Name: _____ Class: _____ Date Rec: _____ Date Due: _____

Linearization Practice (Forces & Motion)

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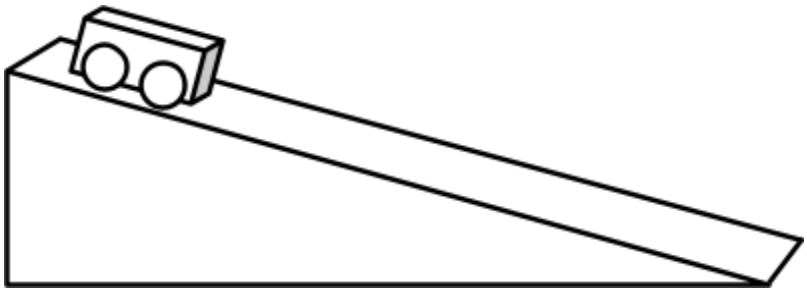
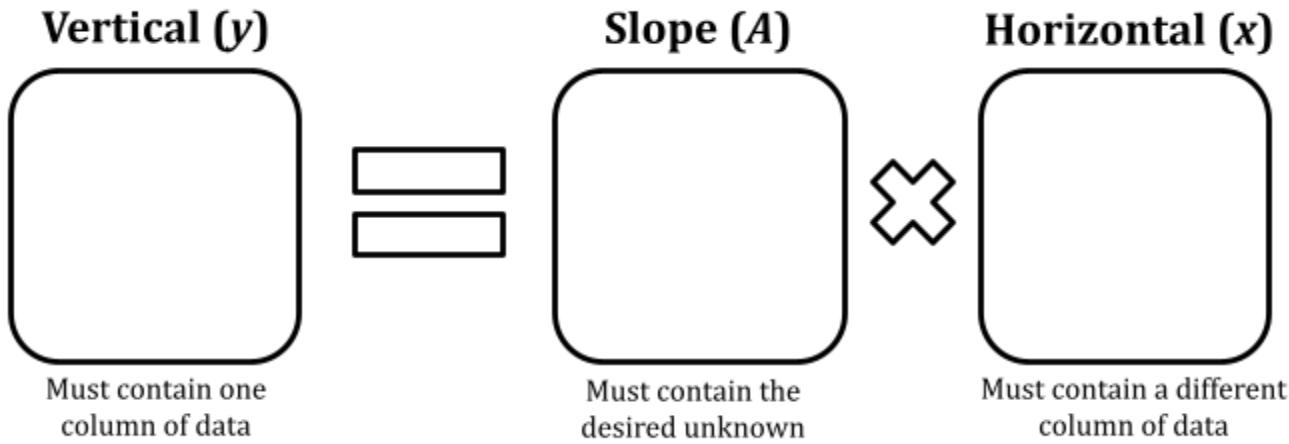
Problem 1: A cart is released from rest on a ramp at $t = 0$. Students record distance traveled and time elapsed for the cart as it moves down the ramp with uniform acceleration.



	d (cm)	t (s)	
	0	0	
	10	0.53	
	20	0.67	
	30	0.87	
	40	0.95	
	50	1.12	
	60	1.18	

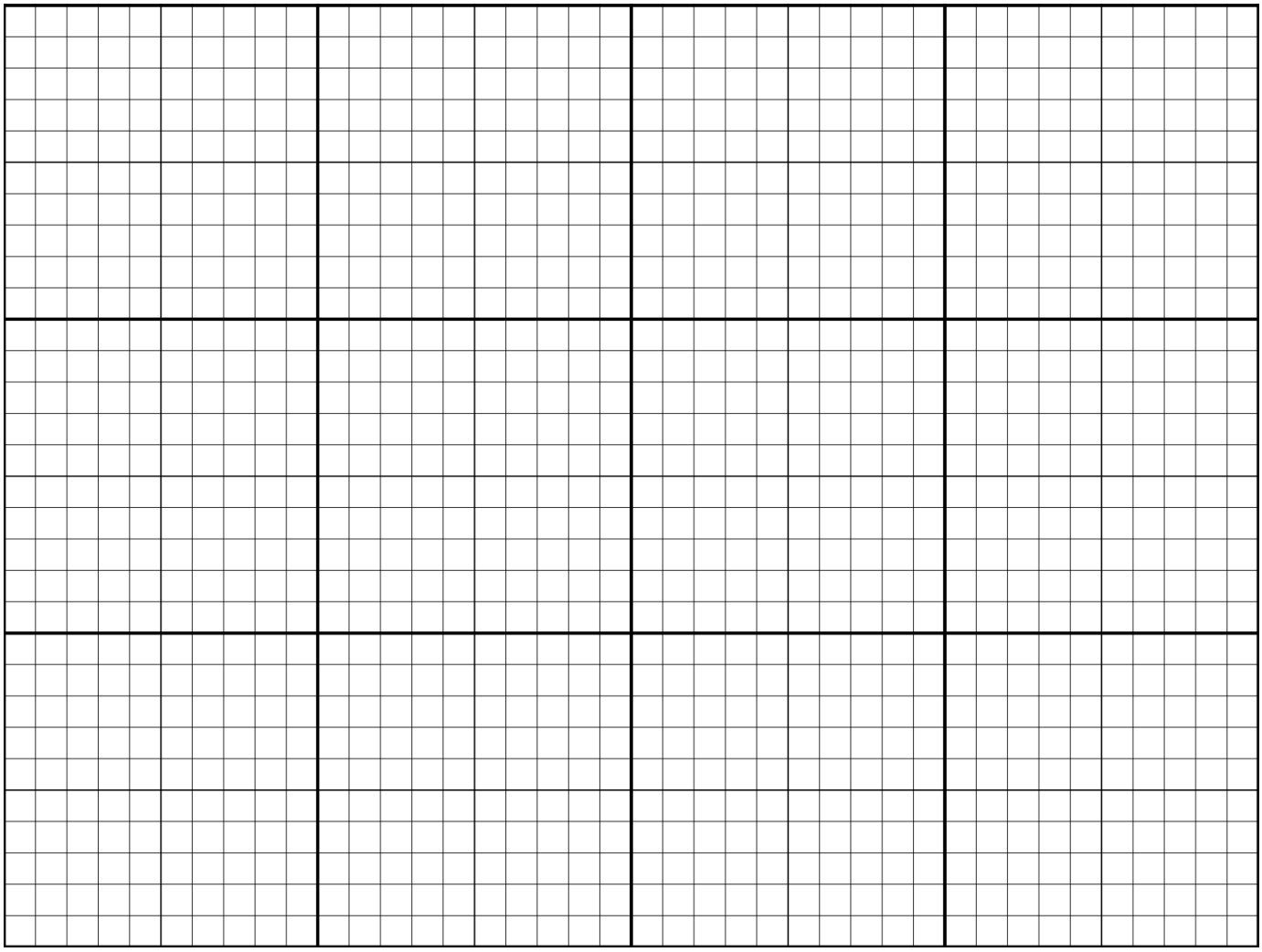
a) Show that the distance traveled d, time elapsed t, and acceleration down the ramp can be related by the equation: $d = \frac{1}{2}at^2$

b) What could you graph to determine the unknown acceleration of the cart? Separate the equation into the 3 boxes below (there are many ways to do this):



c) If necessary, create a new column or columns of data to match the vertical and horizontal boxes.

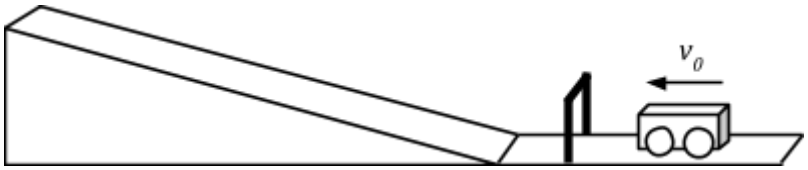
d) Graph the data chosen in the vertical and horizontal boxes. Label the axes.



e) Draw a line of best fit through the data and calculate the slope of the line.

f) Use your slope to find the acceleration of the cart on the ramp. If your slope is equal to the acceleration, state this.

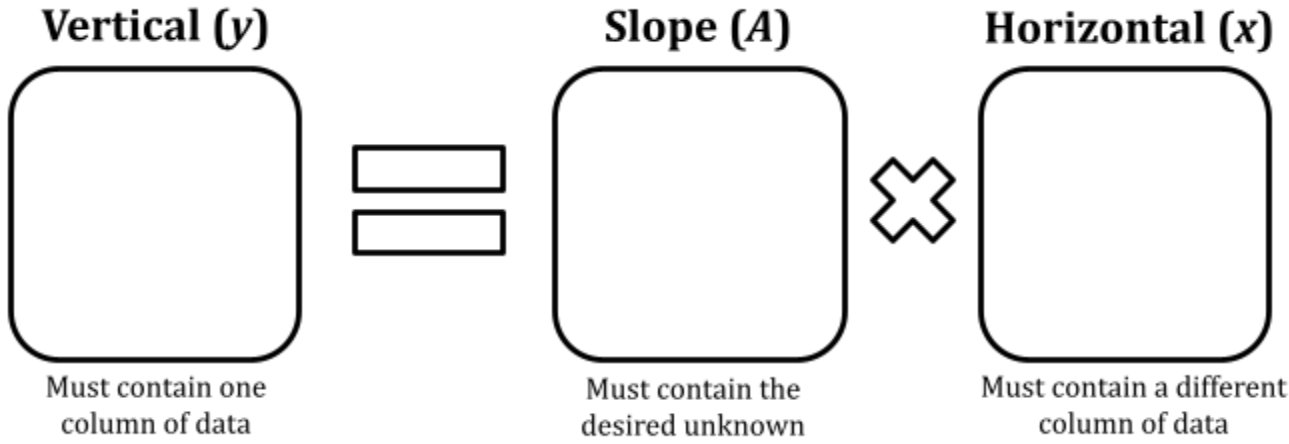
Problem 2: Students are trying to determine how the acceleration up the ramp compares to the acceleration down the ramp. A photogate near the bottom of the ramp allows students to measure the velocity of the cart on flat ground. There is a negligible change in speed between the photogate and the bottom of the ramp. They use a meter stick to measure the distance travelled up the ramp before stopping.



	v_0 (m/s)	d (cm)	
	0.23	3	
	0.38	7	
	0.60	23	
	0.77	34	
	0.93	48	
	1.12	66	
	1.29	94	

a) Show that the uphill distance traveled up the ramp before stopping d, the magnitude of the downhill acceleration on the ramp, and the speed of the cart at the bottom of the ramp v_0 can be related by the equation: $v_0^2 = 2ad$

b) What could you graph to determine the unknown acceleration of the cart? Separate the equation into the 3 boxes below (there are many ways to do this):



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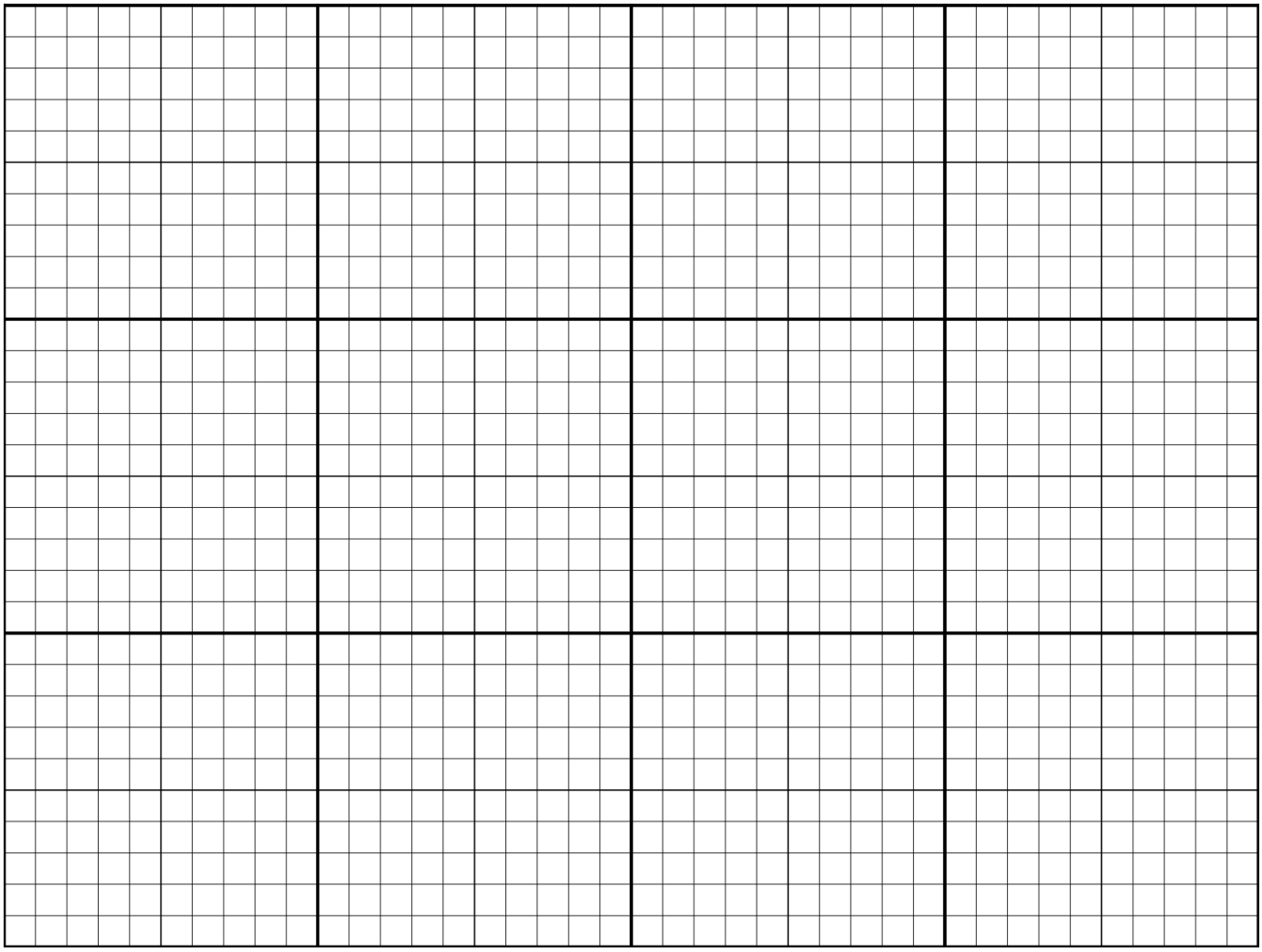
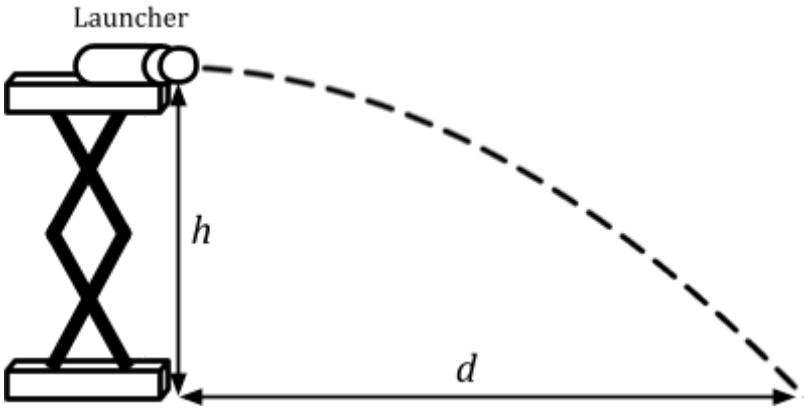
d) Graph the data chosen in the vertical and horizontal boxes. Label the axes.



e) Draw a line of best fit through the data and calculate the slope of the line.

f) Use your slope to find the acceleration of the cart on the ramp. If your slope is equal to the acceleration, state this.

Problem 3: Students are trying to determine the speed (v_0) of their marble launcher. They shoot marbles horizontally from several different heights *h* above the floor and record the horizontal distance *d* traveled before hitting the ground.

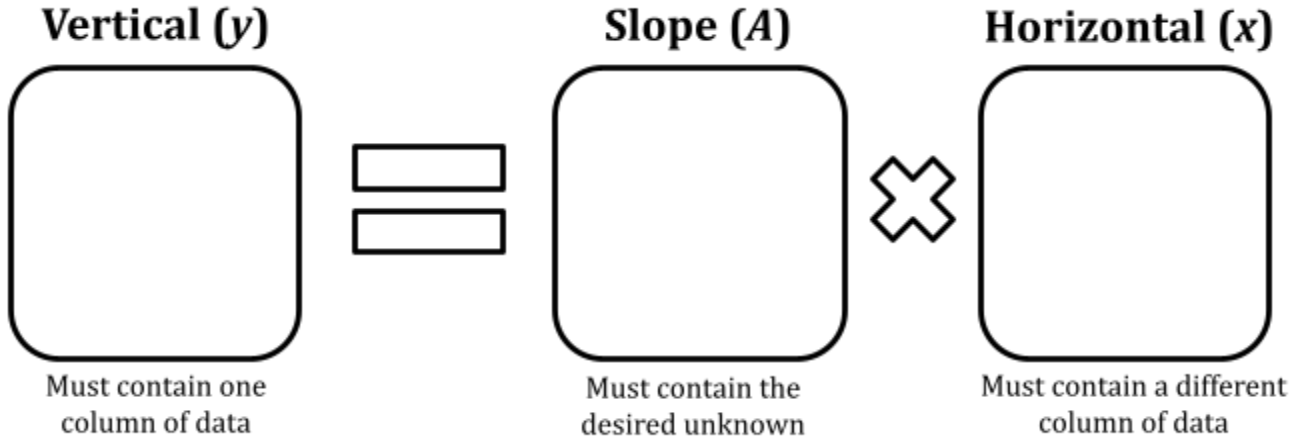


	h (m)	*d* (m)	
	0.4	1.10	
	0.6	1.42	
	0.8	1.59	
	1.0	1.86	
	1.2	1.96	
	1.4	2.18	
	1.6	2.25	

a) Show horizontal distance traveled can be related to the initial height by the equation:

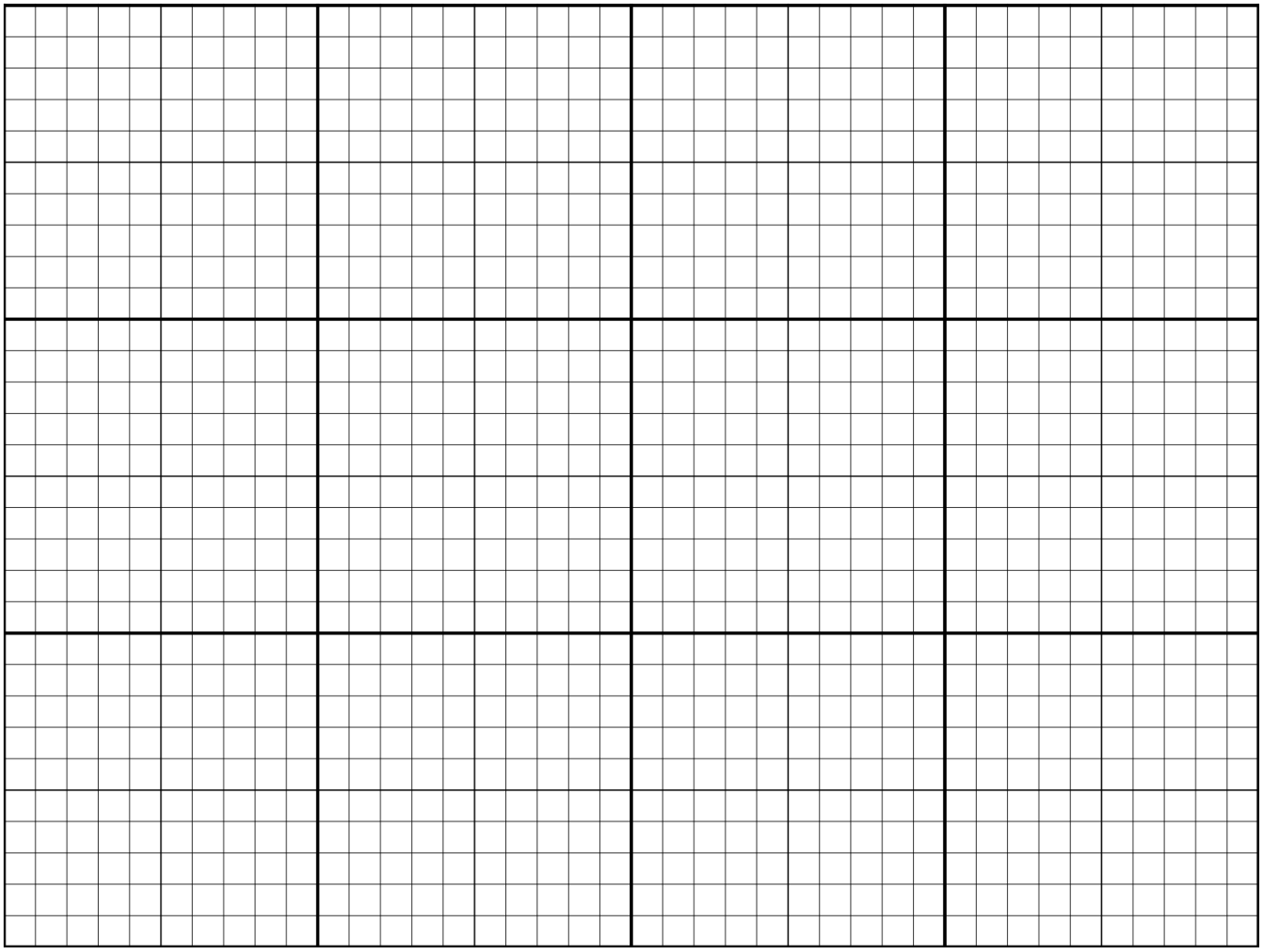
$$d = v_0\sqrt{\frac{2h}{g}}$$

b) What could you graph to determine the unknown initial speed of the marble? Separate the equation into the 3 boxes below (there are many ways to do this):



c) If necessary, create a new column or columns of data to match the vertical and horizontal boxes.

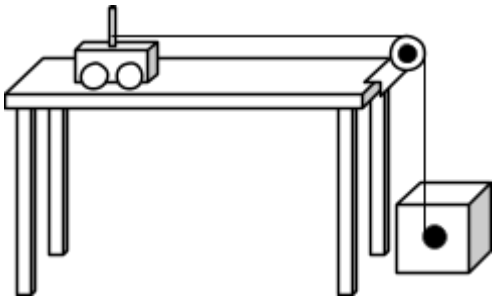
d) Graph the data chosen in the vertical and horizontal boxes. Label the axes.



e) Draw a line of best fit through the data and calculate the slope of the line.

f) Use your slope to find the initial speed of the marble, v_0. If your slope is equal to the initial speed, state this.

Problem 4: Students discover a device in the science lab that holds a constant tension in string, regardless of what it pulls on. Unfortunately, they do not know the magnitude of this force. They attach the string from the device over a pulley with negligible mass and friction, to a low friction cart and measure the time it takes to travel a distance of d = 1.5 meters across a lab table. They repeat this several more times, each time changing the mass of the cart.

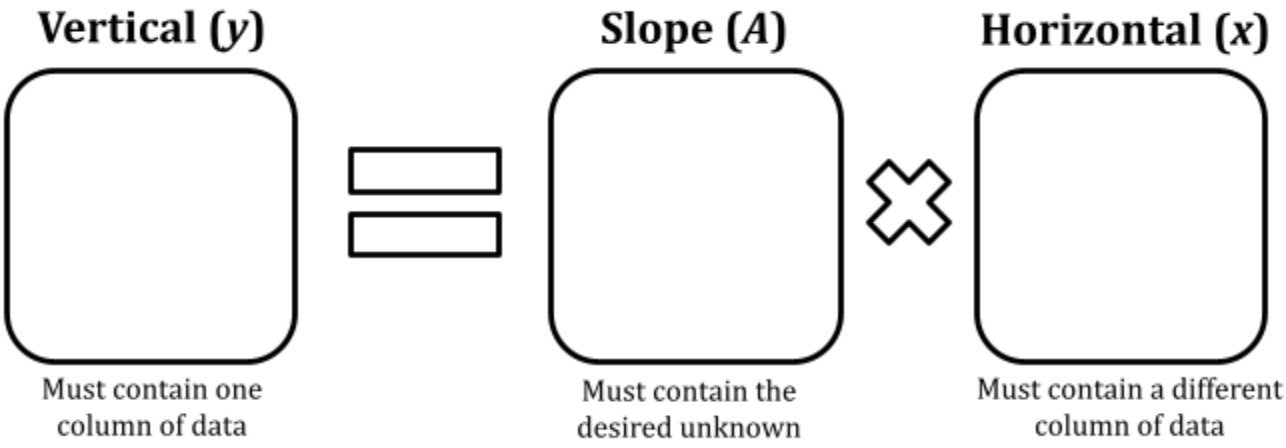


	m (kg)	t (s)	
	0.70	0.26	
	1.20	0.35	
	1.70	0.41	
	2.20	0.47	
	2.70	0.51	
	3.20	0.53	
	3.70	0.63	

a) Show that for a constant horizontal force F on a frictionless cart, the relationship between the mass of the cart m, and the time t to travel a distance d can be written as:

$$\frac{2d}{t^2} = F\left(\frac{1}{m}\right)$$

b) What could you graph to determine the unknown force of tension? Separate the equation into the 3 boxes below (there are many ways to do this):



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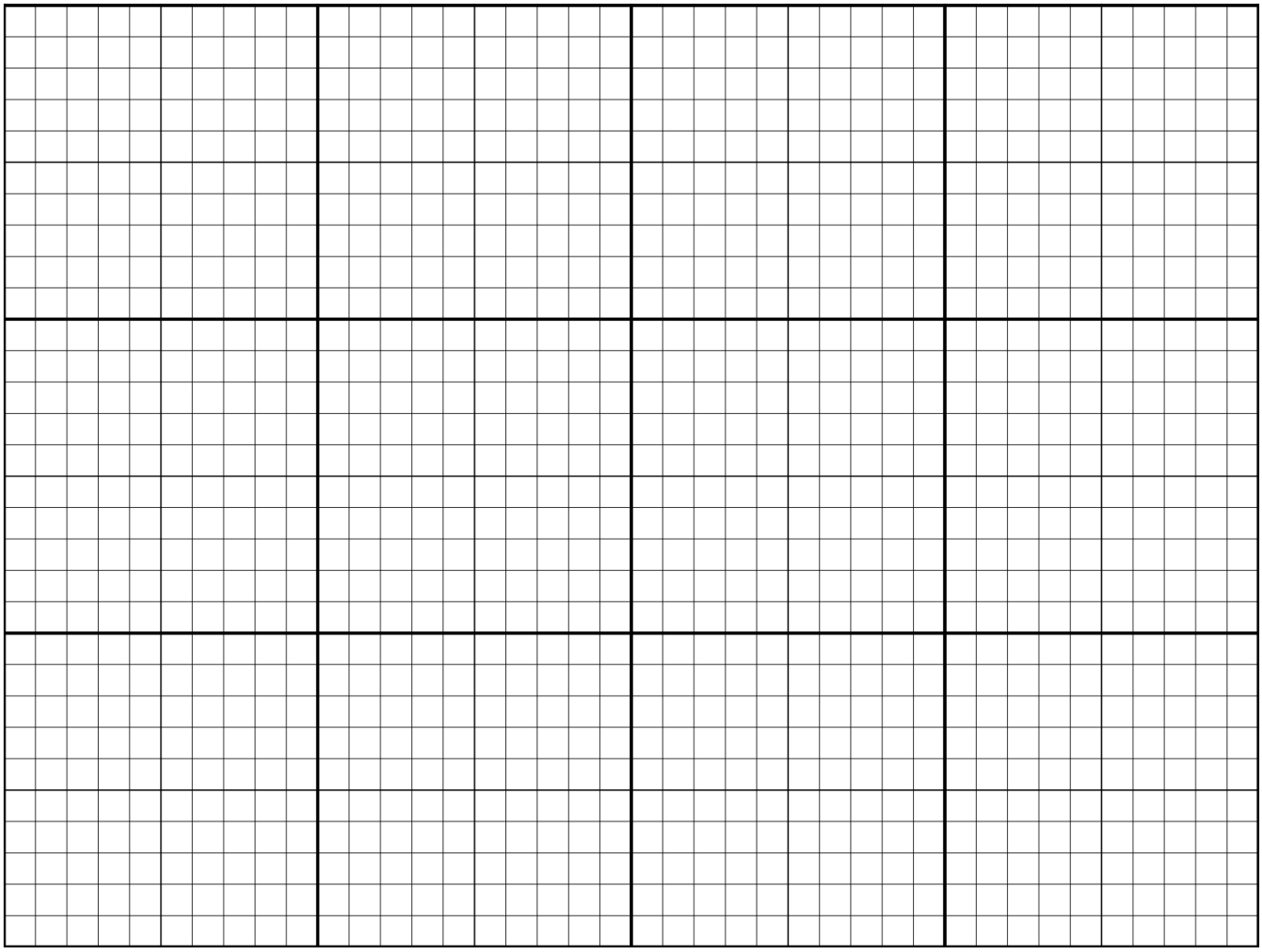
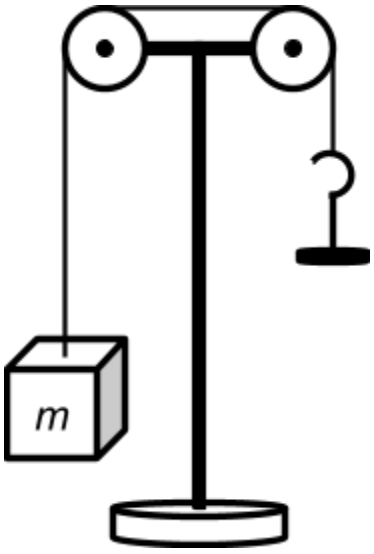


e) Draw a line of best fit through the data and calculate the slope of the line.

f) Use your slope to find the force of tension, *F*. If your slope is equal to the force of tension, state this.

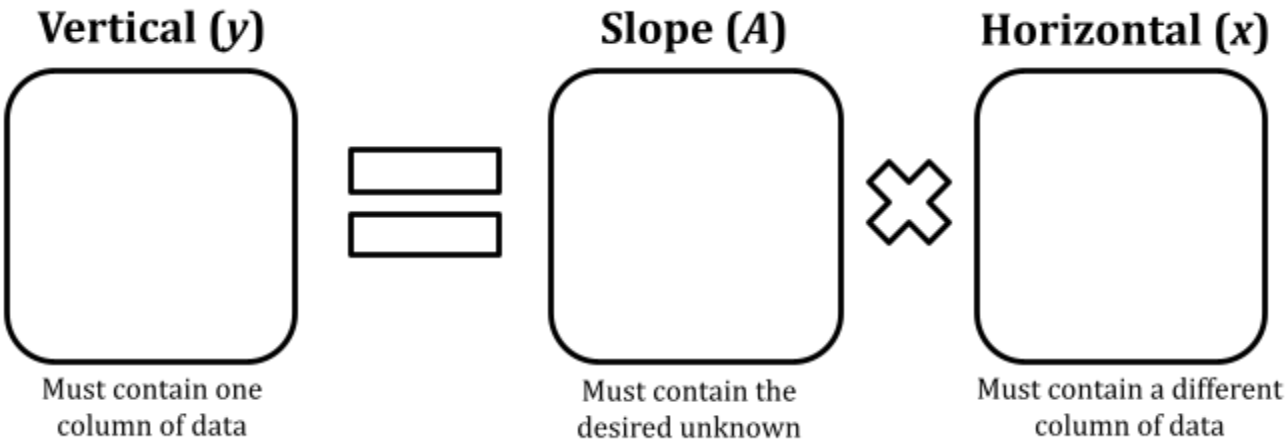
Problem 5: Students are determining an experimental value for the gravitational constant on Earth using a system like the one shown, with pulleys of negligible mass and friction. The block attached on the left has a fixed mass of m = 0.5 kg. The total hanging mass on the right (M) can be adjusted by adding masses. Students use a motion detector to measure the upward acceleration of the block with different masses on the hanger.



	M (kg)	a (m/s^2)	
	0.70	1.4	
	0.90	2.9	
	1.10	3.7	
	1.30	4.3	
	1.50	4.8	
	1.70	5.2	
	1.90	5.8	

a) Show that the relationship between the acceleration and the two masses is given by: $$a = g\left(\frac{M-m}{M+m}\right)$$

b) What could you graph to determine the gravitational constant? Separate the equation into the 3 boxes below (there are many ways to do this):



c) If necessary, create a new column or columns of data to match the vertical and horizontal boxes.

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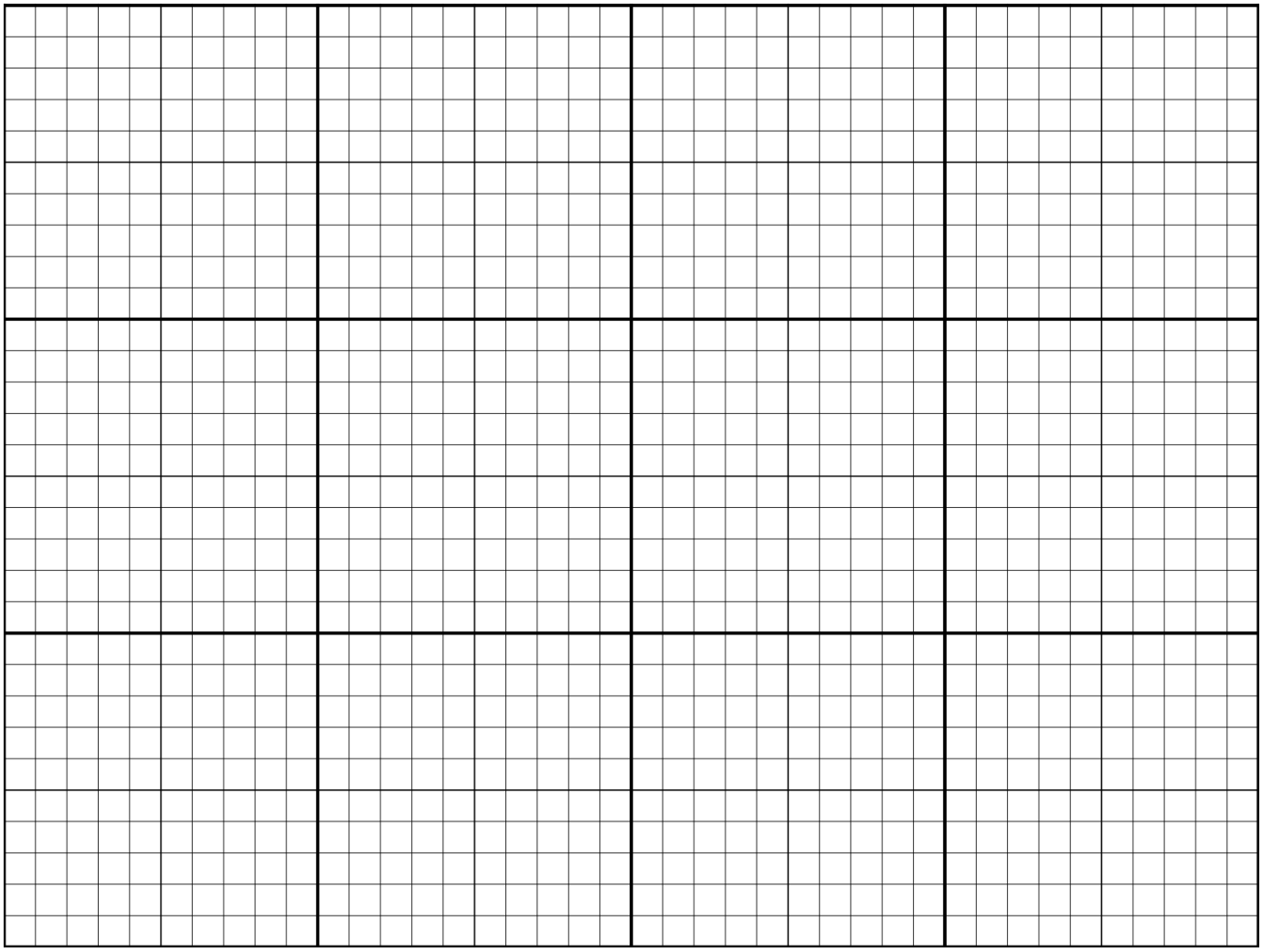
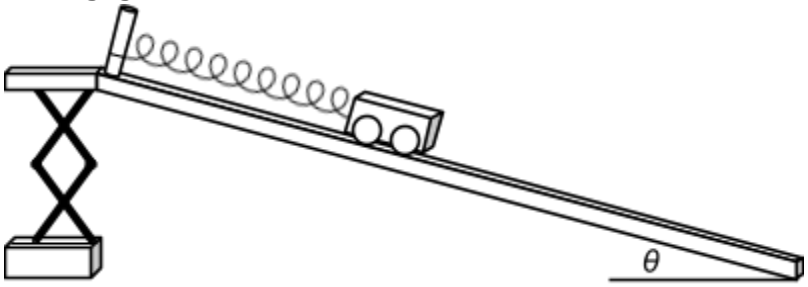


e) Draw a line of best fit through the data and calculate the slope of the line.

f) Use your slope to find the experimental gravitational constant, g. If your slope is equal to the gravitational constant g, state this.

Problem 6: Students are determining the spring force constant k of a Hookean (linear) spring. They only have access to a single cart with mass m = 1.2 kg, and a ramp. They change the incline angle of the ramp, θ, and measure the corresponding spring stretch, d, from its natural length. Assume effects due to friction are negligible.

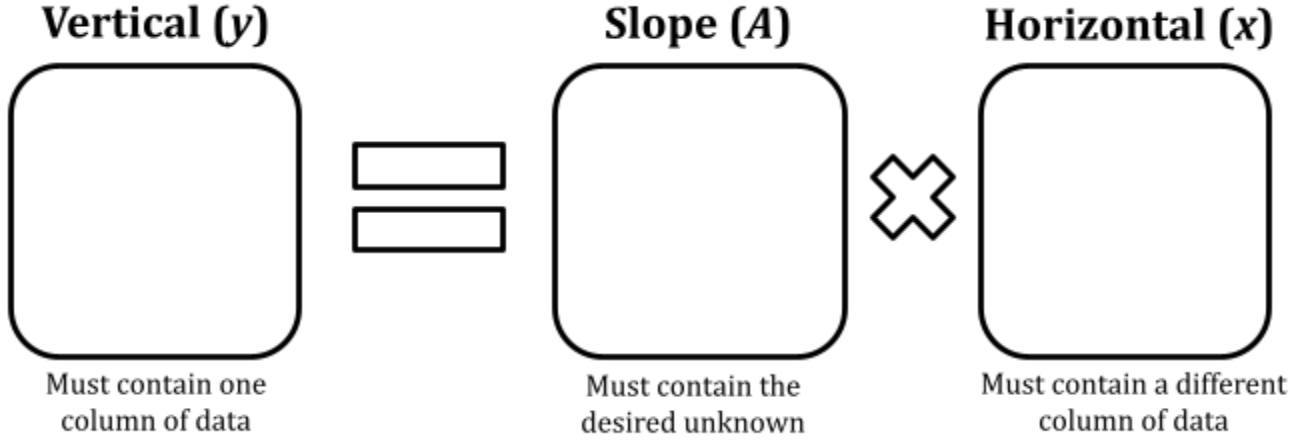


	θ (°)	d (cm)	
	10	8	
	20	16	
	30	24	
	40	30	
	50	36	
	60	40	
	70	44	

a) Show that the incline angle and the stretch of the spring can be related by the equation:

$$mg\sin\theta = kd$$

b) What could you graph to determine the spring force constant k? Separate the equation into the 3 boxes below (there are many ways to do this):



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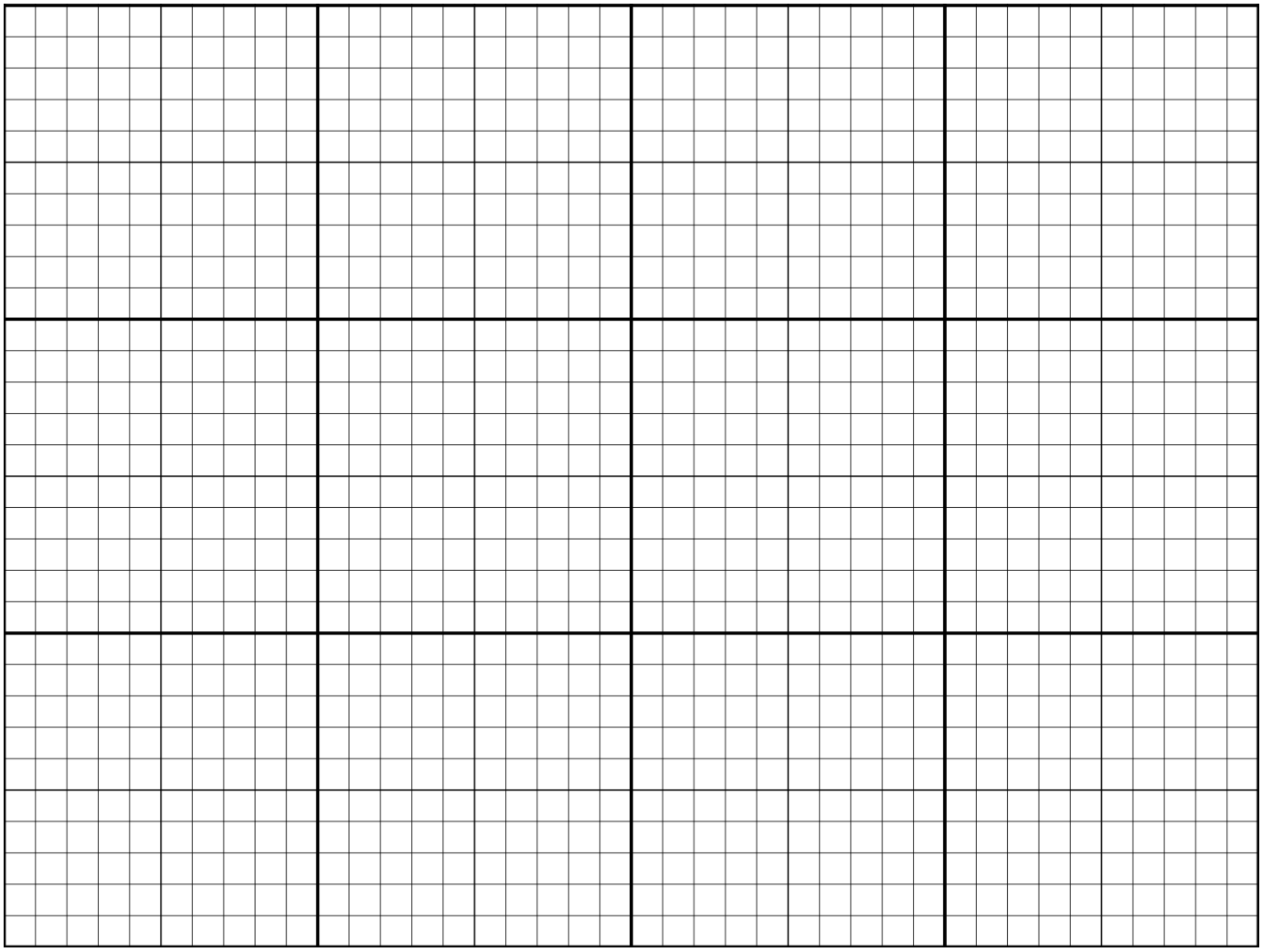
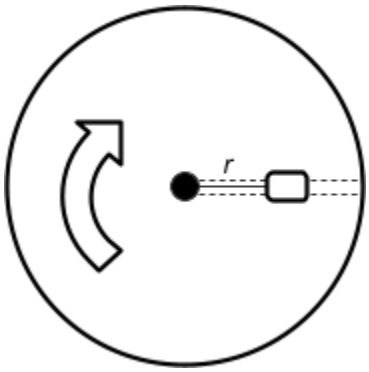


e) Draw a line of best fit through the data and calculate the slope of the line.

f) Use your slope to find the experimental spring force constant. If your slope is equal to the spring force constant, state this.

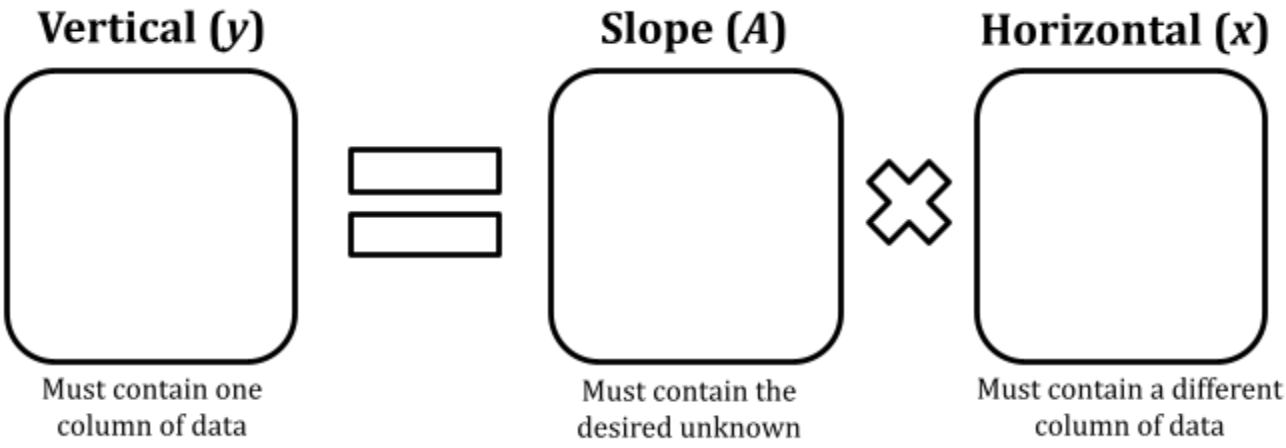
Problem 7: Students are determining the unknown mass of a cart with frictionless bearings. They have a motorized turntable and attach the cart to the center by a force sensor. They set the turntable to a certain speed so that the period of rotation *T* is equal to 0.8 seconds and measure the force, *F*, pulling towards the center. They repeat for strings of different lengths, *r*.



	r (cm)	*F* (N)	
	2	1.8	
	4	3.9	
	6	5.8	
	8	7.3	
	10	9.4	
	12	11.0	
	14	13.1	

a) Show that the period of rotation can be related to the force by the equation: $F = m\frac{4\pi^2 r}{T^2}$

b) What could you graph to determine the cart mass, *m*? Separate the equation into the 3 boxes below (there are many ways to do this):



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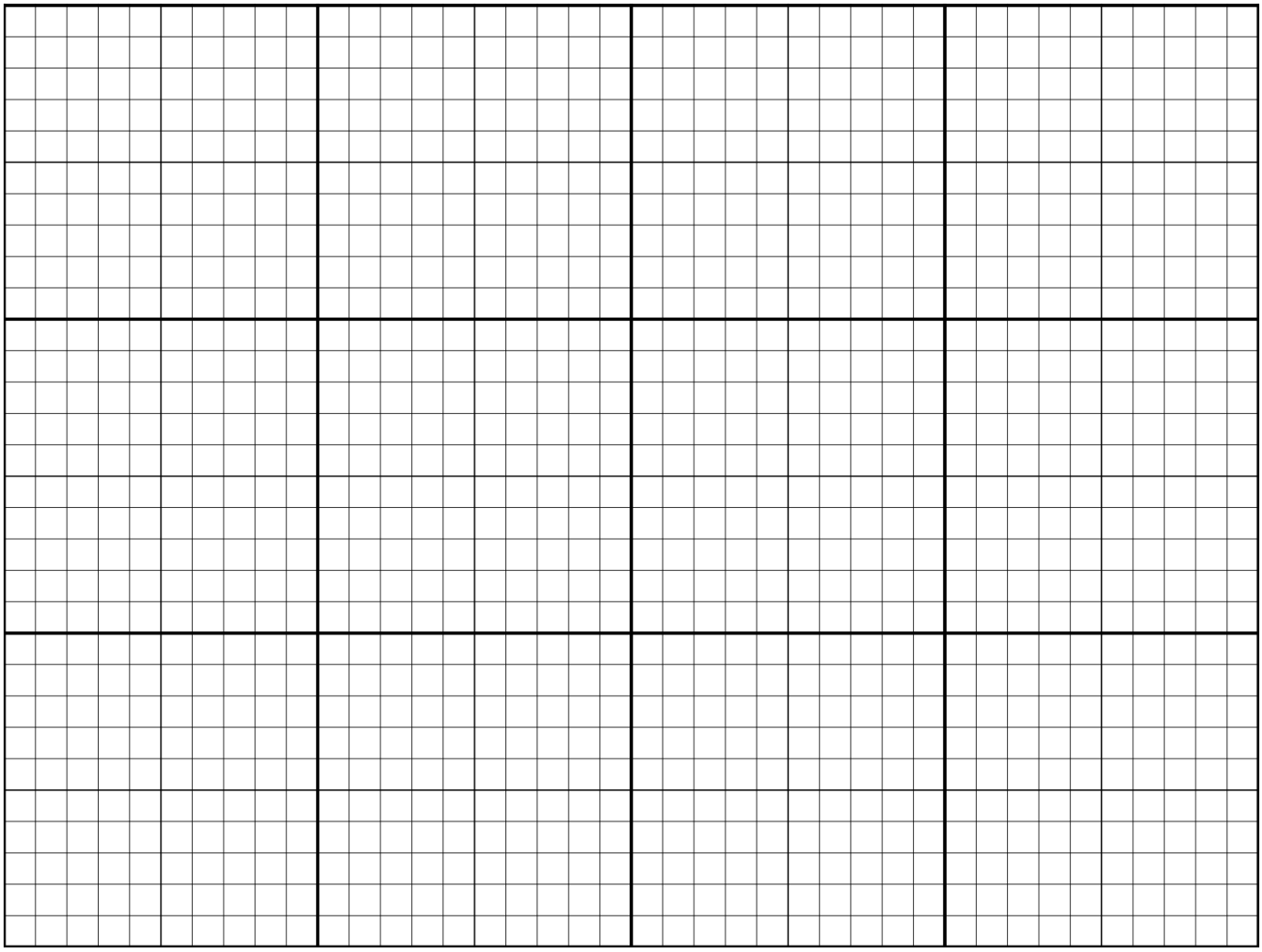

e) Draw a line of best fit through the data and calculate the slope of the line.

f) Use your slope to find the mass of the cart. If your slope is equal to the mass of the cart, state this.