Lesson 2 - Design a Robot

Grades: 6-8

Essential Questions:

- What steps do manufacturers take to design and build a product?
- What role does robotics have in manufacturing?
- How have robotics changed how products are manufactured?
- How is energy transferred between objects or systems?

Lesson Overview:

Students will explore the role of robots in advanced manufacturing and be challenged to apply steps in advanced manufacturing processes to design a robot with markers (or another drawing tool) that moves across a piece of paper. They will design this with markings as it moves. Students will change the size and location of this weight depending on a mock target consumer. Moving the weight influences how the robot moves, changes how it draws, and impacts the overall design. Students will also describe the energy transfers they have created with their product. Finally, students will discuss how their design helps perform a task and how the steps they have taken simulate an authentic manufacturing process.

Content Objectives:

- Identify roles robotics has in manufacturing.
- Explain the type of energy transfer in their robot.
- Explain how robots have changed how products are manufactured.
- Apply an understanding of modern manufacturing to design and build a product.

National Curriculum Standards:

ETS1.B: Developing Possible Solutions

A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem.

M.B.3

Transfer of Energy

a. Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.

Time Frame:
4-5 class periods (45 minutes each)
Day 1 Lesson Plan
Days 2-3 Lesson Plan
Day 4 Lesson Plan

Background for the Teacher:

Advanced manufacturing is the use of technology to improve products and processes. Professionals involed in advanced manufacturing processes and systems must be able to identify problems, create solutions, think critically, effectively communicate as part of a team, and apply new technologies and skills. In this lesson, students will apply all of these skills to design a robot that solves a specific problem. They will also describe how their robot moves by transferring electrical energy to mechanical energy.

Robotics is branch of technology that deals with the design, construction, operation, and application of robots. Robotics plays an important role in science, technology, engineering, and mathematics because it encourages hands-on learning and the integration of science, engineering, and creative thinking.

Robots are working for us every day, in countless ways. Robots can address a broad range of national needs that include advanced manufacturing. In advanced manufacturing, robots work with, beside, and sometimes instead of people to improve processes, create efficiencies, and perform specific skills.

The first generation of industrial robots were installed in a permanent position and carried out simple tasks and routines. Later generations of robots were programmed to carry out specific actions over and over again; others were more flexible, having to identify objects before performing a task. Today's robots work with or beside people to extend or augment human capabilities. Along with increasing productivity in the manufacturing sector, today's robots assist with dangerous missions, help scientists accelerate discoveries, and improve our safety and well-being.

Some robots are referred to as vibrobots. With a vibrobot, the vibration of the motor makes the robot wobble across the table. This type of robot uses vibrating motors to move and is the type of robot students will build in this lesson.

To understand and explain how their robot moves, students will explore energy and energy transfer. All around us, energy is changing from one form to another. Light energy from the sun changes to heat energy in the rocks, soil, and water on Earth's surface.

People make use of energy transformations in nearly every application of modern life, including transportation, industry, and in their use of household appliances and devices. Vehicle engines change chemical energy in gasoline to kinetic energy. In many power plants, chemical energy in coal or other fossil fuels changes to heat energy as it is burned to heat water and produce steam. Heat energy in the boiling water changes to kinetic energy of the pressurized steam, which spins turbines associated with generators that change kinetic energy to electrical energy. This electrical energy is then used to power everything from industrial machines to household appliances. For example, electric ovens change electrical energy to heat energy and light bulbs change electrical energy to light energy. Battery-powered devices change chemical energy in batteries to electrical energy, and then to other forms of energy.

The tasks in this lesson will help students see that they can create solutions, design and build new products, and work collaboratively as they learn about modern manufacturing processes.

Materials:

- Computer access to display videos
- Paper and drawing materials
- Battery-operated car
- Radio

Activity Sheets

- Crafty Robots Request (1 per student)
- Design Journal (1 per student)
- Evaluating Types of Energy Transfer (1 per student)
- Energy Concept Maps (1 per student)
- Design Process Card Sort (optional)
- Scavenger Hunt (optional)

To Build Robot

- 16 ounce cup, tooth brushes or other flat brushes, assorted sponges
- Foam tape (double sided)
- Low-voltage DC motor with leads attached (anything below 5 volts is fine)
  2 AAA batteries and battery holder (with or without built in power switch)
- Large/wide rubber band
- Electrical tape
- Hot-glue gun
- Thin, washable markers
- Materials to decorate

Day 1

Engage (20-30 minutes) - How have robotics changed how products are manufactured?

1. Display a word splash of the following words: energy, energy transfer, robotics, and advanced manufacturing. Note: A world splash is a collection of key terms or concepts taken from a text. The terms represent important ideas in this lesson.

2. Organize students in groups of three or four. Ask groups to brainstorm and generate complete statements, which predict the relationship between each term and the broader topic. Groups will revisit these statements at the end of the lesson to make any changes based on what they have learned. Invite students to present their ideas.

3. Explain to students that many machines work alongside or with assistance from humans to complete tasks more efficiently. For example, bread-making machines automatically knead and bake bread. An automatic car wash can clean the outside of the car while you relax inside. What other machines help humans complete tasks more efficiently? Ask groups to develop a list of machines, the job they do,

and a brief explanation of how the job used to be done. **Note**: If students have difficulty getting started, you can provide the following examples for them to consider:

- Electric toothbrush
- Audio book
- Calculator
- Sewing machine
- Hand mixer
- Dishwasher
- GPS
- Leaf blower

4. Ask students to draw what comes to mind when they hear the word, "robot." Allow five minutes for students to individually sketch their ideas and to share their image with a partner. Ask students to discuss:
    - What purpose, if any, could your robot serve?
    - What are the similarities and differences between your robot and your partner's?

5. Ask students to share out their examples as the teacher charts their ideas to review the different tasks robots can and might be able to do. **Note:** Several examples of robots can be found on the nasa.gov site if students need more direction with visualizing robots. http://robonaut.jsc.nasa.gov/

6. Summarize by explaining to students that robots are intelligent machines that are designed to work for and alongside humans to solve problems, improve processes, and create efficiencies. Share with students that they will be working as part of a team to design and build a small robot that could help humans manufacture a physical good.

Days 2-3

Explore (60-90 minutes) - What roles do robots have in advanced manufacturing?

1. Explain to students that manufacturers use technology to improve processes or products. Robotics is a branch of technology that deals with the design, construction, operation, and application of robots. Robots are designed to perform tasks that humans find dangerous or boring, and they can perform these tasks with consistent speed and precision. For example, a robot might twist the caps onto jars coming down an assembly line. These machines work alongside humans to perform an increasing number of manufacturing tasks.

2. Share the video ***Robotics Technicians***. After watching the video, ask students to discuss the following questions in small groups.
    - What roles do robots play in advanced manufacturing?
    - How do humans and robots work together?
    - What steps in an engineering design process are explored in the video?
    - How has robotics helped to shift jobs within advanced manufacturing fields?
    - What would you want to learn about robots or robotics, after viewing the video?

3. Invite groups to present answers to the questions. Then, explain to students that they will be working as part of a team to simulate a process manufacturers go through to design, maintain, and implement

a product based on a request from a fictional art studio. To complete their task, students must simulate the roles of designers, engineers, and robotics technicians, all part of the world of advanced manufacturing. **Note:** If students need more targeted instruction around the design process, distribute the ***Design Process Card Sort*** cut and shuffled to pairs of students. Students can sequence the cards in the order of the design process. Direct pairs to start with, "Identify a Problem."

4. Distribute the ***Crafty Robots Request,*** and display the materials students will have available to design and build their robots. Organize students into groups of three or four.

5. Invite students to read the request and to summarize in one sentence what the request is asking them to do. Anticipated responses include designing art paper and designing a machine or robot that creates art.

6. Distribute one ***Design Journal*** to each student. Explain that the ***Design Journal*** involves a series of steps that lead to the development of a new product or system. These steps simulate the process that many manufacturers take as they design and build new products. In this design challenge, students are to complete each step and document their work as they design and manufacture their Crafty Robots.

7. Explain to students that the first step in an advanced manufacturing system is often to identify a problem that needs to be solved. Guide groups to read and complete **Step 1** of their ***Design Journal*** using the ***Crafty Robots Request***. Circulate around the room to answer questions and clarify directions. Allow students the opportunity to walk up and view the displayed materials more closely. **Note:** Anticipated responses are in the ***Teacher Key*** for the ***Design Journal****.*

8. Clarify that their robots will use vibrating motors to move. The vibration of the motor makes the robot wobble across a space. Distribute a motor, 2 AAA batteries, and battery holder to each group of students. Provide 5-10 minutes for students to experiment with their materials to work the motor. Students will connect their wires black-black and red-red to engage their motor.

9. Explain to students that the vibrating motion from their motor will move their robot around the paper. Now, ask students to explore the materials available again and complete **Step 2** of their ***Design Journal.*** Students will identify the criteria, constraints, and materials available to build their robot. All of this information can be obtained from their ***Crafty Robots Request*** and available materials in the classroom. **Note:** Anticipated responses are in the ***Teacher Key*** for the ***Design Journal****.*

10. Guide students to break away from their groups and *individually* design a solution, using **Step 3** of their ***Design Journal.*** In this step, students should consider which materials they want to use and start to sketch out ideas. Some additional considerations are also included in **Step 3** of their ***Design Journal.***

11. Guide students to meet back with their groups to complete **Step 4** of their ***Design Journal.*** In this step, group members will evaluate each other's designs to determine which one to build. Step 4 includes a chart for groups of students to evaluate each design by giving it a score. Students will use this score to guide which idea they would like to build. They might combine multiple ideas. Once they have their final labeled sketch in **Step 5** of their ***Design Journal***, they will need teacher initials to start construction.

12. Direct students to collect the materials they need and to start building their robots. Circulate around the room as students are building. After 20 minutes, clarify with students how they will test their robots. Remind them that their robots must use at least three colors, design similar patterns each time, cover 80% of an 8.5 x 11 piece of paper, and complete this task with minimal guidance from a human. They will test this using provided 8.5 x 11 paper. **Note:** As students are testing, you might need to suggest they use weights to off-center their design for it to move in circular motions.

13. Summarize with students by having them capture the following:
    - How do you feel about your design?
    - Did you solve a problem?
    - What parts of your design do you like? Dislike? Why?
    - How did your design perform a task for a human?
    - Did your design meet the criteria of the request from Manufacturing Arts Studio?
    - What would you do differently next time?
    - What did you learn about advanced manufacturing from this activity?

      Note: If there is time display the finished products around the room and allow students to walk around and see how many robots completed the requested task from Manufacturing Arts Studio.

Day 4

Explain (30-45 minutes) - How is energy transferred between objects or systems?

1. Ask students to describe how their robot worked to a partner. Do not give them much guidance to get started. Instead, allow them 5-10 minutes to evaluate the components of their robot and construct their own explanations.

2. Explain to students that their robot is transferring energy from one component to another and that energy is found in several different forms. Guide students to develop a concept map to organize the different forms of energy and examples of each using the ***Energy Concept Map***. The form of energy and definition are provided in the map already. Students should complete the concept map by matching the examples to the form of energy. **Note**: If time allows there is an ***Energy Scavenger Hunt*** provided for students to explore their school and identify additional examples of energy.

3. Explain to students that these forms of energy can change from one form to another. For example, solar panels transform light energy to electrical energy. Provide two models of energy transfer for students to observe.
    - **First**, Place a battery-operated car on the table. Turn the car on and off several times. How does the car get its energy? What forms of energy did you observe?
    - **Second**, Place a radio on the lab desk. Turn the radio on and off several times. How does the radio operate? What forms of energy did you observe?

4. Ask students to evaluate additional examples of energy transfer using ***Evaluating Types of Energy Transfer***. Students will then conclude at the bottom how their robot moved. Students should identify their robot moved by transferring the electrical energy (from the batteries) to mechanical energy (that moves the motor creating a vibration).

5. Display the word splash (again) of the following words: energy, energy transfer, robotics, and manufacturing. Ask students to review their statements and provide time for them to make modifications.

Evaluate (Time varies depending on assessment selected)

1. Students can be evaluated on their ***Design Journal*** and ***Evaluating Types of Energy Transfer*** summary.
2. Assess final word splash statements.

Crafty Robot Request

WANTED

craftyrobot

Manufacturing Arts Studio *requests prototypes of robots that will create a reproducible, unique pattern for art paper.*

Robots must:

- *use at least three colors*
- *design similar patterns that cover 80% of 8 x 11.5 paper*
- *complete the task with minimal assistance from humans*

Manufacturing Arts Studio offers over 1,000 decorative art paper designs. Their paper is most commonly used in collages, framing, invitations, and wrapping paper. Their bestselling papers include at least three colors and cover the entire page with a print.

Their collection of art is unique and inspiring but they are looking for a new line of designs that can be created at home by the consumer. They are hoping to debut a new line of paper that the consumer can create at home with the help of a small robot and their high quality 8 x 11.5 papers.

Manufacturing Arts Studio

555-543-5432

Engineering Design Card Sort

generating ideas	**making a model or prototype**
identifying criteria and specifying constraints	**developing a design proposal**
communicating results	**selecting a design**
testing and evaluating a design	**refining a design**
identifying a problem	**creating or making it**

Design Journal – Key

The engineering design process involves a series of steps that lead to the development of a new product or system. In this design challenge, students are to complete each step and document their work as they manufacture their Crafty Robot.

Step 1-Identify the Problem

1. What is the problem and/or the need that justifies the project?

Manufacturing Arts Studio wants to offer a new line of paper that the consumer can create at home with the help of a small robot.

2. Who is the target population and who will benefit from the solution?

The target population is artists and consumers that are interested in DIY projects. They will both benefit along with the manufacturer of the robot.

3. How will the result of this solution impact peoples' lives, the educational community and/or the world?

A new application of technology will help artisans and crafters to create collages, frames, invitations, and wrapping paper.

4. What do you need to learn before you begin generating ideas to solve the problem?

How to design a robot that can accomplish this task.

5. What questions do you have about the challenge?

Possible Questions:

What materials do I have available?

Can it be any art medium?

Design Journal

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5. What questions do you have about the challenge?

Step 2-Review the Criteria and Constraints – Key

What are the criteria and constraints for the given problem?

Criteria	Constraint
Must use at least three colors Design similar patterns each time Cover 80% of a 8.5 x 11 piece of paper Complete this task with minimal guidance from a human	Materials available Motion being limited to vibration Size of paper Time

Materials List

Determined by teacher

Step 2-Review the Criteria and Constraints

What are the criteria and constraints for the given problem?

Criteria	Constraint

Materials List

Step 3-Generate Ideas

Additional considerations to guide your sketches:
Where will your robot carry the motor and battery pack?
How will you position art tools on the robot for it to draw on paper?

In the boxes below sketch out your ideas.

Step 4-Refine

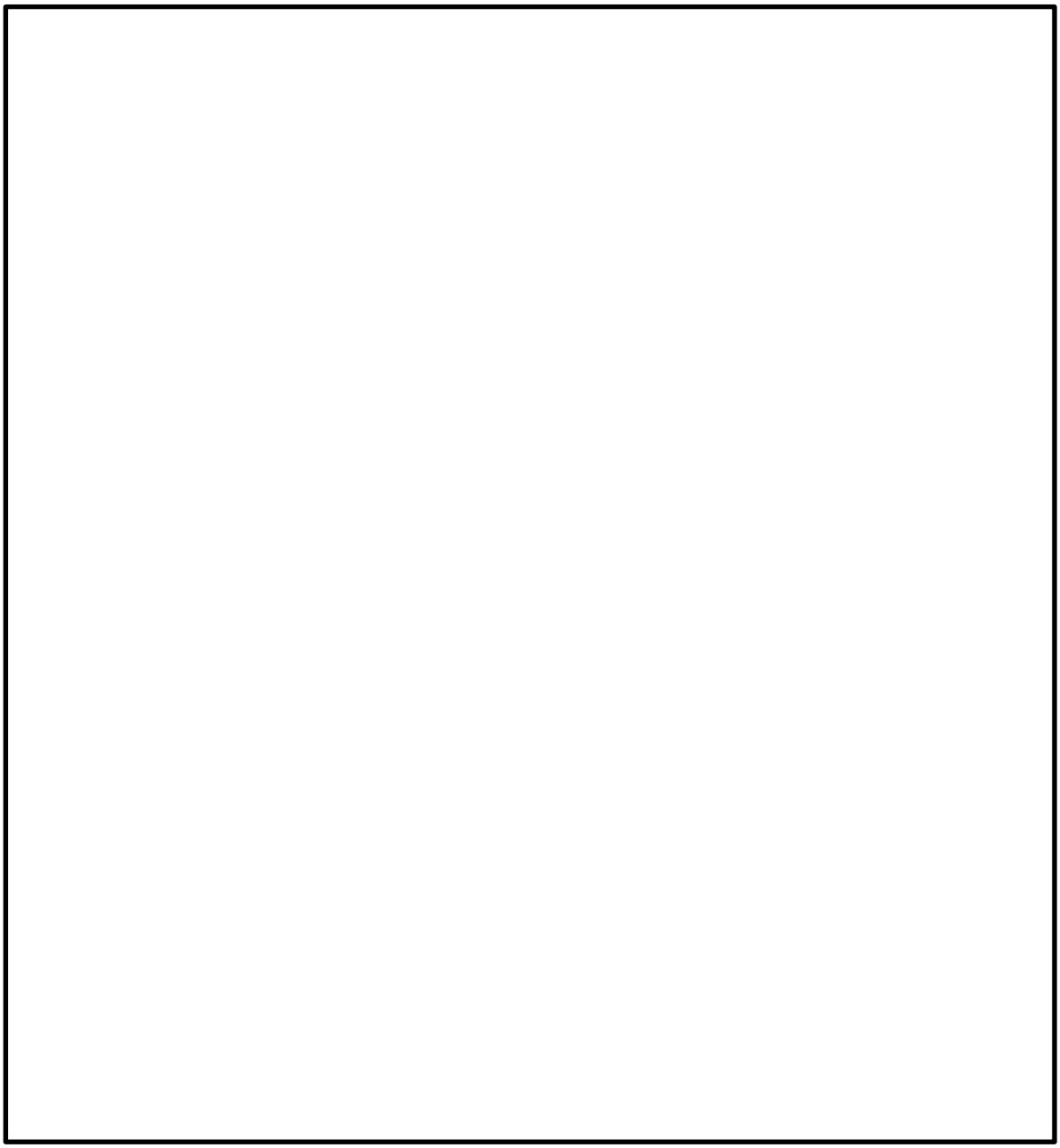
Review your ideas from step 3. Explore some of your ideas in more detail. Record your exploration in the space below. Possible explorations can reflect testing experiments, simulations, peer review, etc. Be sure to include any data collected. To use the tool, complete the following steps:

Enter the criteria and constraints of the project in the first column.
Use a numeric value to rate each solution against the criteria or constraint. (2=totally meets the requirement, 1=somewhat meets the requirement, 0=does not meet the requirement)
Total the columns and circle the highest score.

Constraint	Sketch/Idea 1	Sketch/Idea 2	Sketch/Idea 3
Other criteria: *A single rating for your own "nice-to-have", desirable criteria and universal design criteria, such as:* **Robustness** **Aesthetics** **Cost and Resources** **Time** **Skill Required** **Safety**			
Total			

Step 5-Final Design

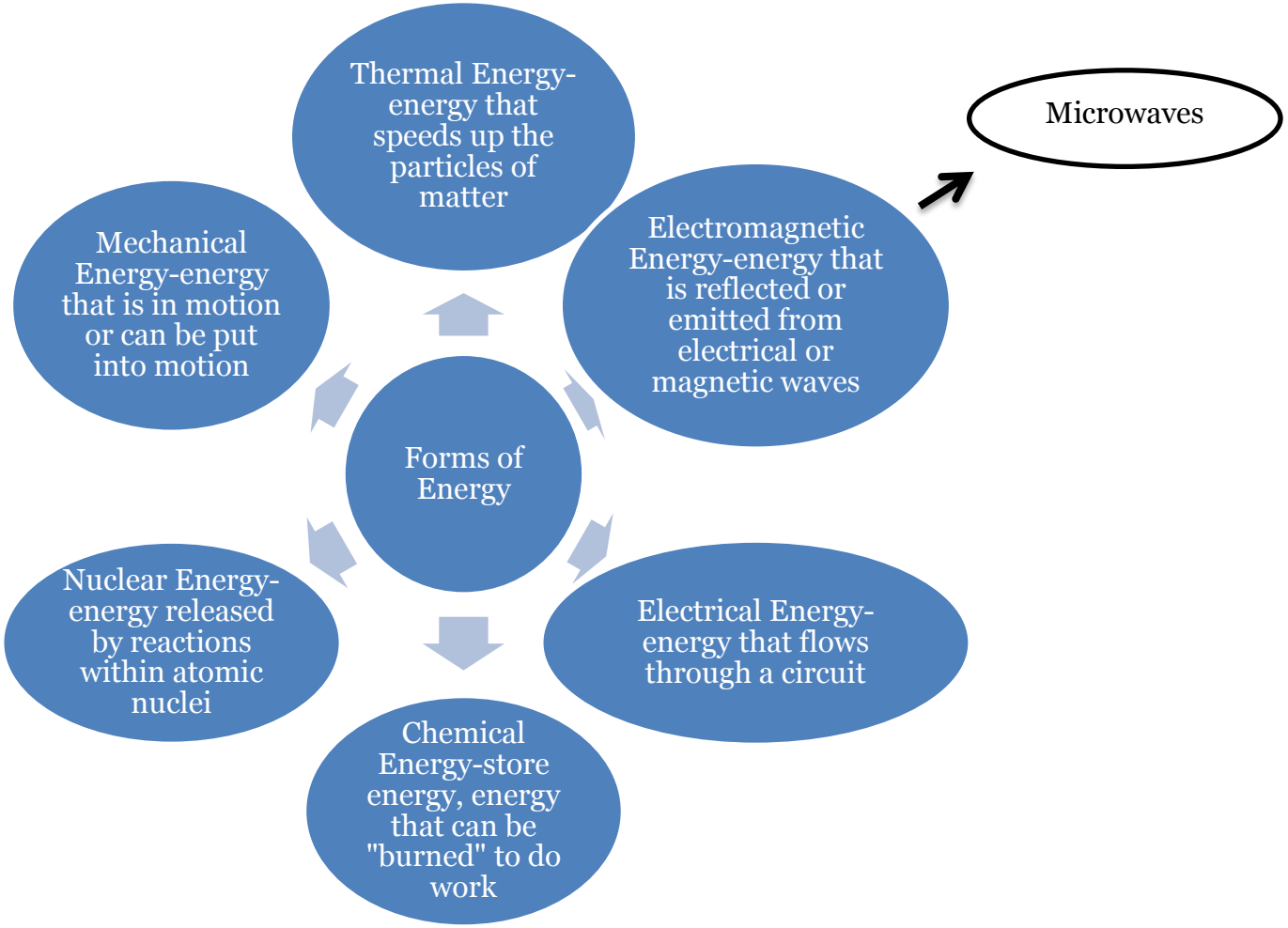
Sketch and label your final design below after consulting with your group.



Teacher Initials _____

Energy Concept Map

Complete the concept map by matching the examples with their form of energy. An example is provided.

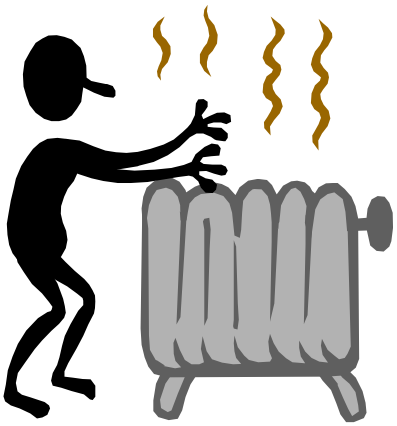


Examples:

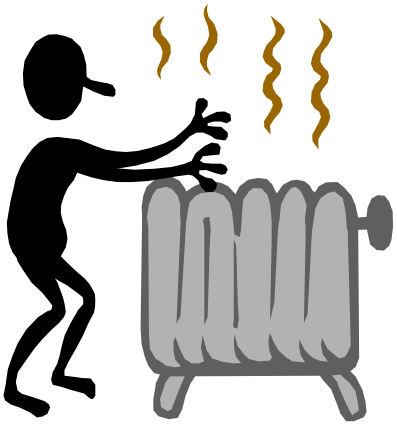
melting ice static electricity moving car food for people batteries

visible light radio waves lightning heating soup nuclear fusion (sun and stars) nuclear power pla

Scavenger Hunt-Key
Walk around your school to identify the following items. Label each example with the form of energy.

 **Nuclear**	 **Electrical**	 **Light Energy**
 **Chemical**	 **(Swing)** **Mechanical**	 **Electromagnetic**
 **Mechanical**	 **Battery**	 **Thermal**

Scavenger Hunt
Walk around your school to identify the following items. Label each example with the form of energy.

		
	 **(Swing)**	
		

Evaluating Types of Energy Transfer

Label the different kinds of energy that are being transformed using your concept map as a guide.

Example	Energy Transformation
A television changes electrical energy into sound and light energy.	
A toaster changes electrical energy into thermal energy and light.	
Nuclear energy generates thermal energy, which can be converted into electrical energy in a nuclear power plant.	
A car changes chemical energy from fuel into thermal energy and mechanical energy.	
A battery-operated car changes electrical energy into mechanical energy to move the wheels.	
A flashlight changes chemical energy from batteries into light energy.	
Light energy is converted into electrical energy using solar panels.	
Campfires convert chemical energy stored in wood into thermal energy.	
Nuclear energy generates thermal energy, which can be converted into electrical energy in a nuclear power plant.	

Summary

I think our motor works by transferring _____ energy in to _____ energy because _____.