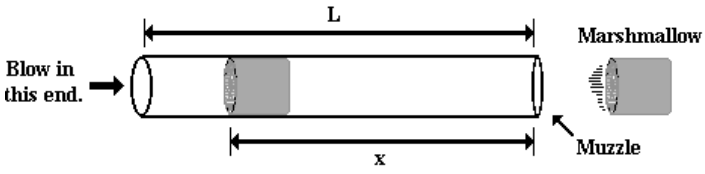
Marshmallow Launcher

A group of students are conducting an experiment to investigate the factors that impact the effectiveness of a marshmallow launcher. They construct th launcher using hollow PVC pipe. The pipe is cut to varying lengths and loaded with a marshmallow. Blowing in one end of the pipe launches the marshmallow out the other end. The students are using pipes of varying length (**L**) and placing the marshmallow varying distances from the muzzle of the launcher (**x**). These two variables are shown in **Figure 1**.

Figure 1

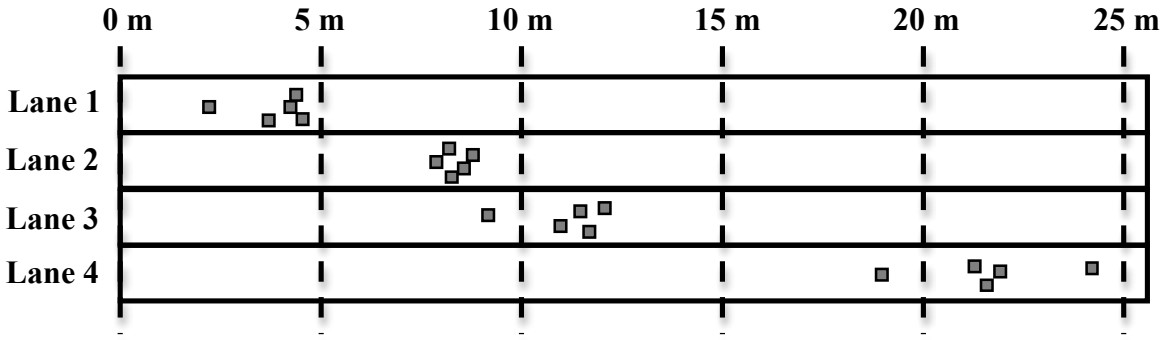


In their experiment, students set up lanes in a hallway and mark distances across the lanes at 5-meter intervals. They shoot the marshmallows down each lane from the same starting position. They repeat the procedure five times within each lane using a unique length of pipe and/or a unique starting position of the marshmallow within the pipe. **Table 1** shows the values of L and x that are used in each lane. The locations where the marshmallow lands are shown in **Figure 2**.

Table 1

Lane	L	x
1	10 cm	2 cm
2	20 cm	2 cm
3	15 cm	5 cm
4	15 cm	13 cm

Figure 2: Landing Location of Marshmallows



Questions:

1. What is the estimated distance traveled through the air by a marshmallow that is launched from a 15-cm long launcher when it is placed 5 cm from the muzzle?
   a. 4 meters
   b. 8 meters
   c. 11 meters
   d. 22 meters

2. Which two lanes best illustrate the effect of the distance of the marshmallow from the muzzle on the landing location of the marshmallow?
   a. Lanes 1 and 2
   b. Lanes 1 and 3
   c. Lanes 2 and 4
   d. Lanes 3 and 4

3. Trials 3 and 4 were conducted in Lanes 3 and 4. What variable was the independent variable in these two trials?
   a. The mass of the marshmallow.
   b. The length of the launcher from which the marshmallow was launched.
   c. The distance that the marshmallow is located from the muzzle of the launcher.
   d. The distance that the marshmallow traveled through the air before landing on the ground.

4. Which of the following would **NOT** be an important variable to control over the course of this study?
   a. The mass of the launcher.
   b. The mass of the marshmallow.
   c. The person who blows on the launcher.
   d. The strength with which the person blows on the open end.

5. Which of the following pre-cautions would not be likely to affect the reliability of this experiment?
   a. Conduct all experiments in the same lane but perform each trial from different heights.
   b. Paint the outside of each launcher a different color so that they can be distinguished from each other.
   c. Conduct all experiments in the same lane but use a different launch angle for each combination of x and L.
   d. Assign a different student in each lab group a different lane so that each student has a chance to launch the marshmallows.

6. Based on the data presented above, how would the variables L and x need to be manipulated in order to have the longest launch distance?
   a. Both the L and the x should be as short as possible.
   b. Both the L and the x should be as long as possible.
   c. The L should be as short as possible and the x should be as long as possible.
   d. The L should be as long as possible and the x should be as short as possible.

7. Suppose that the results of this study are being used to improve the design of a new NERF gun known as the SuperShot. The gun uses a blast of air to launch a NERF dart through a muzzle. The design team must decide on how long the barrel of the gun should be and where the dart should be positioned in the barrel once it is loaded. Which of the following decisions would improve the SuperShot the most?
   a. The barrel of the SuperShot should be very short and the dart should be initially located near the muzzle opening of the barrel.
   b. The barrel of the SuperShot should be very long and the dart should be initially located near the muzzle opening of the barrel.
   c. The barrel of the SuperShot should be very short and the dart should be initially positioned as far as possible from the muzzle opening of the barrel.
   d. The barrel of the SuperShot should be very long and the dart should be initially positioned as far as possible from the muzzle opening of the barrel.

8. Consider the trends found in the data presented above. Which one of the following combinations of tube length (L) and distance between marshmallow and the muzzle (x) would lead to the shortest distance traveled by a launched marshmallow?
   a. L = 10 cm, x = 8 cm
   b. L = 10 cm, x = 2 cm
   c. L = 20 cm, x = 2 cm
   d. L = 20 cm, x = 18 cm

9. Consider the trends in the data presented above. What would be a reasonable prediction of the landing location for a marshmallow launched by a 20-cm tube when placed 18 cm from the muzzle?
   a. Between 4 meters and 8 meters.
   b. Between 8 meters and 11 meters.
   c. Between 11 meters and 22 meters.
   d. More than 22 meters.

10. Which one of the following theories best explains the results obtained in Lanes 3 and 4?
   a. More massive marshmallows have a greater resistance to the blowing force and thus leave the launcher at slower speeds.
   b. Marshmallows that travel the furthest distance through the pipe will encounter the greatest friction and leave the muzzle with the lowest speeds.
   c. The longer the length of the pipe through which the launcher is blown, the greater the force that is exerted on the marshmallow and the greater the speed.
   d. The longer the time the blowing force acts on the marshmallow, the greater the momentum that the marshmallow will obtain when being launched.

11. The dependent variable in this experiment is _____.
   a. The length of the pipe.
   b. The mass of the marshmallow.
   c. The landing location of the marshmallow.
   d. The distance of the marshmallow to the muzzle of the pipe.
   e. Two of the above.