Rube Goldberg Machine—Part 1

Name: _____

Date: _____

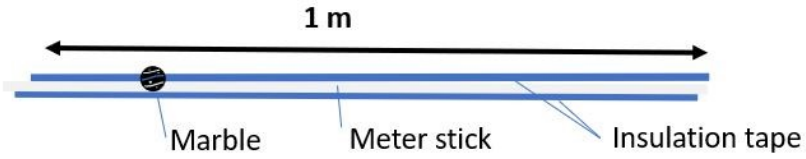
Student worksheet

Goal: Find out how the kinetic energy of a moving object (the marble) depends on the object's mass and speed.

DIRECTIONS: Set up your experiment as described below.

1. Prepare the ramp:

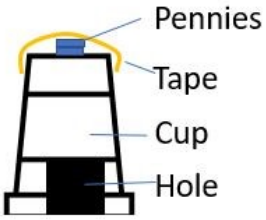
   Apply insulation tape along both long edges of the meterstick, as shown in the figure. Make sure you can still read the distance indications on the meterstick.



2. Prepare the cup.

   a. Cut a hole in the mouth of a small disposable cup, at the top edge, so the marble can roll into the cup.

   b. Place two pennies centered on top of the cup. Use tape to keep the pennies in place.



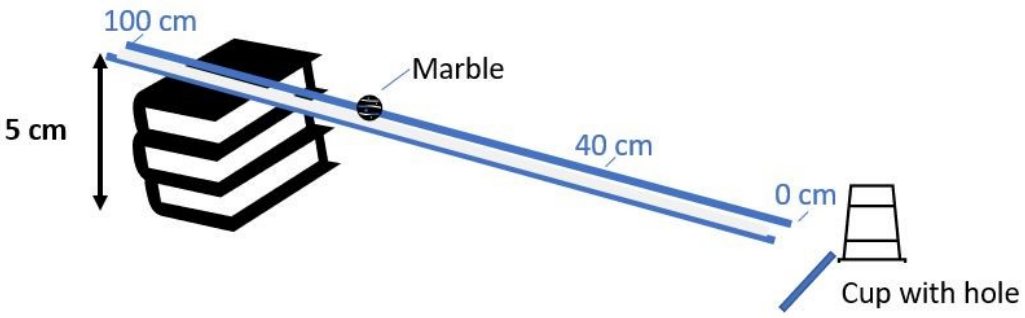
3. Set up the experiment on a smooth surface.

   a. Stack books to elevate the far end of the ramp 5 cm.

   b. Put the ramp in place and use tape to keep the ramp from moving.

   c. Align the cup so a marble rolling down the ramp rolls into the hole in the cup.

   d. Indicate the initial placement of the cup with a piece of painter's tape.



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DIRECTIONS: Follow the directions below to collect data.

4. Collect data for a single marble rolling down the ramp.
    a. Place one marble at 40 cm from the lower end of the ramp.
    b. Let the marble roll.
    c. Measure how far this marble can move the cup. This is a measure of how much kinetic energy this marble had.
    d. Record your data in Table 1 next to Trial 1.
    e. Repeat the measurement one more time for a second trial.
    f. Optional: Perform a third trial to get more-accurate data.
    g. Repeat steps a.-f. with the marble rolling from the 60-cm mark.
    h. Repeat steps a.-f., but let the marble roll from the 80-cm mark.
    i. Calculate the averages for each marble position.
5. Collect data for two marbles rolling down the ramp simultaneously.
    a. Repeat steps 4.a.-4.i with two identical marbles, one resting against the other, rolling simultaneously down the ramp.
6. Collect data for three marbles rolling down the ramp.
    a. Repeat steps 4.a.-4.i with three identical marbles, all resting against each other, rolling simultaneously down the ramp.
    b. If marbles push the cup up and roll on, write this observation in your data table.
7. Collect qualitative data.
    a. How does the speed of a marble at the end of the ramp change when the marble rolls from farther up the ramp? Briefly describe what you notice?
8. Find the speed of the marbles.
    a. Use the graph on the next page to find the speed of a marble starting from 40 cm up the ramp. Write this speed in Table 1, next to "Starting position: 40 cm."
    b. Repeat step a. for 60 cm up the ramp, and then for 80 cm up the ramp.

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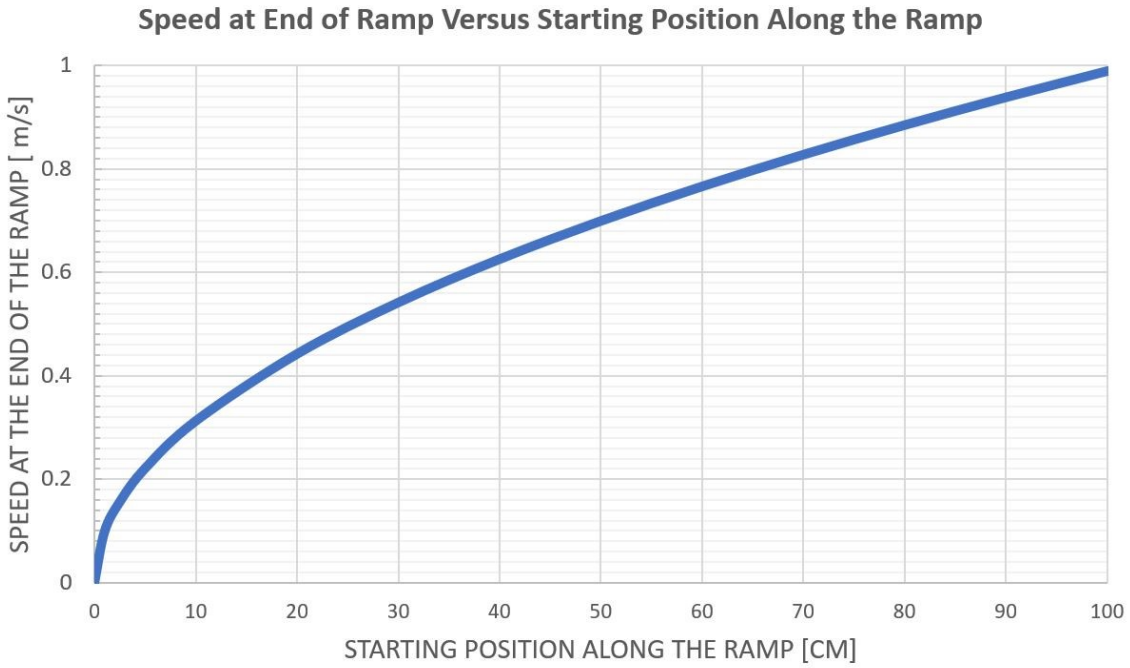

	Table 1: Distance the cup moves [cm]		
Number of Marbles	**1**	**2**	**3**
	Starting position: 40 cm up the ramp / Speed:		
Trial 1			
Trial 2			
Trial 3			
Average			
	Starting position: 60 cm up the ramp / Speed:		
Trial 1			
Trial 2			
Trial 3			
Average			
	Starting position: 80 cm up the ramp / Speed:		
Trial 1			
Trial 2			
Trial 3			
Average			

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DIRECTIONS: Visualize the data collected in Table 1 and use the graphs to draw conclusions.

The graphs can be made on graph paper or using a data visualization tool.

9. Graph the distance the cup shifts versus the number of rolling marbles.
    a. Graph the distance the cup shifts (vertical y-axis) versus the number of marbles (horizontal x-axis) for marbles starting 40 cm up the ramp.
    b. Repeat step a. for marbles starting 60 cm up the ramp, and then for marbles starting 80 cm up the ramp. This can be done on the same graph with a different color for each starting position, or on different graphs.

10. Draw conclusions from the graph(s) showing the distance the cup shifts versus the number of rolling marbles.
    a. Describe what you notice.

    b. Can this/these graph(s) give us information about how kinetic energy (the distance over which the cup shifts) changes with the total mass of the rolling marble(s)? Why, or why not?

    c. If you answered "Yes" on b., according to the graph(s), is kinetic energy (the distance over which the cup shifts) [directly proportional to/ indirectly proportional to/ proportional to the square of] (select the best answer) the total mass of the rolling marble(s)? Briefly explain your choice.

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11. Graph kinetic energy versus speed.
    a. Graph the distance the cup shifts (vertical axis) versus the speed of a single marble. Include the point: kinetic energy of 0 for a speed of 0 m/s.
    b. Repeat step a. for two marbles rolling simultaneously, and then for three marbles rolling simultaneously. This can be done on the same graph with a different color for each number of marbles, or on different graphs.
    c. **Optional:** Graph the distance the cup shifts (vertical axis) versus **the square of** the speed of a single marble. Include the point: kinetic energy of 0 for a (speed)^2 of 0 m^2/s^2.
    d. **Optional:** Repeat step c. for two marbles rolling simultaneously, and then for three marbles rolling simultaneously. This can be done on the same graph with a different color for each number of marbles.

12. Draw conclusions from the graph(s) showing distance the cup shifts versus the speed of the rolling marble(s). Include the graph showing distance the cup shifts versus the square of the speed of the rolling marble(s) if you made this graph.
    a. Describe what you notice.

    b. Does this/these graph(s) show that kinetic energy (the distance over which the cup shifts) changes with speed? Why or why not?

    c. If you answered "Yes" on b., according to the graph(s), is kinetic energy (the distance over which the cup shifts) [directly proportional to / indirectly proportional to/ proportional to the square of] (select the best answer) the speed of the rolling marble(s)? Briefly explain your choice.

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Goal: Use the concept of kinetic energy to design and build a rube Goldberg machine.

Directions: Complete each section as described.

1. Write down the task your Rube Goldberg machine will execute.

2. Plan the Rube Goldberg machine.

   In your group:

   a. Brainstorm ideas for sections of the machine (e.g. a marble rolling down a ramp) and ideas for how these could connect with each other (e.g. a marble rolling into a series of dominos). Sketch the ideas below. (Use extra paper if this space is too small).

b. Look critically at the sketches. Which ones look feasible? Can you tweak some ideas to make them feasible? Select three or four sections you would like to build and think about ways to connect these. What order will work best? Agree on a selection and draw your complete plan in the area below.

c. Analyze the plan critically. Are the connections likely to work? Will the moving parts have enough or too much kinetic energy to execute their task?

   Adjust or add specifications to the plan where needed.

   Explain how you used the concept of kinetic energy for three design choices.

   1.

   2.

   3.

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3. Build, test, rebuild and retest the Rube Goldberg machine.

   Advice:

   a. Divide, communicate, and conquer. Rube Goldberg machines consist of several contraptions that work together. Communicate and find ways to use everyone's time efficiently.

   b. Test individual parts and connections while you are building them. It is ok to make adjustments, but be sure to communicate them, especially if they impact other sections of the machine.

   c. Learn from failure. Pause when failure happens and use the knowledge you have to plan and think through adjustments.

Briefly explain three changes you made to the plan.

Change	Why we made the change:	Why we chose this solution: