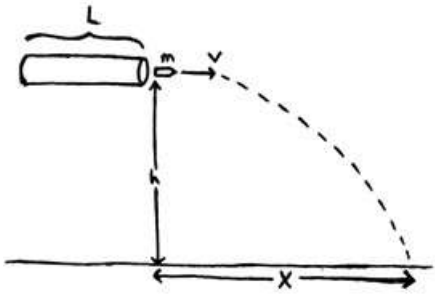
NAME _____ DATE _____

Scenario

A constant force F is exerted on a dart of mass m in the horizontal direction as it moves through a tube of length L. The tube is situated a height h above the ground. Upon exiting the tube, the dart travels a horizontal distance x before striking the ground, as depicted in the diagram at right.



PART A: Suppose students experiment with the tube and a variety of darts. Some darts have higher masses than others but are the same aerodynamic shape. Assuming air resistance is negligible for the darts. Should the students use a dart with large mass or small mass to launch the dart the farthest distance possible?

_____ Large mass _____ Small mass _____ Neither; the mass does not matter.

Briefly explain your reasoning without manipulating equations.

PART B: On the internet, a student finds the following equation used in a similar lab situation: $x = \frac{mh^2 g}{FgL^2}$.

Regardless of whether this equation to find the horizontal distance is correct, does it agree with your qualitative reasoning in Part A? In other words, does this equation for x have the expected dependence as reasoned in Part A?

_____ Yes _____ No

Briefly explain your reasoning without deriving an equation for x.

PART C: Another student makes a mistake in their derivation and develops the following expression to predict the landing location of the dart: $x = \frac{Fhg}{mL}$. Without deriving the correct equation, how can you tell that this equation is not plausible? In other words, that it does not make physical sense. If there is more than one reason, make sure you discuss each.

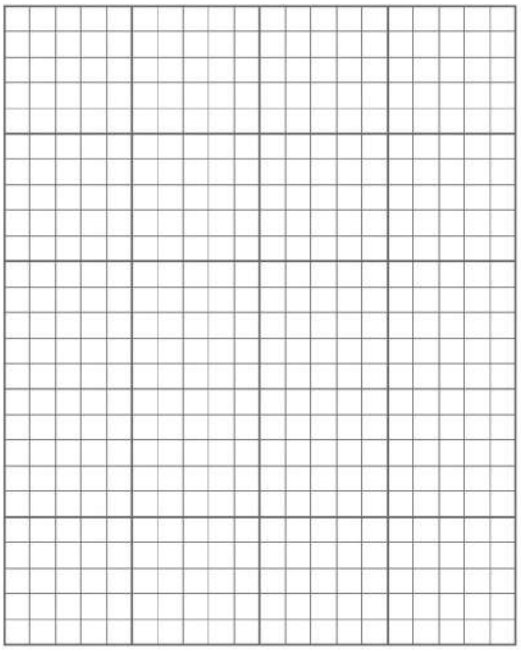
PART D: The group of students is then given a task: Experimentally determine the height of the tube using a linear regression analysis. The students are able to change the magnitude of the constant force exerted on the darts but not the length of the tube or the mass of the dart. In their derivation, the students correctly determine that the height of the table can be expressed as $h = \frac{mgx^2}{4FL}$.

What quantities should be graphed to produce a linear graph from which the vertical height of the tube could be obtained? Justify your answer. Calculations or equations may be used in your answer, but calculations alone are not a sufficient justification.

PART E: An experiment is then performed in which the force exerted on the dart is varied, resulting in the dart traveling various horizontal distances x, which are recorded in the table below.

Trial	*1*	*2*	*3*	*4*	*5*	*6*
Force exerted (*N*)	0.2	0.5	0.8	1.2	1.7	2.0
Horizontal Distance x (*m*)	3.5	5.5	7.0	8.6	10.2	11.1

Use the grid below to plot a linear graph of x squared as a function of F. Use the empty boxes in the data table, as appropriate, to record the calculated values you are graphing. Label the axes as appropriate (with correct units), and place numbers on both axes.



PART F: From the graph, determine the height of the tube given the mass of the dart is 0.020 kg and the length of the tube is 0.35 m.