientific changes in regions may have global consequences).
  - VI.1.MS.3 (Public Discourse and Decision Making: Explain how culture and experiences shape positions that people take on an issue).

Timeline: 5 class periods (50 - 60 minutes) depending on the amount of assistance the students need to complete and test the models

Class Structure: small group building & testing

Assessment Strategy: EEK! Daily Assessment
General Assessment Strategy #4
Post-Module Assessment #1, #2, #3

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Background Information

I. NREL Resources

The National Renewable Energy Lab holds an annual model solar car competition every year. Even if your class or school is not competing in this race, there are a variety of well-researched, thorough, and explicit model solar car plans and curricula available for free. Please utilize the following websites if you or your students need assistance in any aspect of building the models.

- www.teachersdomain.org/resources/psu06/energy21/sci/solarracing/index.html
- www.nrel.gov/docs/gen/fy01/30830.pdf
- www.pspb.org/e21/media/Solar%20Racing_v105_LP.pdf