Lesson Plan: The Marvelous Machine Mission

Subject: Physics, Engineering Design, Creative Problem-Solving

Grade Level: Middle School (Approx. age 12)

Time Allotment: 2-3 hours (flexible, can be spread over multiple days)

Materials Needed

This project is all about using what you have! Be creative and resourceful. Here are some ideas to get you started:

- **Structure & Ramps:** Cardboard boxes, books, wood scraps, LEGOs, plastic containers, cardboard tubes (from paper towels or toilet paper).
- **Rolling & Falling Objects:** Marbles, dominoes, toy cars, various balls (golf ball, tennis ball, ping pong ball).
- **Levers & Connectors:** Rulers, paint stirrers, pencils, string, yarn, rubber bands, paper clips.
- **Tools:** Scissors, masking tape or painter's tape (it's easier to remove!), a small cup or bucket.
- **Optional Fun Items:** A small bell, a toy pulley, a mousetrap (for the spring action, with adult supervision!), balloons, funnels.
- **Documentation:** Paper and pencil for sketching, a camera or phone to record the final machine.

Lesson Plan Details

1. Learning Objectives

By the end of this lesson, you will be able to:

- **Define** what a Rube Goldberg machine is and explain the concept of a chain reaction.
- **Identify** and incorporate at least three different simple machines (like a lever, inclined plane, or pulley) into a design.
- **Design, build, and test** a machine that completes a simple task using a multi-step chain reaction.
- **Apply** problem-solving skills to troubleshoot and improve your machine when it doesn't work as planned.

2. Alignment with Standards (NGSS)

- **MS-ETS1-1:** Define the criteria and constraints of a design problem. (Your goal is the criteria; your materials are the constraints).
- **MS-ETS1-3:** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution. (This is what you do when you test and fix your machine!)
- **MS-PS2-2:** Plan an investigation to provide evidence that an object's change in motion depends on the sum of the forces on it and its mass. (You'll see this in action as objects push, pull, and

knock each other over).

3. Lesson Activities & Instructional Strategies

Part 1: The Spark - Introduction & Brainstorming (20-30 minutes)

1. **Get Inspired (5 min):** Watch a fun video of a complex Rube Goldberg machine. Search for "OK Go - This Too Shall Pass" or "Joseph's Machines" for amazing examples. As you watch, think: What is the goal of the machine? What's the most clever step you see?
2. **Define the Terms (5 min):**
    - **Rube Goldberg Machine:** A comically complex machine built to perform a very simple task.
    - **Chain Reaction:** A series of events where each event triggers the next one. Think of falling dominoes!
    - **Simple Machines:** The basic building blocks of complex machines. Let's review the main ones:
        - **Inclined Plane:** A flat, sloped surface (a ramp).
        - **Lever:** A stiff bar that rests on a support called a fulcrum to lift or move something (like a seesaw).
        - **Wedge:** Used to separate two objects (like an axe).
        - **Screw:** An inclined plane wrapped around a cylinder.
        - **Wheel and Axle:** A wheel with a rod through its center (like on a toy car).
        - **Pulley:** A wheel with a groove for a rope or string.
3. **Define Your Mission (10-20 min):**
    - **Choose Your Simple Task:** What will be the final goal of your machine? It should be very simple.
      Examples: Ring a bell, drop a cookie into a glass of milk, turn the page of a book, water a small plant, press a button on a keyboard.
    - **Sketch It Out:** On a piece of paper, draw a plan for your machine. Don't worry about it being perfect! Think about the steps. How will step 1 trigger step 2? How will step 2 trigger step 3? Try to design a machine with at least **5 steps**. Label any simple machines you plan to use.

Part 2: The Build - Construction & Testing (90+ minutes)

1. **Gather Your Gear:** Collect the household items you planned to use, and feel free to grab other things that spark ideas.
2. **Build One Step at a Time:** Start building your machine from the beginning. Build the first step and test it. Does the ball roll down the ramp correctly? Then, build the second step and see if the first step can trigger it. Testing in small sections is much easier than building the whole thing at once!
3. **Troubleshoot and Persevere:** Your machine will probably fail many times. **This is normal and part of the fun!** It's how engineers learn. Ask yourself:
    - Did the object not have enough force? Maybe the ramp needs to be steeper.
    - Did it miss its target? Maybe you need to add cardboard "bumpers" to guide it.
    - Is the string not pulling hard enough? Maybe the object pulling it needs to be heavier.

   Keep adjusting, testing, and improving your design. This is called the **iterative process**.

Part 3: The Grand Finale - Demonstration & Reflection (15 minutes)

1. **Record the Run:** Set up a phone or camera to record your machine in action. It might take a few tries to get a perfect run-through, so be patient!

2. **Explain Your Creation:** As you show off your machine (either live or in the video), explain what it does. Point out the different steps and identify the simple machines you used.
    - "First, the marble rolls down this book, which is an **inclined plane**..."
    - "...it hits this ruler, which acts as a **lever** to launch the cotton ball..."
3. **Reflect:** What was the hardest part to get right? What part of your machine are you most proud of? If you were to do it again, what would you do differently?

4. Differentiation and Inclusivity

- **For Extra Support:** Start with a smaller goal, like a 3-step machine. Work together to build the first two steps to build confidence. Look at sketches of simple machines online for ideas on how to build them.
- **For an Extra Challenge:**
    - Increase the number of required steps to 10 or more.
    - Require the use of at least four different types of simple machines.
    - Challenge yourself to have the machine make a 90-degree turn at some point.
    - Incorporate a non-physical transfer of energy, like light (triggering a sensor) or sound.

5. Assessment Methods

Your success on this mission will be based on your process and final creation! We'll look at:

- **Design Sketch:** Did you create a thoughtful plan for your machine before building?
- **Machine Functionality:** Does the machine successfully complete the simple task? (Even if it takes a few tries!)
- **Explanation:** Can you clearly explain the steps of your machine and point out at least three simple machines you used in your design?
- **Problem-Solving:** Can you talk about a problem you faced during the build and explain how you fixed it?