Marvelous Machines Making Work Easier:
Simple Machines and Industrial Engineering for Elementary Students
Student Notebook
**What is Technology?**

*Directions: Which of these things are examples of technology? Circle all of the items that you think are technology.*

<table>
<thead>
<tr>
<th>Wind-up Toy</th>
<th>MP3 Player</th>
<th>Bird</th>
<th>Bicycle</th>
<th>Keyboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running Shoes</td>
<td>Volcano</td>
<td>Windmill</td>
<td>Hand-held Fan</td>
<td>Cell Phone</td>
</tr>
<tr>
<td>Sandals</td>
<td>Piano</td>
<td>Oak Tree</td>
<td>Roller Blades</td>
<td>Game Controller</td>
</tr>
<tr>
<td>Broom</td>
<td>Laptop</td>
<td>Bonnet</td>
<td>Basket</td>
<td>Dandelion</td>
</tr>
</tbody>
</table>

What is YOUR definition of the word “technology”?  

_________________________

_________________________

_________________________

_________________________

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### What is an Engineer?

**Directions:** Are these things that an engineer would do at work? Circle YES or NO.

1. Develop better bubblegum  
   - **YES**  
   - **NO**

2. Design ways to clean polluted air  
   - **YES**  
   - **NO**

3. Improve bandages  
   - **YES**  
   - **NO**

4. Figure out how to package bottles so they don’t break  
   - **YES**  
   - **NO**

5. Repair cars  
   - **YES**  
   - **NO**

6. Figure out ways to explore the ocean  
   - **YES**  
   - **NO**

7. Test the properties of soil  
   - **YES**  
   - **NO**

8. Come up with ways to keep soup hot for a picnic  
   - **YES**  
   - **NO**

9. Install cable television  
   - **YES**  
   - **NO**

10. Develop smaller cell phones  
    - **YES**  
    - **NO**

11. Create warmer kinds of cloth  
    - **YES**  
    - **NO**

12. Install wiring  
    - **YES**  
    - **NO**

13. Fix computers  
    - **YES**  
    - **NO**

14. Put roofs on buildings  
    - **YES**  
    - **NO**

15. Improve camera lenses  
    - **YES**  
    - **NO**

16. Create waterproof materials  
    - **YES**  
    - **NO**

17. Fix headlights on cars  
    - **YES**  
    - **NO**

18. Drive garbage trucks  
    - **YES**  
    - **NO**

19. Design tools for surgery  
    - **YES**  
    - **NO**

20. What is an engineer?  
   ____________________________

---

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What is Technology?
Directions: Which of these things are examples of technology? Circle all of the items that you think are technology.

<table>
<thead>
<tr>
<th>Item 1</th>
<th>Item 2</th>
<th>Item 3</th>
<th>Item 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>apple and worm manzana y gusano</td>
<td>cucumber picker pescador de pepino</td>
<td>protective gear equipo protectivo</td>
<td>apple blight tizón de manzana</td>
</tr>
<tr>
<td>map of Mexico mapa de México</td>
<td>apple picking basket bolsa manzanera</td>
<td>hat and scarf pañuelo</td>
<td>Paricutin Volcano * Volcán Paricutín</td>
</tr>
<tr>
<td>moth trap trampa de polillas</td>
<td>Clothing- ropa</td>
<td>sprayer fumigador</td>
<td>hoe- azadón</td>
</tr>
<tr>
<td>guitaron</td>
<td>cell phone fon celular</td>
<td>lady bugs mariquitas</td>
<td>robot suit -traje robótico</td>
</tr>
<tr>
<td>molcajete</td>
<td>blender- licuadora</td>
<td>top- trompo</td>
<td>irrigation system Sistema de riego</td>
</tr>
</tbody>
</table>

What is YOUR definition of the word “technology?” *Paricutín Volcano near San Juan Parangaricutiro, Michoacán
Tower Power Challenge

How can we use 100 index cards and 12" of tape to develop a tower that can hold a bear?

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Picture of tower...

Engineering Showcase: Questions to ask on your tower walk...

- How did your group come up with your design?
- What parts of your design do you think will work well?
- In what ways did your design change as you were building it?
Technology in a Bag...

*What are technologies and who designs them?*

<table>
<thead>
<tr>
<th>What is an engineer?</th>
<th>What is technology?</th>
</tr>
</thead>
<tbody>
<tr>
<td>My First Ideas....</td>
<td></td>
</tr>
</tbody>
</table>

| My New Ideas...     |                     |

*How has your thinking about engineering and technology changed?*

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Technology Around Us

1. What is your object?

2. Draw a picture of your object in this box. Label the parts.

3. What does your object do? What problem does it solve?

4. What material or materials is your object made of?
Lesson 1:
Aisha Makes Work Easier

Focus Question: Who are industrial engineers?

- What kind of problems do industrial engineers solve?
- What projects or jobs might industrial engineers work on?

<table>
<thead>
<tr>
<th>What type of work do you think industrial engineers might do?</th>
<th>Can you suggest any projects that you think industrial engineers might work on?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Aisha Spies Simple Machines

<table>
<thead>
<tr>
<th>What simple machine is used?</th>
<th>Where is the simple machine found? What is its common name?</th>
<th>What problem does it solve?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lever</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulley</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inclined Plane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheel and Axle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wedge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screw</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Lesson 1: Aisha Makes Work Easier

1-2
Lesson One: Alisha Makes Work Easier
Enhanced Vocabulary List

<table>
<thead>
<tr>
<th>Word</th>
<th>Definition</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineer (5-6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial Engineer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(pp.9-10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simple Machine (pg. 11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subsystem (pg. 11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulley (pg. 17)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology (pg. 24)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Vocabulary:</strong> Students can include their initial ideas prior to reading the story. Definitions and pictures can be revised based on context clues within the reading. Additional revisions can also be made after first hand experiences.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Aisha and the Engineering Design Process

*Directions: In the boxes below, write or draw a picture explaining how Aisha completed each step of the Engineering Design Process.*

<table>
<thead>
<tr>
<th>Step of the Engineering Design Process</th>
<th>How did Aisha complete this step?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ask</td>
<td></td>
</tr>
<tr>
<td>Imagine</td>
<td></td>
</tr>
<tr>
<td>Plan</td>
<td></td>
</tr>
<tr>
<td>Create</td>
<td></td>
</tr>
<tr>
<td>Improve</td>
<td></td>
</tr>
</tbody>
</table>
Reflection:

What were some examples of projects industrial engineers worked on at the potato chip factory?

Can you think of any other places where industrial engineers might work?

How do you think the work that industrial engineers do is similar to the work that other types of engineers do?

Extension:

Draw a picture of a simple machine you found in your classroom, school building or neighborhood.
Lesson 2:
Assembly Lines

Focus Question: Is it always most efficient to work alone?

Vocabulary Review:

- Technology:
- Process:
- Engineering Design Process:

Building Assembly Lines:

<table>
<thead>
<tr>
<th>How was making folders by yourself and in groups the same?</th>
<th>Similarities in the Process:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Differences in Process:</th>
<th>Working Alone</th>
<th>Working in a Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Engineering Folder Instructions

1. Using a ruler and a pencil, draw straight lines ¼ inch (or 0.5 cm) from the edge of three sides (both short and one long side) of a piece of construction paper.

2. Put a second piece of construction paper behind the first piece, holding them horizontally.

3. Staple along the pencil lines, placing staples about one inch (or 3 cm) apart.

4. Tape the half sheet of paper (pencil pocket) to the front of the folder.

5. Draw a straight, horizontal line across the pencil pocket. Write the word "Engineering" on the line.
Part 1: Making Engineering Folders
On Our Own

1. Working on our own, the class made ____ folders in 10 minutes.

2. What problems did you have when you made folders on your own?

3. What could you do to solve some of these problems?
Part 2: Making Engineering Folders in an Assembly Line

1. Working in assembly lines, the class made _____ folders in 10 minutes.

2. Which folder-making method was faster? Why do you think so?

   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

3. What are some things that you could do to improve your assembly line?

   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________
Lesson 3
Using Simple Machines

Focus Question: How do simple machines make a job easier?

Predictions:

Which simple machines do you predict will work best to lift heavy things? Why?

Move heavy things sideways? Why do you think so...

Be the most comfortable to use? Why do you think so?

Vocabulary:

Double Pulley  Effort
Inclined Plane  Ergonomics
Lever  Fulcrum
Pulley  Load
Simple Machine  Newton
Wheel and Axle  Test
Trade Off
# Testing Simple Machines: Lever

*Directions: Record your testing results in the table below.*

<table>
<thead>
<tr>
<th>Simple Machine</th>
<th>Scale Reading</th>
<th>Ergonomics</th>
<th>Summary Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lever: Position A</td>
<td>How many Newtons of force did it take to move the load using the simple machine?</td>
<td>Circle the types of movements you needed to do to move the load.</td>
<td>What is the relationship between the length of the lever arm and the amount of force needed to lift the load? Which position felt easiest?</td>
</tr>
<tr>
<td><img src="image" alt="Lever A" /></td>
<td></td>
<td>Bend over Pull upward Pull downward Push the load</td>
<td></td>
</tr>
<tr>
<td>Lever: Position B</td>
<td></td>
<td>Bend over Pull upward Pull downward Push the load</td>
<td></td>
</tr>
<tr>
<td>Lever: Position C</td>
<td></td>
<td>Bend over Pull upward Pull downward Push the load</td>
<td></td>
</tr>
</tbody>
</table>
# Testing Simple Machines: Inclined Plane

**Directions:** Record your testing results in the table below.

<table>
<thead>
<tr>
<th>Simple Machine</th>
<th>Scale Reading</th>
<th>Ergonomics</th>
<th>Summary Question</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inclined Plane:</strong></td>
<td></td>
<td>Circle</td>
<td></td>
</tr>
<tr>
<td>Long Board</td>
<td>How many Newtons of force did it take to move the load by hand?</td>
<td>the types of movements you needed to do to move the load.</td>
<td>What is the relationship between the length of the inclined plane and the amount of force needed to move the load?</td>
</tr>
<tr>
<td>Short Board</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Bend over
- Pull upward
- Pull downward
- Push the load
## Testing Simple Machines: Pulley

**Directions:** Record your testing results in the table below.

<table>
<thead>
<tr>
<th>Simple Machine</th>
<th>Scale Reading</th>
<th>Ergonomics</th>
<th>Summary Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Pulley</td>
<td>How many Newtons of force did it take to move the load using the simple machine?</td>
<td>Circle the types of movements you needed to do to move the load.</td>
<td>• Compare how many Newtons of force were needed to lift the load using the single pulley and the double pulley.</td>
</tr>
<tr>
<td>Double Pulley</td>
<td>Bend over</td>
<td>Pull upward</td>
<td>• Now, think about how much rope you had to pull to lift the load the same distance using each pulley.</td>
</tr>
<tr>
<td></td>
<td>Pull downward</td>
<td>Push the load</td>
<td>• What is the trade-off?</td>
</tr>
</tbody>
</table>

**3-17**

**Lesson 3: Using Simple Machines**
# Testing Simple Machines: Wheel and Axle

**Directions:** Record your testing results in the table below.

<table>
<thead>
<tr>
<th>Simple Machine</th>
<th>Scale Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cart: No Wheels</td>
<td>How many Newtons of force did it take to move the load by hand?</td>
</tr>
<tr>
<td>Cart: Wheels and Axles</td>
<td>Circle the types of movements you needed to do to move the load.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Summary Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which cart felt easier to pull, the one with wheels and axles or the one without?</td>
</tr>
<tr>
<td>What do you think the advantage of using the wheel and axle is?</td>
</tr>
</tbody>
</table>

- Cart: No Wheels
  - Bend over
  - Pull upward
  - Pull downward
  - Push the load

- Cart: Wheels and Axles
  - Bend over
  - Pull upward
  - Pull downward
  - Push the load
## Testing Simple Machines: Class Results

<table>
<thead>
<tr>
<th>Simple Machine</th>
<th>Load</th>
<th>Scale Reading</th>
<th>Ergonomics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>How many Newtons of force did it take to move the load by hand?</td>
<td>How many Newtons of force did it take to move the load using the simple machine?</td>
<td>What type of motion did you need to make to move the load?</td>
</tr>
<tr>
<td>Lever: Position A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lever: Position B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lever: Position C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inclined Plane: Long Board</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inclined Plane: Short Board</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single Pulley</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double Pulley</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cart: No Wheels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cart: Wheel and Axle</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Lesson 4
Improving a Factory Subsystem

Focus Question: How can we use our knowledge of simple machines and the Engineering Design Process to design and improve a factory subsystem that makes work easier?

Vocabulary:
- System
- Subsystem
- Factory
- Force

Engineering Design Process
Improving a Factory Subsystem
Engineering Design Process:
Ask!

1. Our goal is:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

2. What materials can you use in your factory subsystem design?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

3. Some things we already know about simple machines are:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

4. How will you know if your design is successful?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Improving a Factory Subsystem
Engineering Design Process:
Imagine! (Page 1)

- What simple machine do you have to use?
- What other simple machines can you use?
- Draw pictures or write your ideas in the box below.
- Circle the idea that you think will work the best.

Idea #1
Improving a Factory Subsystem
Engineering Design Process:
Imagine! (Page 2)

- What simple machine do you have to use? ______________________
- What other simple machines can you use?
- Draw pictures or write your ideas in the box below.
- Circle the idea that you think will work the best.

Idea #2
Improving a Factory Subsystem
Engineering Design Process: Plan!

Directions: Draw a diagram of your factory subsystem design in the box below. Label the parts.

1. List the simple machines you will use in your subsystem design:

   ____________________________________________  ____________________________________________

2. List the other materials that you will need to build your subsystem design:

   ____________________________________________  ____________________________________________  ____________________________________________

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Design #

Improving a Factory Subsystem
Engineering Design Process: Create!

1. The total score for moving the load by hand was ____________.

2. The total score for our subsystem design was ____________.

3. What happened when you tested your subsystem design?

   ____________________________________
   ____________________________________
   ____________________________________
   ____________________________________

4. What parts of your design worked well? Why do you think so?

   ____________________________________
   ____________________________________
   ____________________________________
   ____________________________________

5. What parts of your design did NOT work well? Why not?

   ____________________________________
   ____________________________________
   ____________________________________
   ____________________________________
Scoring Sheet

Directions: Complete the table below after you have tested your subsystem design.

<table>
<thead>
<tr>
<th>Force Score</th>
<th>Moving the Load By Hand</th>
<th>Moving the Load Using a Factory Subsystem</th>
</tr>
</thead>
<tbody>
<tr>
<td>What was the total force (in Newtons) needed to move the load from the floor to the Loading Dock?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(If you used more than one step to move the load, add all of the forces together.)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ergonomic Score</th>
<th>Moving the Load By Hand</th>
<th>Moving the Load Using a Factory Subsystem</th>
</tr>
</thead>
<tbody>
<tr>
<td>When moving the load, did you have to</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ bend over? (+2 points)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ pull upward? (+2 points)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ push the load? (+2 points)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ pull downward? (-2 points)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Score</th>
<th>Moving the Load By Hand</th>
<th>Moving the Load Using a Factory Subsystem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add your Force Score and Ergonomic Score</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Improving a Factory Subsystem
Engineering Design Process: Improve!

Ask Again:
What parts of your factory subsystem design could work better?

Imagine Again:
How could you improve your factory subsystem?

Plan Again:
Draw a diagram of your improved subsystem design in the box below.
Label the parts. List the materials that you will need.

Materials:
Directions: Complete the table below after you have tested your subsystem design.

<table>
<thead>
<tr>
<th>Force Score</th>
<th>Moving the Load By Hand</th>
<th>Moving the Load Using a Factory Subsystem</th>
</tr>
</thead>
</table>
| What was the total force (in Newtons) needed to move the load from the floor to the Loading Dock?  
(If you used more than one step to move the load, add all of the forces together.) | | |

<table>
<thead>
<tr>
<th>Ergonomic Score</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>When moving the load, did you have to</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ bend over? (+2 points)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ pull upward? (+2 points)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ push the load? (+2 points)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ pull downward? (-2 points)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Score</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Add your Force Score and Ergonomic Score</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Lesson 4
Improving a Factory Subsystem

Reflection:

*Did the redesign/improvements to our subsystem result in less force to lift the load?*

<table>
<thead>
<tr>
<th>Claim:</th>
<th>Evidence:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Justification:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>