The Marvelous Machine Challenge: A 2-Week Physical Science Adventure

Materials Needed:

- **General Supplies:** Science notebook/journal, pencils, markers, scissors, strong tape (masking and/or duct), glue, ruler, smartphone or camera for recording video.
- **Recyclables & Household Items:** Cardboard boxes of various sizes, paper towel/toilet paper tubes, plastic bottles, yogurt cups, string or yarn, rubber bands, paper clips, aluminum foil.
- **Experiment-Specific Items:** Marbles, small toy cars, dominoes, books (for weights and ramps), wooden plank or sturdy cardboard for a ramp, a pencil, a spool of thread, small toy or object to lift (like an action figure), skewers or dowels, bottle caps, a small bell, a balloon, baking soda and vinegar (optional).

Overall Learning Objectives

By the end of this two-week unit, the student will be able to:

- Identify the six classical simple machines and explain how they make work easier.
- Describe the difference between potential and kinetic energy using examples from their experiments.
- Apply knowledge of forces (gravity, friction) and energy transfer to design, build, and troubleshoot a multi-step machine.
- Demonstrate creativity, problem-solving skills, and resilience through the engineering design process.

Alignment: This lesson aligns with Next Generation Science Standards (NGSS) for energy (4-PS3-1, 4-PS3-3) and engineering design (3-5-ETS1-1, 3-5-ETS1-2).

Week 1: The Science of Motion & Machines

This week is about exploration and discovery through fun, hands-on experiments. Each day focuses on a core concept that will be used in the final project.

Day 1: Energy in Motion

- **Learning Goal:** Understand the difference between stored (potential) energy and moving (kinetic) energy.
- **Spark Curiosity (10 min):** Hold a marble at the top of a ramp. Ask, "Does this marble have energy right now? How can we give it moving energy?"
- **Explore & Learn (25 min):** Build a simple "roller coaster" using cardboard tubes cut in half lengthwise and propped up by books. Let the marble go from the top. Discuss where the marble has the most potential energy (at the highest point) and where it has the most kinetic energy (when it's moving fastest). Experiment by changing the height of the ramp.
- **Apply & Create (15 min):** In the science journal, draw the roller coaster. Label the points of

highest potential energy and highest kinetic energy. Write one sentence explaining the difference.
- **Reflect (5 min):** "Where else do you see potential and kinetic energy in our house?" (e.g., a stretched rubber band, a bouncing ball).

Day 2: Amazing Levers & Pulleys

- **Learning Goal:** Demonstrate how levers and pulleys can be used to lift heavy objects.
- **Spark Curiosity (10 min):** Try to lift a heavy stack of books with just one finger. Then, ask, "Can we use science to make you strong enough to lift this?"
- **Explore & Learn (25 min):**
    1. **Lever Lab:** Create a simple lever by placing a ruler on top of a pencil (the fulcrum). Place a small object (like an eraser) on one end and press down on the other. Move the fulcrum closer to the object. Is it easier or harder to lift?
    2. **Pulley Power:** Tie a string to a small toy. Try to lift it straight up. Now, loop the string over a doorknob or a securely taped spool of thread. Pull down on the string. Does it feel easier? A pulley changes the direction of the force.
- **Apply & Create (15 min):** Draw a diagram of a lever and a pulley in the science journal. Label the parts (fulcrum, load) and explain how each one helps.
- **Reflect (5 min):** "Can you find any levers or pulleys around us?" (e.g., scissors, bottle opener, window blinds).

Day 3: Inclined Planes & Wheels

- **Learning Goal:** Explain how ramps (inclined planes) and wheels/axles reduce effort.
- **Spark Curiosity (10 min):** Ask, "What's easier: lifting a heavy box straight up onto a table, or sliding it up a ramp?"
- **Explore & Learn (25 min):**
    1. **Ramp Race:** Use a wooden plank or sturdy cardboard to create a ramp. Push a toy car up the ramp. Then, lift it straight up to the same height. Which way took less effort?
    2. **Build a Car:** Create a simple wheel and axle system by poking two skewers through a small cardboard box and attaching four bottle caps as wheels. Test how easily it rolls compared to just pushing the box.
- **Apply & Create (15 min):** Sketch the ramp experiment and the car. Write a caption explaining why it's easier to move things with an inclined plane or wheels.
- **Reflect (5 min):** "Why do you think moving trucks have ramps and skateboards have wheels?"

Day 4: Invisible Forces - Gravity & Friction

- **Learning Goal:** Identify the effects of gravity and friction on moving objects.
- **Spark Curiosity (10 min):** Drop a crumpled piece of paper and a flat piece of paper at the same time. Ask, "Why did one fall faster if gravity is pulling on them both?" (Air resistance, a type of friction).
- **Explore & Learn (25 min):**
    1. **Gravity Drop:** Drop two objects of different weights but similar shapes (e.g., a golf ball and a bouncy ball) from the same height. They should land at the same time, showing gravity pulls on them equally.
    2. **Friction Slide:** Send a toy car sliding across different surfaces: a smooth wood floor, a rug, a piece of aluminum foil, and sandpaper. Measure how far it slides on each. Discuss how friction is a force that slows things down.
- **Apply & Create (15 min):** Make a chart in the journal listing the surfaces tested and the distance the car traveled. Rank them from "least friction" to "most friction."
- **Reflect (5 min):** "Is friction helpful or unhelpful? Can it be both?" (Helpful for brakes, unhelpful

when you want to go fast).

Day 5: Chain Reactions & Project Kick-Off!

- **Learning Goal:** Plan a multi-step machine that uses at least three concepts from this week.
- **Spark Curiosity (10 min):** Set up a long, winding line of dominoes. Tip the first one and watch the chain reaction.
- **Explore & Learn (20 min):** Introduce the final project: The Marvelous Machine Challenge! The goal is to build a Rube Goldberg-style machine that accomplishes a simple task (e.g., rings a bell, pops a balloon, waters a small plant).
- **Apply & Create (25 min):** Brainstorm! In the science journal, sketch out initial ideas for the machine. What is the final goal? What steps could lead to it? Try to incorporate a ramp, a lever, and a falling object. This is just a first draft!
- **Reflect (5 min):** "What part of this challenge seems most exciting? What seems most difficult?"

Week 2: The Engineering & Design Lab

This week is all about applying Week 1's knowledge. We'll follow the engineering design process: Ask, Imagine, Plan, Create, and Improve.

Day 6: Design & Blueprint

- **Learning Goal:** Create a detailed, labeled diagram of the final machine design.
- **Activity (45-60 min):** Today is all about planning. On a large piece of paper or in the journal, draw the "blueprint" for the machine. Label the different parts: the marble, the ramp (inclined plane), the dominoes, the lever, etc. Label where energy transfers will happen (e.g., "Potential to Kinetic Energy here!").

Day 7: Gather & Build

- **Learning Goal:** Begin constructing the first one or two steps of the machine.
- **Activity (45-60 min):** Gather all the recycled and household materials needed. Start building the first part of the machine based on the blueprint. For example, build the initial ramp and test that the marble successfully rolls down and hits the next target (like a domino).

Day 8: Construct & Test

- **Learning Goal:** Continue building the machine, focusing on connecting the different steps.
- **Activity (45-60 min):** Build the next few steps of the machine. The key today is testing connections. Does the falling domino successfully trigger the lever? Does the lever push the car? Test each small sequence repeatedly. This is where most of the problem-solving happens!

Day 9: Troubleshoot & Refine

- **Learning Goal:** Use critical thinking to identify and fix problems in the machine.
- **Activity (45-60 min):** The machine probably has some bugs. Today is "Improve" day. Is the marble not heavy enough? Is the ramp not steep enough? Is the tape not holding? Work together to identify the "failure points" and brainstorm solutions. Don't get frustratedâ€”this is the most important part of engineering! Make adjustments and re-test.

Day 10: Final Presentation!

- **Learning Goal:** Successfully demonstrate the machine and explain the scientific principles at work.
- **Activity (45-60 min):**
    1. **Final Touches:** Make any last-minute adjustments to the machine.
    2. **The Grand Finale:** Set up a camera to record. Start the machine and watch it go! It's okay if it takes a few tries.
    3. **Scientist's Explanation:** While showing the video, have the student explain their machine. They should point out the simple machines they used, where potential energy changed to kinetic, and how forces like gravity and friction helped (or hindered) their machine.
    4. **Reflection:** Discuss what they are most proud of, what they would do differently next time, and what they learned about science and engineering.

Assessment

The final project is assessed based on application and explanation, not just success. Use this simple rubric:

- **Design & Creativity (4 points):** The machine includes at least 3 distinct steps and shows creative use of materials.
- **Science Application (4 points):** The student can identify and explain at least 2 simple machines and one energy transfer (potential to kinetic) in their machine.
- **Problem-Solving & Resilience (4 points):** The student actively participated in troubleshooting and did not give up when the machine failed.

Differentiation & Inclusivity

- **For Support:** Simplify the final task. A 2-step machine is a great achievement. Work together more closely on the troubleshooting phase, offering suggestions.
- **For a Challenge (Ramp Up):** Require the machine to use at least 5 of the 6 simple machines. Set a more complex task (e.g., must transport water from one cup to another). Add a time constraint for the machine to run.