# Pre-Engineering Program

A LEGO® Education Program

Introductory Simple Machines Program

# Pre-Engineering Program

**LEGO® Education Simple Machines Introductory Program**

**Program Overview:**

This 4-day introductory pre-engineering program outline will provide students with STEM-focused, hands-on activities to promote 21st century skills as well as design engineering. Each day, students will participate in team building activities, engage in opportunities for physical activity, and receive a daily team briefing for daily challenges aligned to standards. Daily challenges will help students develop skills and knowledge to complete the culminating project of designing a geared, wheeled vehicle.

| | Essential Questions | Daily Activities |
|---|---|---|
| Day 1 | **Welcome to Orientation**<br>What are simple machines? What are some things that utilize simple machines? | Explore simple machines<br>What are some machines that utilize them? |
| Day 2 | **Exploration of Gears**<br>What types of gears make machines move? What types of movement can gears have? Where are gears used? | Machines with Gears<br>Trundle Wheel<br>Click Clock |
| Day 3 | **Using Gears and Pawl and Ratchet Together**<br>How can you combine gears and pawl and ratchet to make a windmill? What are ways that wheels can be combined with axles? | Combining Simple Machines<br>Windmill<br>Wheels and Axles<br>Freewheeling |
| Day 4 | **Creating Complex Machines**<br>How can simple machines be combined to make more complex machines? | Complex Machines<br>Power Car<br>Flywheeler<br>Culminating Project: Build your own geared, wheeled vehicle |

**Prior to First Day of the Program:**

1. Sort the sets.
2. Add the AA batteries to the battery pack. Make sure they are turned off. You might wish to keep all the battery packs in a secure location so they are not turned on accidentally. They are used on Day 4.
3. Determine a naming convention for each set and label. Suggestions include school initials and a number (Example: Millcreek Elementary simple machine sets names could be MES1; MES2; MES3) and write name on the battery pack and the motor and on the set.
4. Gather any consumable materials needed for the week.
5. Determine a procedure for when a LEGO® piece is dropped (everyone freeze; say LEGO® down/LEGO® found) and where to place LEGO® pieces if found and does not belong to the finder.
6. Ramps will be needed that cars can roll down and that cars can climb up.
7. A large, multispeed fan will be needed for use with the windmills.

**Simple and Powered Machines Program Day 1**

## Welcome to Orientation

**Big Question:**

- What are simple machines?
- What are some things that utilize simple machines?

**Materials needed for the day:**

- Simple and Powered Machines sets
- Chart paper
- Student journals (could be paper stapled together with students creating the outside of the journal using construction paper and other consumable materials)
- Various craft materials
- Pens
- Pencils
- Markers

**Day 1: Outline for the Day**

| Outline of Day | Tasks | Time | Materials |
|---|---|---|---|
| 9:00 - 10:30 | Introductions | 30 min | • LEGO® bricks |
| | Establishing group rules and expectations | 15 min | • Chart paper<br>• Markers<br>• Pens |
| | Team Building Activity | 15 min | • LEGO® bricks |
| | Team Briefing 1 | 5 min | • None |
| | Partner selection, team name and team badge | 25 min | • Varies, based on the activity selected<br>• Team badge templates<br>• Markers<br>• Pencils |

| | | | |
|---|---|---|---|
| | | | • Scissors |
| 10:30 - 10:35 | Break | | |
| 10:35 - 11:25 | Workplace Wellness (physical activity) | 10 min | Varies, based on the activity selected |
| | Design a journal for record keeping | 20 min | Student journals (see note in materials section)<br>Markers<br>Scissors<br>Construction Paper<br>Other craft materials |
| | Reading and wondering about simple machines | 20 min | Book about simple machines<br>Student journals |
| 11:25 | Get ready for lunch | | |
| 11:30 - 12:00 | Lunch | | |
| 12:00 - 2:10 | Team Briefing 2 | 5 minutes | • None |
| | Challenge 1: Exploring Pawl and Ratchet | 30 min | • Student journals<br>• Simple and Powered Machines sets<br>• Student worksheets<br>• Building Instruction Booklet I |
| | Challenge 2: Gears – Different Types for Different Jobs | 75 min | • Student journals<br>• Simple and Powered Machines sets<br>• Student worksheets<br>• Building Instruction Booklet I |
| | Break | 5 min | • None |
| | Disassemble and inventory sets | 15 min | • Simple and Powered Machines sets |
| 2:10 - 2:30 | Daily debrief and wrap up | 20 min | • Student journals |

**Introductions**
**Time: 30 minutes**
Materials:

- Loose LEGO® bricks

Purpose: For students to get to know each other

Show a video of a Rube Goldberg machine asking students to look at different parts of the machine to see how it works. Using the LEGO® bricks, have students build a model that shows something they really like to do and one thing they really hope to learn in this simple machines program. When it is time to share, have students say their name and share their model. The teacher can record what the group hopes to learn on a piece of chart paper.

**Group Rules and Expectations**
Time: 15 minutes
Materials:

- Chart paper
- Markers

Using a piece of chart paper, establish group rules and expectations for the week as a class. You can have students sign the chart paper and then place the rules and expectations in a location that can be reviewed each day.

**Team Building Activity**
Time: 15 minutes
Materials:

- Loose LEGO® bricks

Explain to students that each day will include a team building challenge. Working together is an important skill and just like other skills, we can practice it to get better and better.

**Build the tallest tower**

Have students work in pairs. Make sure each group has the same bricks or give a constraint of using a specific number of bricks. Challenge students to build the tallest tower they can within 5 minutes. At the end of the 5 minutes, encourage students to reflect on:

- What was challenging?
- How did you overcome the challenge?
- What was successful?
- How did you work together?
- If you were to do this tower build again, what would you change?

**Team Briefing 1:**
Time: 5 minutes
Materials: None

*Welcome to orientation! Your first tasks for today are as follows:*

- *Determine a partner for training exercises*
- *Work with partner to determine a name for your design company and a logo*
- *Design a journal for keeping important records this week*
- *Explore different ways we use simple machines*

**Partner Selection, Design Company Name and Logo**
Time: 25 minutes
Materials:

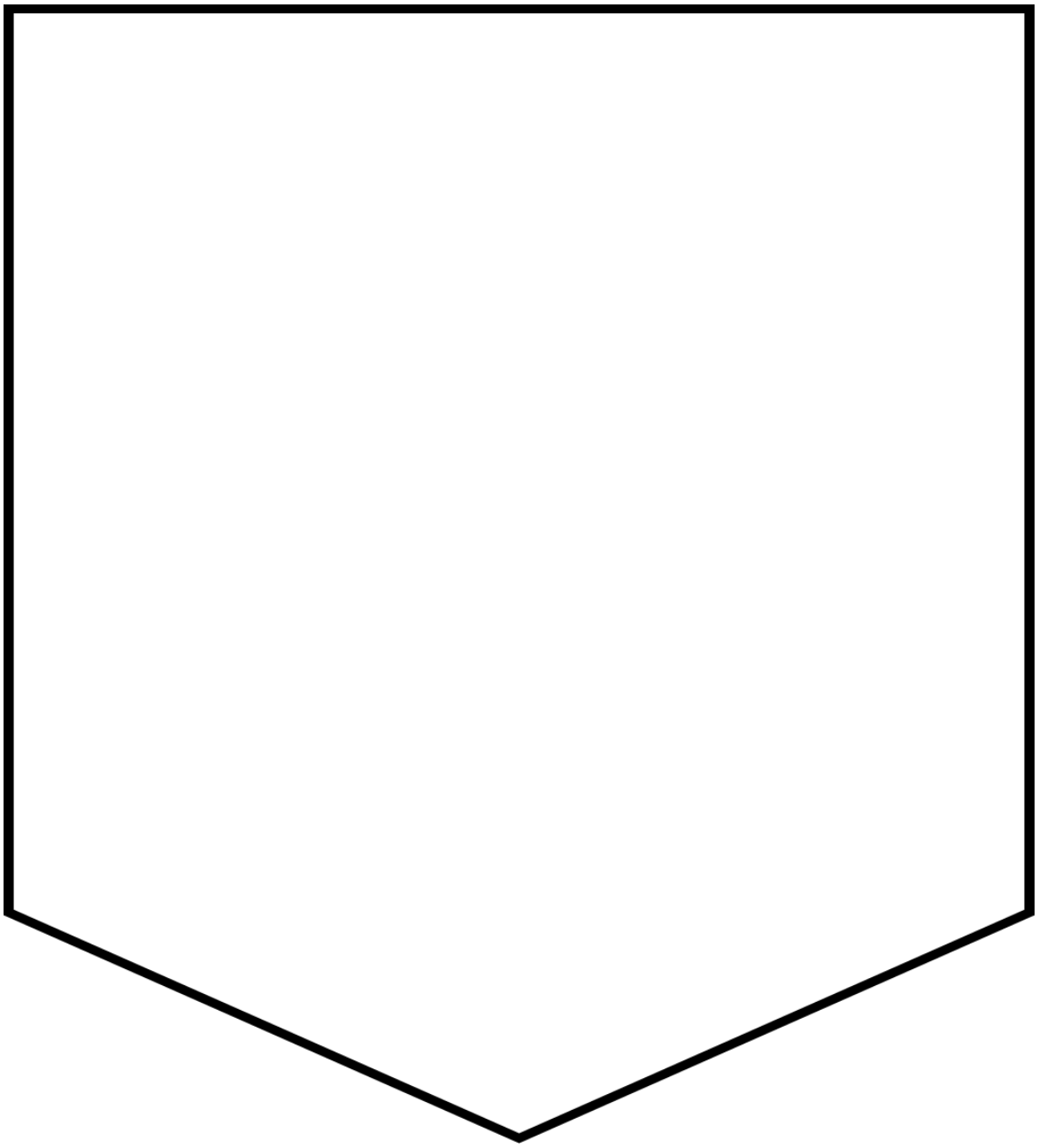
- Student journals (see note in materials section)
- Markers
- Scissors
- Construction paper
- Other craft materials

You can use several different activities to help students find a partner to work with for the week.

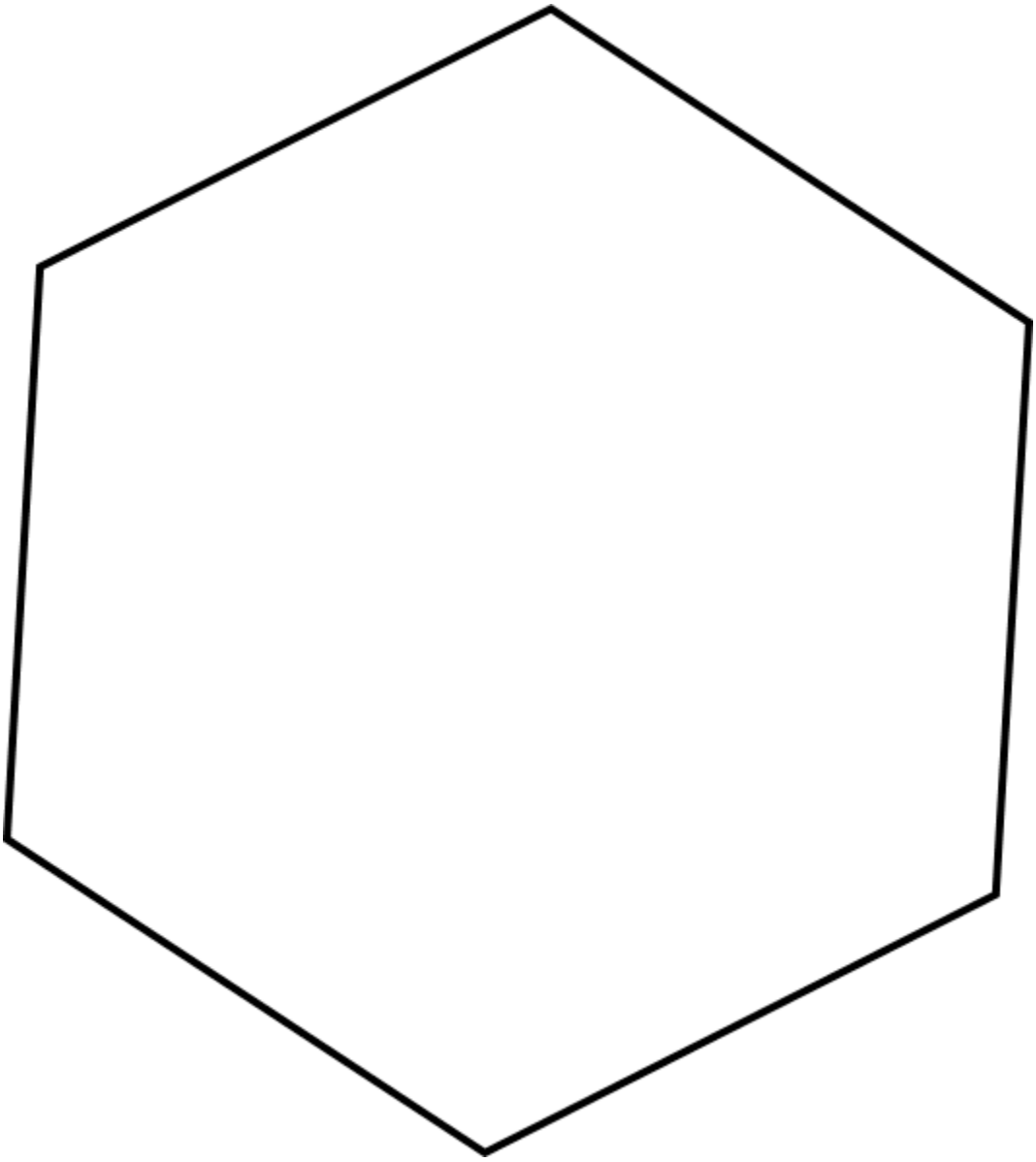
Once partners have been established, student teams can determine a design company name (team name) for their team and design a logo.

While teams are working, assign each group a Simple and Powered Machines set to use for the week.

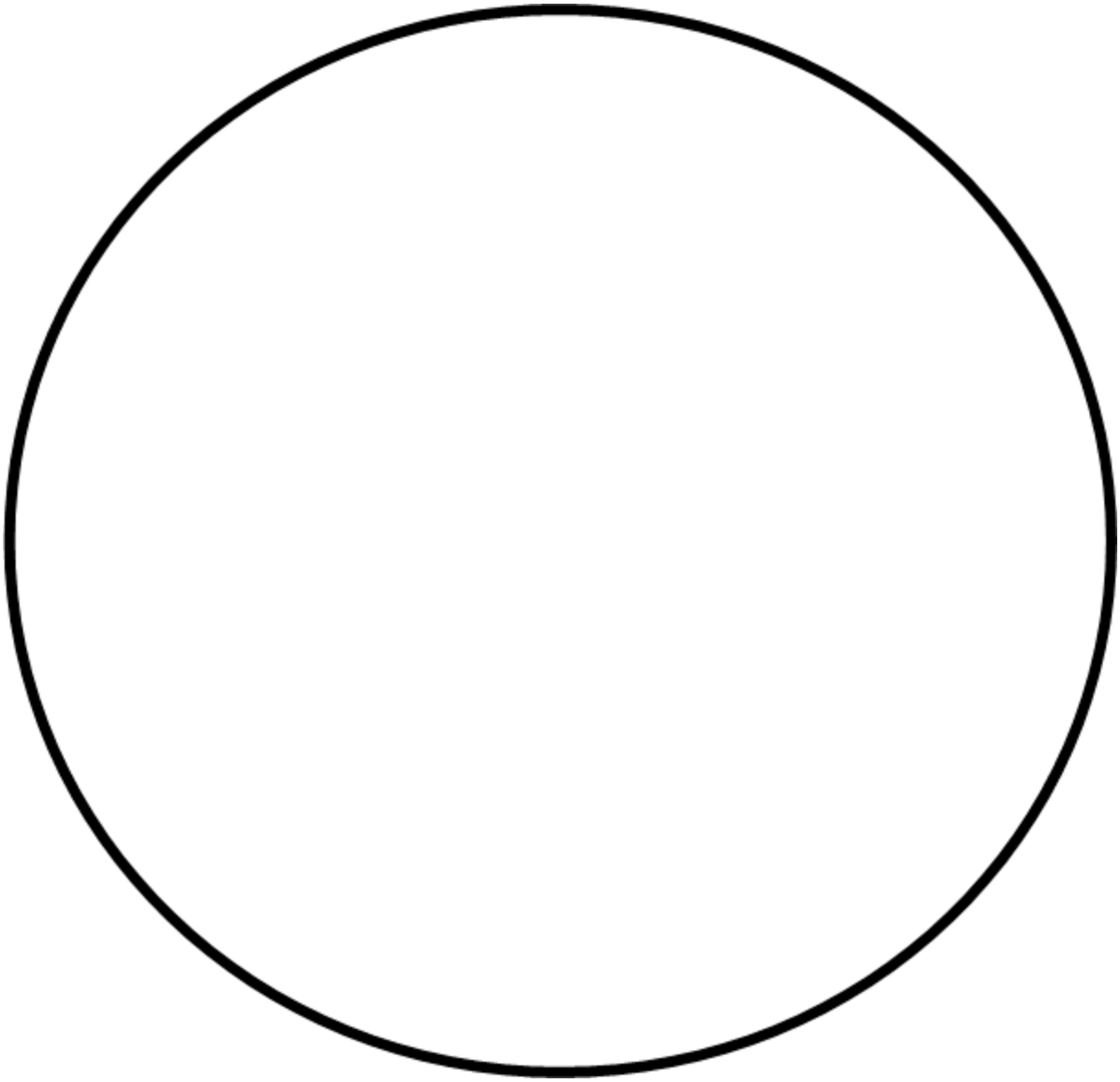
## Logo Templates



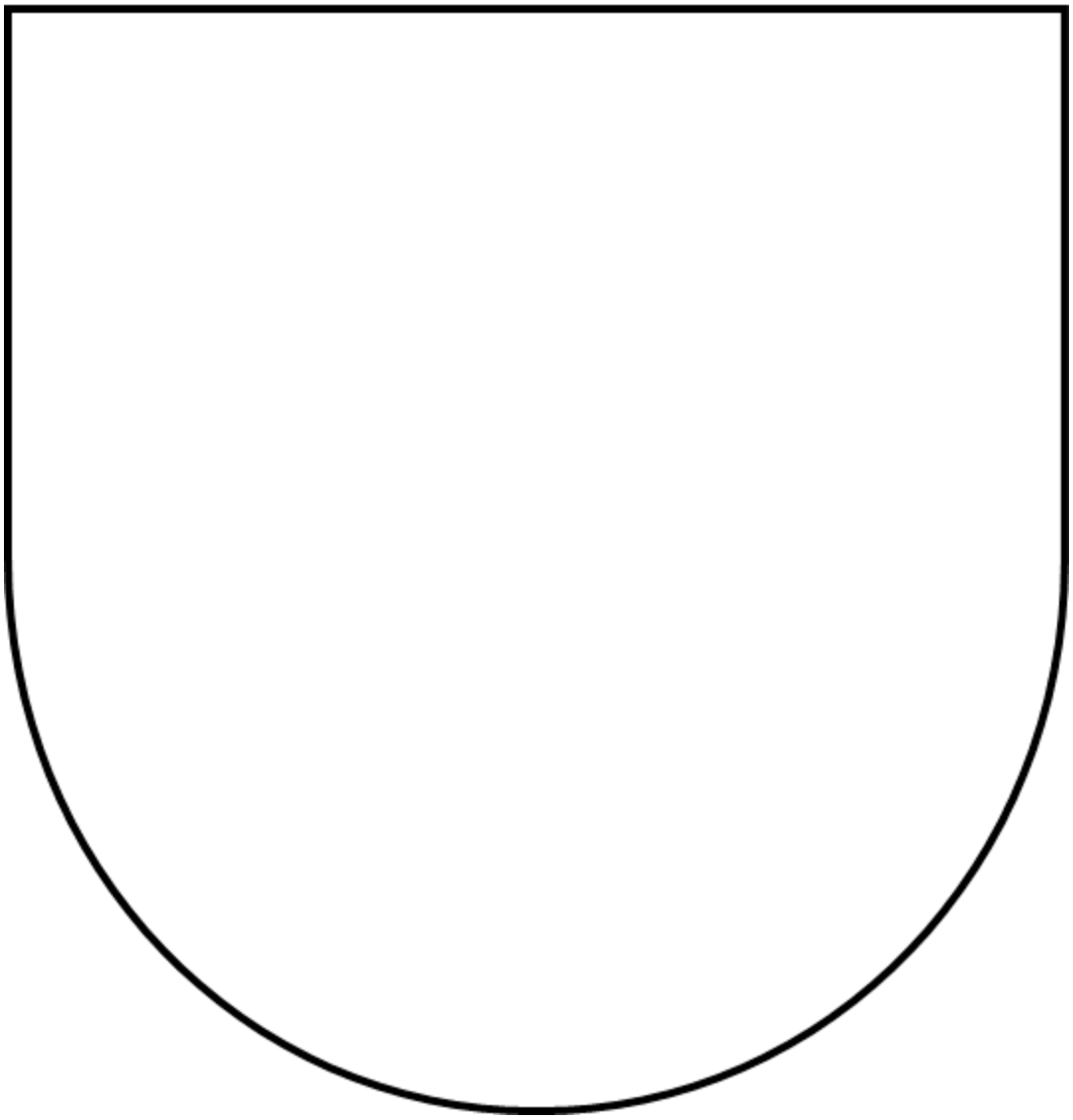
Logo Template



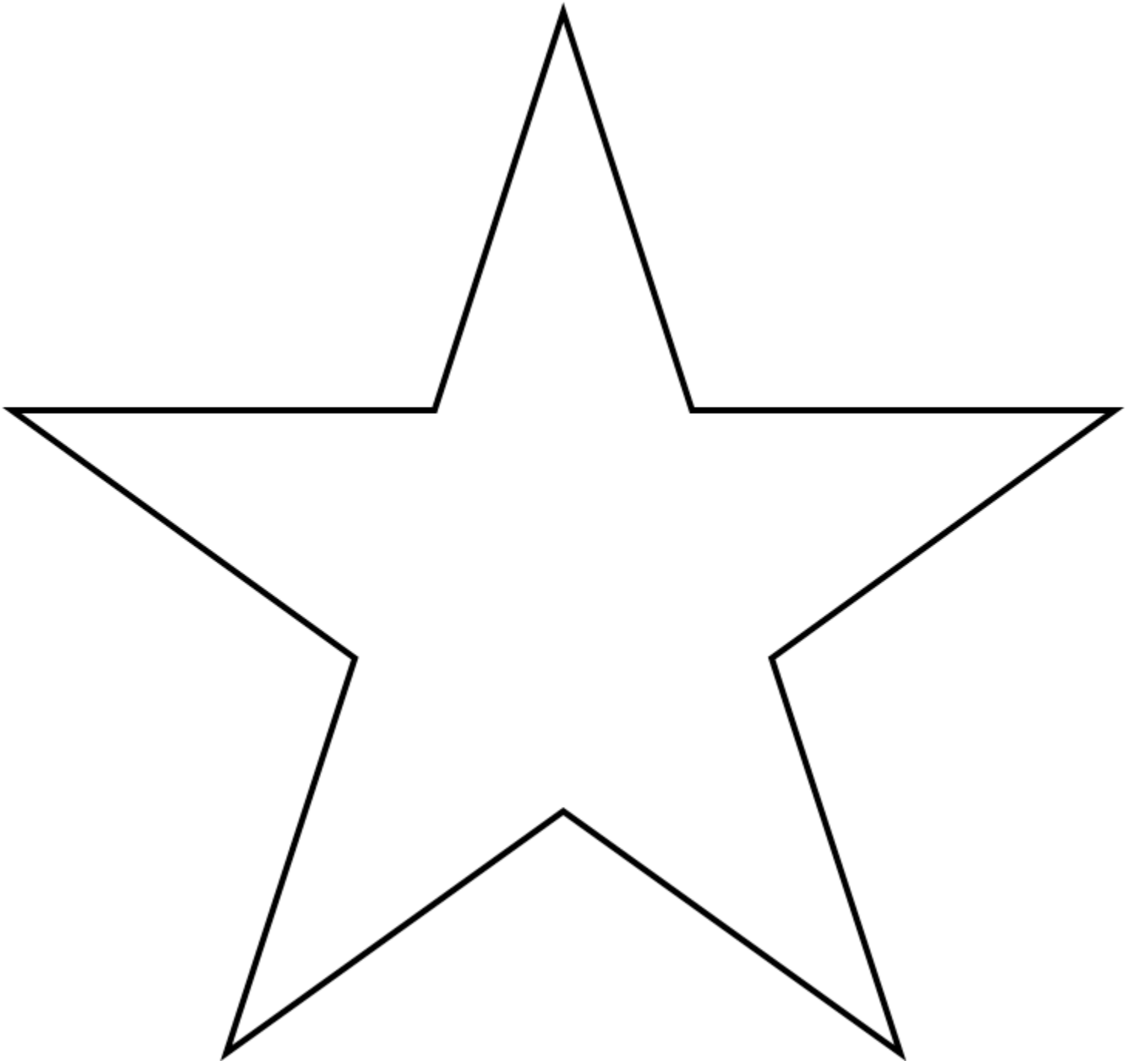
Logo Template



Logo Template



Logo Template



**Break**
Time: 5 minutes

**Workplace Wellness: Physical Fitness**
Time: 10 minutes
Materials:

- May vary depending on what activity is selected

Take a minute to complete a short physical activity. You may find several ideas for short physical activities for students through a simple web search. Ideas could include simple exercises like jumping jacks or running in place. Many companies encourage physical activity during the workday.

**Design a Journal**
Time: 20 minutes
Materials:

- Student journals (see note in materials section)
- Markers
- Scissors
- Construction paper
- Other craft materials

Have students create a design journal to take notes, share wonderings, write reflections, and collect ideas. Ideas for types of journals can be found online.

**Readings and Wonderings**
Time: 20 minutes
Materials:

- Book or articles about simple machines

Read a book or a kid friendly journal article about simple machines and what they can do to make work easier. The focus today is on pawl and ratchet and gears. Have students write things they wonder about simple machines in their journals.

**Lunch**
Time: 30 minutes

**Team Briefing 2**
Time: 5 minutes
Materials: None

> *Now that you have your team and have some background information about simple machines, you have a new challenge. To be better prepared for the days ahead, you will need some basic training on the tools we will use this week. Your mission this afternoon is to explore how machines use pawl and ratchets.*
>
> *Be sure to work together, take good notes, and have fun.*

Go over a few general guidelines for using the Simple and Powered Machines sets (what to do if you drop a piece on the floor, where do you put a piece you have found, what sharing looks like, etc.).

**Challenge 1 – Exploring Pawl and Ratchet**
Time: 30 minutes
Materials:

- Simple and Powered Machines sets
- Student journals
- Student worksheet – Pawl and Ratchet
- Building Instructions Booklet I

Students will:

- Create a pawl and ratchet device.
- Make the pawl and ratchet move.
- Determine where and how it will move and where it will stop and why.
- Think of ways that it could be utilized.

Ask students: Why do engineers use simple machines, specifically a pawl and ratchet? Lead a discussion on how a pawl and ratchet can make work easier.

Designers use multiple types of simple machines when they create a machine. Why would they use a pawl and ratchet in a machine? What types of machines use pawl and ratchet? (Examples include luggage straps, tie downs for car trunks.)

### Part 1

Have students complete the principle model activity I-1 from Booklet I. Access the building instructions, teacher notes, and the PDF of the student worksheet to download here: https://education.lego.com/en-us/lessons/advancing-with-spm/pawl-and-ratchet#Planitem0.

Have students complete the student worksheet. Have students explain how they work and why they would be used. Students should take notes in their student journals. They should be able to answer questions like:

- How does a pawl and ratchet work?
- What types of machines use a pawl and ratchet?
- How does it make work easier?

### Part 2

Take the elements apart and have students reflect in their journals:

- What was easy about this challenge?
- What was difficult about this challenge?
- What did I learn from this challenge?

**Challenge 2: Gears – Different Types for Different Jobs**
Time: 75 minutes

Materials:

- Simple and Powered Machines sets
- Student journals
- Student worksheet Gears
- Building Instruction Booklet I

Gears are an important element in designing an action for a machine to carry out because they allow for movement. Let's explore how gears can affect movement.

Have students take out the different gears from the set to look at them and talk about their characteristics. Ask students to think about where they have seen gears before?

Ask students if they know any names for different types of gears. Complete principle model G-1. con Access the building instructions, teacher notes and a PDF of the student worksheet here: https://education.lego.com/en-us/lessons/advancing-with-spm/gear#Planitem0

We will start with spur gears. Identify the names of the gears, the direction of motion, which gear is the driver and the driven, and the gear ratio. Have students draw examples and write important ideas in their journals. Complete worksheet for G-1.

Complete principle model G-2. Access the building instructions, teacher notes and a PDF of the student worksheet here: https://education.lego.com/en-us/lessons/advancing-with-spm/gear#Planitem0

Identify the names of the gears, the direction of motion, which gear is the driver and the driven, and the gear ratio. Determine if this is gearing up or gearing down. Have students draw examples and write important ideas in their journals. Complete worksheet for G-2.

Complete principle model G-3. Access the building instructions, teacher notes and a PDF of the student worksheet here: https://education.lego.com/en-us/lessons/advancing-with-spm/gear#Planitem0

Identify the names of the gears, the direction of motion, which gear is the driver and the driven, and the gear ratio. Determine if this is gearing up or gearing down. Have students draw examples and write important ideas in their journals. Complete worksheet for G-3.

Complete principle model G-4, which adds an idler gear. Access the building instructions, teacher notes and a PDF of the student worksheet here: https://education.lego.com/en-us/lessons/advancing-with-spm/gear#Planitem0

Identify the names of the gears, the direction of motion of the two large gears and the small idler gear. Which gear is the driver and which is driven? What is the gear ratio? Have students draw examples and write important ideas in their journals. Complete worksheet for G-4.

Complete principle model G-5.  Access the building instructions, teacher notes and a PDF of the student worksheet here: https://education.lego.com/en-us/lessons/advancing-with-spm/gear#Planitem0

Identify the names of the gears, the direction of motion, and which gear is the driver and the driven. What makes this more complicated? Is there another way to have the same effect on motion and speed? Have students draw examples and write important ideas in their journals. Complete worksheet for G-5.

Complete principle model G-6. Access the building instructions, teacher notes and a PDF of the student worksheet here: https://education.lego.com/en-us/lessons/advancing-with-spm/gear#Planitem0

Identify the names of the gears, the direction of motion, which gear is the driver and the driven. Why isn't there constant motion? Is there slippage? How does that affect the motion? Where would you see periodic motion? Have students draw examples and write important ideas in their journals. Complete worksheet for G-6.

Complete principle model G-7. Access the building instructions, teacher notes and a PDF of the student worksheet here: https://education.lego.com/en-us/lessons/advancing-with-spm/gear#Planitem0

Now we move from spur gears to bevel gears, which change the direction of motion. Identify the names of the gears, the direction of motion, which gear is the driver and the driven, and the gear ratio. How do the teeth of the bevel gear differ from those of a spur gear? Have students draw examples and write important ideas in their journals. Complete worksheet for G-7.

**Break**
Time: 5 minutes

**Disassemble and Inventory Check**
Time: 15 minutes
Materials:

- Simple and Powered Machines sets

Ask students to take apart their gearing model. Then, working with their partner, students collaborate to conduct an inventory check of the pieces in their set to ensure all pieces are in the correct spots and no pieces are missing.

For a full inventory: Have students place elements from one compartment on the lid of the box. Then, using the card that is placed under the lid of the box to have students count and replace pieces back to the compartment. Teams should be able to complete two compartments in ten minutes. If pieces are missing, have students search other compartments, looks to see if the piece is stuck in or on another piece, and check the LEGO® lost and found area in your classroom.

For today, we suggest you conduct only a “quick inventory” of the sections that pieces from the gearing model came from. Students will not need to count pieces from all sections.

**Daily Debrief and Wrap Up**
Time: 20 minutes
Materials:

- Sticky notes
- Student journals
- Pencils
- Pens
- Markers

Have students use sticky notes to write down three things they really enjoyed about the day. Have students use a different sticky notes to write down one thing they are still wondering about. Place sticky notes in their student journals.

**Simple and Powered Machines Program Day 2**

## Exploration of Gears

**Big Question:**
What types of gears make machines move? What types of movement can gears have? Where are gears used?

Materials needed for the day:

- Simple and Powered Machine sets
- Chart paper
- Student journals
- Various craft materials
- Pens
- Pencils
- Markers

**Day 2: Outline for the Day**

| Outline of Day | Tasks | Time | Materials |
|---|---|---|---|
| 9:00 - 9:50 | Welcome | 5 min | • Student journals |
| | Team building activity | 15 min | • LEGO® bricks<br>• Bricktionary Cards |
| | Review group rules and expectations and activities from yesterday. | 5 min | • Group Rules Chart |
| | Team Briefing 1 | 5 min | • None |
| | Readings and Wonderings | 20 min | • Book or journal article about gears used in machines |
| 9:50 - 10:50 | Challenge 1: Types of gears and how they move | 60 min | • Simple and Powered Machines sets<br>Student journals<br>• Building Instruction Booklet I<br>• Student worksheets |
| 10:50 - 10:55 | Break | | |

| | | | |
|---|---|---|---|
| 10:55 – 12:05 | Workplace Wellness (physical activity) | 15 min | • Varies, based on the activity selected |
| | Team Briefing 2 | 5 min | • None |
| | Challenge 2: Using Gears to Measure Distance – Trundle Wheel | 50 min | • Simple and Powered Machines sets<br>• Student Journals<br>• Building Instruction Booklets 5A and 5B<br>• Student worksheets |
| 12:05 - 12:10 | Get ready for lunch | | |
| 12:10 - 12:45 | Lunch | | |
| 12:45 - 12:50 | Team Briefing 3 | 5 min | • None |
| 12:50 - 1:55 | Challenge 3: Click Clock | 60 min | • Simple and Powered Machines set<br>• Student journals<br>• Building Instruction Booklets 7A and 7B<br>• Student worksheets |
| | Break | 5 min | • |
| 1:55 - 2:10 | Continue Challenge 3: Click Clock | 35 min | • Simple and Powered Machines sets<br>• Student Journals<br>• Building Instruction Booklets 7A and 7B<br>• Student worksheets |
| 2:10 - 2:30 | Clean up<br>Daily debrief and wrap up | 20 min | • Student journals |

**Welcome**
Time: 5 minutes
Materials:

- Student journals

Welcome students back! Have students take a minute to read over the sticky notes placed in their journals from the previous day. Have students share their favorite moments from the previous day with a partner.

**Team Building Activity**
Time: 15 minutes
Materials:

- Loose LEGO® bricks and cards with objects to build

Place students in groups of 4-5 for team building activity- Bricktionary.

Bricktionary:

Have students play one round of Bricktionary. Students will draw a card from the stack without showing the word to their teammates. Then using bricks, students will build the object while teammates try to guess what it is. The game is over when everyone has had a turn. Below are some example cards you can use for the game.

Bricktionary Cards

| | |
|---|---|
| Truck | Place |
| Bridge | TV |
| Flower | Tree |
| Boat | House |



**Review Group Rules Chart**
Time: 5 minutes
Materials:

- Group Rules Chart (from Day 1)

Quickly review the group rules and expectations created on Day 1 by the students. Highlight positive moments from Day 1 (times when students helped each other, asking great questions, teamwork, helping to clean up…)

**Team Briefing 1**

> *Hello, fellow engineers! Your task today is to work with different types of gears. Yesterday you worked with gears to move machines at different speeds. Today you will work with differential gearing and the worm gear.*

**Readings and Wonderings**
Time: 20 minutes
Materials:

- Internet research on different types of gears, types of movement gears have, and machines that use gears.
- Videos on machines that use gears.
- Student journals
- Student worksheet for Gears
- Building Instruction Booklet I

Discuss different types of gears based on your research, readings, and videos. Think about how they move or cause movement. Have students write the types of machines that use gears. Which of these machines are used, made, or sold in the local area?

**Challenge 1: Different Types of Gears and How They Move**
Time: 60 minutes
Materials:

- Simple and Powered Machine sets
- Student Design Journals

Complete principle model G-8. Access the building instructions, teacher notes and a PDF of the student worksheet here: https://education.lego.com/en-us/lessons/advancing-with-spm/gear#Planitem0

This model shows differential gearing. Identify the names of the gears, the direction of motion, which gear is the driver and the driven, and the gear ratio. What happens when one output pointer is stopped? What happens when both output pointers are stopped? Have students draw examples and write important ideas in their journals. Complete worksheet for G-8.

Complete principle model G-9. Access the building instructions, teacher notes and a PDF of the student worksheet here: https://education.lego.com/en-us/lessons/advancing-with-spm/gear#Planitem0

This model introduces a worm gear which is a one-tooth gear. Can a spur gear turn a worm gear? Can a worm gear turn a spur gear? Why or why not? Identify the names of the gears, the direction of motion, which gear is the driver and the driven, and the gear ratio. How do the teeth of the worm gear differ from those of a spur gear? Have students draw examples and write important ideas in their journals. Complete worksheet for G-8.

**Break**
Time: 5 minutes

**Workplace Wellness: Physical Fitness**
Time: 15 minutes
Materials:

- May vary depending on what activity is selected

Take a minute to complete a short physical activity. You may find several ideas for short physical activities for students through a simple web search. Ideas could include simple exercises like jumping jacks or running in place. Many companies encourage physical activity during the workday.

**Team Briefing 2:**

*Hello Engineers! Now you are ready to apply your knowledge to a real machine. Let's build a machine to measure distance.*

**Challenge 2: Using Gears to Measure Distance – Trundle Wheel**
Time: 50 minutes
Materials:

- Simple and Powered Machine sets
- Student journals
- Student worksheet for Trundle Wheel
- Building Instruction Booklets containing instructions 5A and 5B

Complete Trundle Wheel activity, which is available at https://education.lego.com/en-us/lessons/spm/trundle-wheel Student worksheet and building instructions can be found here also. Complete the student worksheet during the lesson.

Work with your students to discover if the trundle wheel can measure:

- Straight, flat surfaces
- Curved surfaces
- Bumpy surfaces

Ask students questions like:

- What would be the most accurate measurement?
- Why would someone want to use a trundle wheel instead of a ruler, meter stick, tape measure?
- What distance do you think would be too small or too large to measure with a trundle wheel?

Take apart your model and put the pieces accurately back into the correct tray locations.

Have students write a brief reflection on the activity in their design journals.

- What was easy about this challenge?
- What was difficult about this challenge?
- What did I learn from this challenge?

**Lunch**
Time: 30 minutes

Lunch will fall in the middle of Challenge 2. Allow students to start the challenge and then complete after lunch.

**Team Briefing 3**
Time: 5 minutes
Materials: None

Now that you have investigated several types of gears and a pawl and ratchet, it is time to put them together. You can make a machine that can determine a fixed rate of time between clicks. Then, you can have some fun races and see how few clicks it takes to win!

**Challenge 3: Click Clock**
Time: 60 minutes
Materials:

- Simple and Powered Machines set
- Student journals
- Student worksheet for Click Clock
- Building Instruction Booklets containing 7A and 7B

Complete the Click Clock activity, which is available at https://education.lego.com/en-us/lessons/spm/click-clock The student worksheet, building instructions, and teacher notes are also available here. Have students complete the student worksheet during the lesson.

You created a machine that can determine how much time has passed. How can you make the clock tick faster or slower? How do gears affect speed? How does the length of the pendulum affect speed?

Keep the Click Clock model built and have students reflect in their journals:

- What was easy about this challenge?
- What was difficult about this challenge?
- What did I learn from this challenge?

**Continue Challenge 3: Using Click Clock to Time a Race**
Time: 35 min
Materials:

- Simple and Powered Machines set
- Student journals
- Click Clock model

Determine an action that can be timed by the clock. It could be running from Point A to Point B in the hallway. It could be completing a number of steps in the correct order – like touch head, shoulders, knees, and toes, knees and toes. Think of something that can get students moving.

Have teams challenge one another while the rest of the group counts the clicks. Before they begin, have the group discuss how fast the clock should click and adjust it accordingly.

**Cleanup, Daily Debrief and Wrap Up**
Time: 15 minutes
Materials:

- Student journals
- Markers
- Colored pencils
- Crayons

Have students take apart the models and put the pieces back into the correct locations in the bin trays.

Have students write one word that they feel reflects what they have learned today. Write and illustrate the word in their student journals.

**Simple and Powered Machines Program Day 3**

## Using Gears and Pawl and Ratchet Together

**Big Question:**
How can you combine gears and a pawl and ratchet to make a windmill? What are ways that wheels can be combined with axles?

Materials needed for the day:

- Simple and Powered Machine sets
- Student journals
- Student worksheets
- Building Instruction Booklets 3A and 3B
- Building Instruction Booklets 8A and 8B
- Fan (large)
- Ramp
- Various craft materials
- Pens
- Pencils
- Markers

**Day 3: Outline for the Day**

| Outline of Day | Tasks | Time | Materials |
|---|---|---|---|
| 9:00 - 10:30 | Welcome | 5 min | • Student journals |
| | Team building activity | 15 min | • LEGO® bricks |
| | Review Group Rules Chart | 5 min | • Group Rules Chart |
| | Team Briefing 1 | 5 min | • None |
| | Readings and Wonderings | 10 min | • Internet research<br>• Student journals |
| | Inventory Check | 5 min | • Simple and Powered Machines sets |
| | Challenge 1: Windmill | 45 min | • Simple and Powered Machines sets<br>• Fan |

| | | | |
|---|---|---|---|
| | | | • Building Instruction Booklets 8A and 8B<br>• Student worksheets<br>• Student journals<br>• Ramp |
| 10:35 - 10:40 | Break | | |
| 10:40 - 10:45 | Team Briefing 2 | 5 min | • None |
| 10:45 - 11:25 | Challenge 2: Wheels and Axles – the principles | 40 min | • Simple and Powered Machines set<br>• Student journals<br>• Student Worksheets<br>• Building Instruction Booklet I<br>• Ramp |
| 11:25 - 11:30 | Get ready for lunch | | |
| 11:30 - 12:00 | Lunch | | |
| 12:00 - 1:35 | Workplace Wellness (physical activity) | 10 min | • Varies, based on the activity selected |
| | Team Briefing 3 | 5 min | • None |
| | Challenge 3: Freewheeling | 50 min | • Simple and Powered Machines sets<br>• Student journals<br>• Building Instruction Booklets 3A and 3B<br>• Building Instruction Student worksheets<br>• Ramp |
| 1:35 - 1:40 | Break | 5 min | |

| | | | |
|---|---|---|---|
| 1:40 - 2:10 | Challenge 4: The Competition | 30 min | Simple and Powered Machines sets<br>Student journals<br>Ramp |
| 2:10 - 2:30 | Cleanup<br>Daily debrief and wrap up | 20 min | • Student journals |

**Welcome**
Time: 5 minutes
Materials:
- Student journals

Welcome students back! Have students take a minute to share their word they created the day in their journals with a neighbor. Compile a list of the words as a group. You can create a word cloud to share on the last day of the program.

**Team Building Activity**
Time: 15 minutes
Materials:
- LEGO® bricks

Place students in pairs.

Build a Bridge
Challenge students to build a LEGO® bridge that spans two tables. You can determine the length. Allows students only 5 minutes to complete their bridge working together with their partner.

Extensions:
- Build the longest bridge
- Build the tallest bridge
- Build a bridge that can hold the most weight (use a bucket and some weights to test)

**Review Group Rules Chart**
Time: 5 minutes
Materials: Group Rules Chart (from Day 1)

Quickly review the group rules and expectations created on Day 1 by the students. Highlight positive moments from Day 2 (times when students helped each other, asking great questions, teamwork, helping to clean up…)

**Team Briefing 1**
Time: 5 minutes
Materials: None

> *Hello! This morning, your task is to investigate different ways we combine gears and pawl and ratchet to make a useful machine. Where are windmills used in your state or where could they be? What can a windmill do beyond creating electricity? You will be building a windmill to lift a weight.*

**Research and Wonderings**
Time: 10 minutes
Materials: None

Discussion and conduct Internet research on how windmills work

Have students research windmills and the transfer of energy. Have students find locations of wind farms and correlate those with average number of windy days.

Lead a discuss on how windmills work. Ask students to think about how they take wind energy and change it into other types of usable energy. What other activities can windmills be used for? Do you have windmills in your state? What are the requirements for building a wind farm?

**Inventory Check**
Time: 5 minutes
Materials:
- Simple and Powered Machines sets

Ask students to find their partner from Day 1.

Have students check to see all items in the bin are in the proper trays.

**Challenge 1: Build and Use a Windmill**
Time: 45 minutes
Materials:
- Simple and Powered Machine sets
- Building Instruction Booklets containing 8A and 8B
- Student worksheet - Windmill
- Student journals

Complete the Windmill activity, which is available at https://education.lego.com/en-us/lessons/spm/windmill. The building instructions, student worksheets, and teacher notes are also available here.

Use the fan on different speeds to try and lift the weight. Complete the student worksheet.

Create experiments to test your windmill. Record your findings in your student journal.

**Break**
Time: 5 minutes

**Challenge 2: Wheels and Axles - Principles**
Time: 40 minutes
Materials:

- Simple and Powered Machines set
- Student journals
- Student worksheet – Wheels and Axles
- Building Instruction Booklet I

Complete B1, which is available at https://education.lego.com/en-us/lessons/advancing-with-spm/wheel-and-axle. This site contains building instructions, lesson plans, student worksheet, and teacher notes. This model has split axles. Try going in a straight line. Try going in a very curvy line. Write in your journals your findings. Complete the student worksheet for B1.

Complete B2, which is available at https://education.lego.com/en-us/lessons/advancing-with-spm/wheel-and-axle. This site contains building instructions, lesson plans, student worksheet, and teacher notes. This model has fixed axles. Try going in a straight line. Try going in a very curvy line. Write in your journals your findings. Complete the student worksheet for B2.

Compare your findings between B1 and B2. Which model would you prefer to use for a racecar?

Complete B3, which is available at https://education.lego.com/en-us/lessons/advancing-with-spm/wheel-and-axle. This site contains building instructions, lesson plans, student worksheet, and teacher notes. This model adds a steering system. Complete the student worksheet for B3. Is it easier, harder, or the same to control this model as it was B2? Write your findings in your journal.

There are three types of turns:

- Point – one wheel turns clockwise, the other wheel turns counterclockwise; this is the tightest turn like on a zero-turn radius mower
- Pivot – one wheel turns, the other wheel does not turn; this is a turn like a basketball player uses when she has the ball
- Arc – both wheels turn in the same direction, but each wheel turns at a different speed; this is the turn your car makes with the front tires

Try making the three types of turns with your steering system model. Is it easy or difficult? Write your findings in your student journal. Explain the three types of turns in your journal – how do they differ?

**Lunch**
Time: 30 minutes

**Workplace Wellness: Physical Fitness**
Time: 10 minutes

Materials:

- May vary depending on what activity is selected

Take a minute to complete a short physical activity. You may find several ideas for short physical activities for students through a simple web search. Ideas could include simple exercises like jumping jacks or running in place. Many companies encourage physical activity during the workday.

**Team Briefing 3**
Time: 5 minutes
Materials: None

*Today you will make a car and see how far it can roll after if comes off a ramp. You will be able to redesign the car and see if you can make it go further.*

**Challenge 2: Freewheeling**
Time: 50 minutes
Materials:

- Simple and Powered Machines sets
- Student journals
- Student worksheets
- Ramps
- Building Instruction Booklets 3A and 3B

Complete the Freewheeling activity, which is available at https://education.lego.com/en-us/lessons/spm/freewheeling. This site contains building instructions, lesson plans, student worksheet, and teacher notes. Complete the student worksheet during the lesson.

Hint: Students may wish to add a yellow half bushing to the axle where the yellow rubber band goes around it. That will help keep the rubber band in place and aid motion.

Now, remove the rubber band so the counter is disconnected. How does that affect performance?

Ask students questions like:

- How does the counter work?
- How can you reset it?
- Does the counter add friction? If so, how does it impact the movement of the car?

Keep your freewheeler together for the next activity.

**Challenge 4: The Competition**
Time: 30 minutes
Materials:

- Simple and Powered Machines sets
- Ramp(s)
- Student journals

Now teams compete to see who can go the farthest – officially. Students cannot push their vehicles; they just let go of them at the top of the ramp. They can change the chassis – make it narrower, wider, shorter, longer. They can add or subtract weight, etc.

Allow students to make as many changes to their freewheeler model as they want in the time given. Be sure to have students write about the changes they make and the effect on the distance rolled in their student journal.

Make a chart with the top distances and the name of the team. This will change as teams change their models. You may wish to create a certificate for first, second, and third longest roll.

Have students draw a sketch or take pictures of the final build.

Take the models apart. Place pieces into the correct trays in the bin.

**Daily Debrief and Wrap Up**
Time: 20 minutes
Materials:

- LEGO® Bricks
- Student journals

Have students use LEGO® bricks to build a model that represents two things they learned today. Have students draw a picture and jot down the two things in their journal as well.

# Simple and Powered Machines Program Day 4

## Create Complex Machines

**Big Question:**
How can simple machines be combined to create more complex models?

**Materials needed for the day:**

- Simple and Powered Machines sets
- Student journals
- Ramp
- Student worksheets
- Chart paper
- Various craft materials
- Old magazines that can be cut up (optional)
- Pens
- Pencils
- Markers
- Glue sticks

**Day 4: Outline for the Day**

| Outline of Day | Tasks | Time | Materials |
|---|---|---|---|
| 9:00 - 10:25 | Welcome | 5 min | • Student journals |
| | Team building activity | 15 min | • LEGO® bricks |
| | Review group rules and expectations and activities from yesterday | 5 min | • Group Rules Chart |
| | Team Briefing 1 | 5 min | • None |
| | Research and Wonderings | 10 min | • Discussion<br>• Internet research<br>• Student journals |
| | Inventory Check | 5 min | • Simple and Powered Machines sets |

| | | | |
|---|---|---|---|
| | Challenge 1: Power Car | 40 min | • Simple and Powered Machines sets<br>• Student worksheets<br>• Building Instruction Booklets 11A and 11B<br>• Student journals<br>• Ramp |
| 10:25 - 10:30 | Break | | |
| 10:30 - 11:35 | Team Briefing 2 | 5 min | • None |
| 10:35 - 11:45 | Challenge 2: Flywheeler | 70 min | • Simple and Powered Machines sets<br>• Student journals<br>• Building Instruction Booklets 10A and 10B<br>• Student worksheets |
| 11:45 - 11:50 | Get ready for lunch | | |
| 11:50 - 12:20 | Lunch | | |
| 12:20 - 2:00 | Workplace Wellness (physical activity) | 10 | • Varies, based on the activity selected |
| | Team Brief 3<br>Culminating Activity: Building your own geared and motorized car | 90 min | • Simple and Powered Machines sets<br>• Student journals |
| 2:00 - 2:30 | Clean up<br>Daily Debrief and Wrap Up<br>Celebration | 30 min | • Student journals |

**Welcome**
Time: 5 minutes
Materials:

- Student journals

Welcome students back!  Have each student share pictures of their models from Day 3 with a friend as a way to review what they had learned yesterday.

**Team Building Activity**
Time: 15 minutes
Materials: LEGO® bricks

Create a Creature
Have each student create a creature using LEGO® bricks. Have them give their creature a name and a special characteristic. Have students share their creature with their partner. Have the pair create a short story that includes both creatures.

**Review group rules and expectations**
Time: 5 minutes
Materials: Group Rules Chart

Quickly review the group rules and expectations. Highlight positive moments from Day 3 (times when students helped each other, asking great questions, teamwork, helping to clean up…)

Explain that they will have guests today and that they will be telling the guests about the cool new vehicle that they created. This will happen after lunch.

**Team Briefing 1**
Time: 5 min
Materials: None

*Yesterday, you worked with cars that used gravity to power their motion. Today, you will investigate a geared car with a motor and a battery pack. The energy from the motor helps your car to defy gravity.*

**Research and Wonderings**
Time: 10 minutes
Materials:

- Discussion and Internet research
- Student journals

Determine what types of vehicles use gears. Which ones need more speed or more torque? Why? What is the structure and function of the machine?

**Inventory Check**
Time: 5 minutes
Materials:

- Simple and Powered Machines sets

Ask students to find their partner from Day 1.

Have students confirm that all pieces in the bin are in the correct tray compartments.

**Challenge 1:  Power Car**
Time: 60 minutes
Materials:

- Simple and Powered Machines sets
- Student journals
- Ramp
- Student worksheets – Power Car
- Building Instruction Booklets 11A & 11B

Complete the Power Car activity, which is available at https://education.lego.com/en-us/lessons/spm/power-car. This site contains building instructions, lesson plans, student worksheet, and teacher notes. Complete the student worksheet.

If you do not have a ramp, have students create a ramp that cars can go UP instead of down. Also, make a path that is wavy or has bumps that the car with have to traverse. Complete the options so students can explore more about gearing.

**Break**
Time: 5 minutes

**Team Briefing 2**
Time: 5 min
Materials: None

*You used a battery pack to provide energy for the car you just used. Now you will use a different form of energy – potential energy – to power your car. You will change potential energy into kinetic energy.*

Give students examples of potential and kinetic energy. The car at the top of the ramp has potential energy. When it moves down the ramp, it has kinetic energy.

**Challenge 2: Flywheeler**
Time: 60 minutes
Materials:

- Simple and Powered Machines sets
- Student journals
- Ramp
- Student worksheet – Flywheeler
- Building Instruction Booklets 10A & 10B

Complete the Flywheeler activity, which is available at https://education.lego.com/en-us/lessons/spm/flywheeler. This site contains building instructions, lesson plans, student worksheet, and teacher notes. Complete the student worksheet during the lesson.

Look at the car you built. Now make it work. Observe it carefully as you make it move several times. Discuss with your partner and describe in your journal how the car works. Next, predict how far the car will roll. Test your predictions. Write your prediction and the actual distance in your journal.

Now, make the modifications in the lesson. Write what you changed about the car and how it affected the car's performance.

Optional: Allow students to make their own modifications. Have students compare the performance of the modified cars.

Ask students questions like:

- What made the best flywheel?
- How does weight affect the function of the flywheel?

**Lunch**
Time: 30 minutes

**Workplace Wellness**
Time: 10 minutes
Materials:

- May vary depending on what activity is selected

Take a minute to complete a short physical activity. You may find several ideas for short physical activities for students through a simple web search. Ideas could include simple exercises like jumping jacks or running in place. Many companies encourage physical activity during the workday.

**Team Briefing 3**
Time: 5 min
Materials: None

*You have learned a lot about wheeled vehicles. Now, you will be given the opportunity to create your own wheeled vehicle. Your car can be geared, powered, or neither. It can be used going up or down a ramp or on bumpy or straight roads. You make all the decisions. Then, when you are satisfied with your model, you will create a poster to help you sell your idea to the guests who will arrive this afternoon.*

Talk with students about the expectations for the showcase and how the event will run.

**Culminating Project: Create your own Geared Vehicle**
Time: 90 minutes
Materials:

- Simple and Powered Machines sets
- Student journals
- Tape
- Chart paper
- Markers

Students will take what they have learned and create their own geared vehicle. They should name their creation. They will create a poster on chart paper that showcases the name and features of their geared vehicle – as if they were selling the idea.

Have students practice selling or marketing their vehicle to another group before the audience arrives.

**Showcase: Geared Vehicles**
Time: 30 minutes
Materials:

- Geared Vehicles
- Student journals
- Group Rules Chart
- Student worksheets
- Chart paper
- Markers

Students will name their car and explain the ideas behind their vehicle and how it works. Then, they will demonstrate the car and show it working.

**Cleanup, Daily Debrief, Wrap Up, and Celebrate**
Time: 30 minutes
Materials:

- Student journals
- Old magazines that can be cut up
- Colorful paper
- Markers
- Stickers
- Glue sticks

Ask students to create a “self-portrait” collage that only uses positive words about themselves. Have them include words related to positive contributions they can make to a team! Place collage in their student journals.