* This is an important skill!

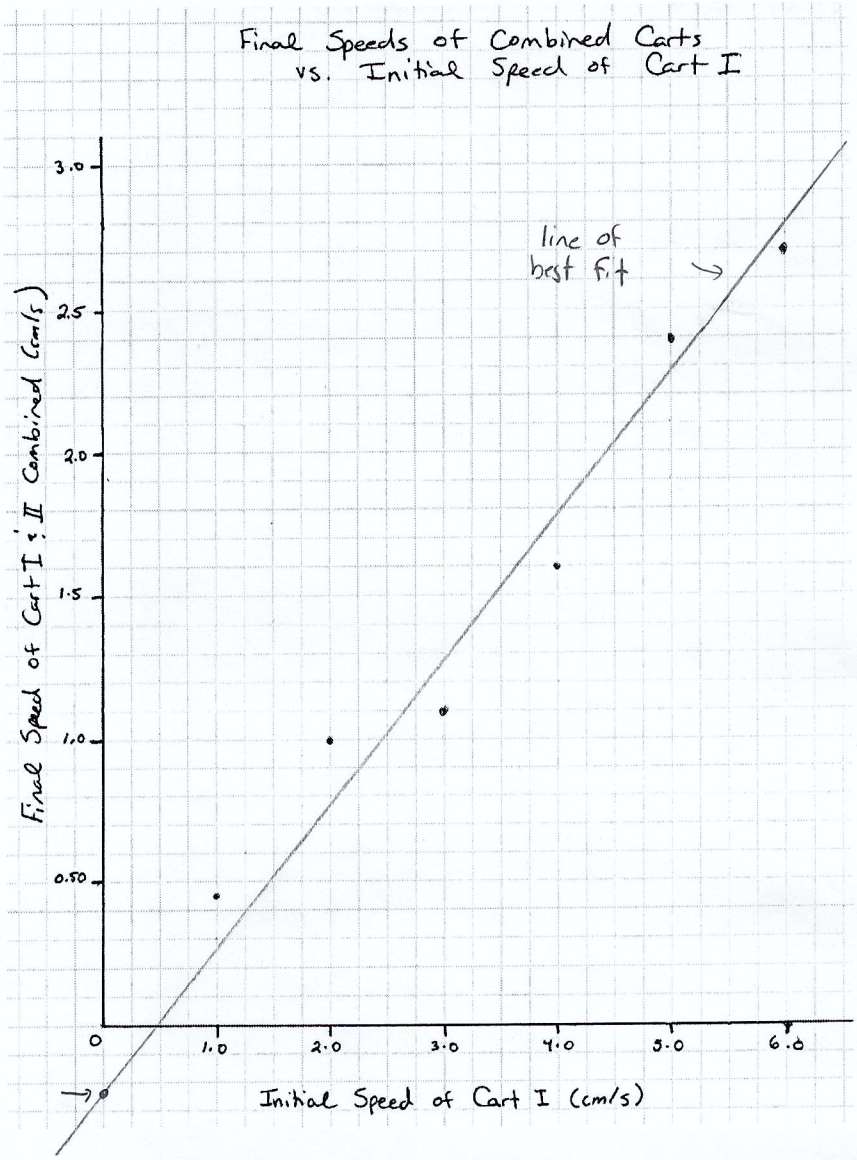
Graphing Linear Momentum

In a simple experiment, a student collides two identical carts together in a head on collision. The student varies the velocity of cart I for each trail, but ensures that the velocity of cart II remains the same. The student also ensures that after each collision, the carts stick together. The student measures the resultant velocity of the two carts stuck together after the collision. To keep the experiment somewhat simplified, the student puts the carts on a set of tracks to keep the carts on a linear path before and after the collision. The student also decides to always make the speed of cart I greater than cart II so that the two carts stuck together after the collision will always head in the same direction as cart I.

The student ran the experiment several times and used the collected data to create the following graph.

1. What is the theoretical value of the slope (ie. interpret what the slope means/equals)?

2. Use the graph to calculate the velocity of cart II before the collision.



y-intercept
= -0.23 cm/s

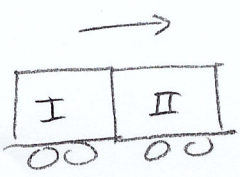
Before

m
v_1

m
v_2 (constant)

where $v_1 = x$

After



$2m$
v'

where $v' = y$

$$mv_1 + mv_2 = 2mv'$$

$$\therefore v' = \frac{\cancel{m}v_1 + \cancel{m}v_2}{2\cancel{x}}$$

$$v' = \frac{v_1}{2} + \frac{v_2}{2}$$

$$\therefore \quad y = m\,x + b$$

$$v' = \left(\frac{1}{2}\right) v_1 + \left(\frac{v_2}{2}\right)$$

Slope (theoretical) $= 1/2$

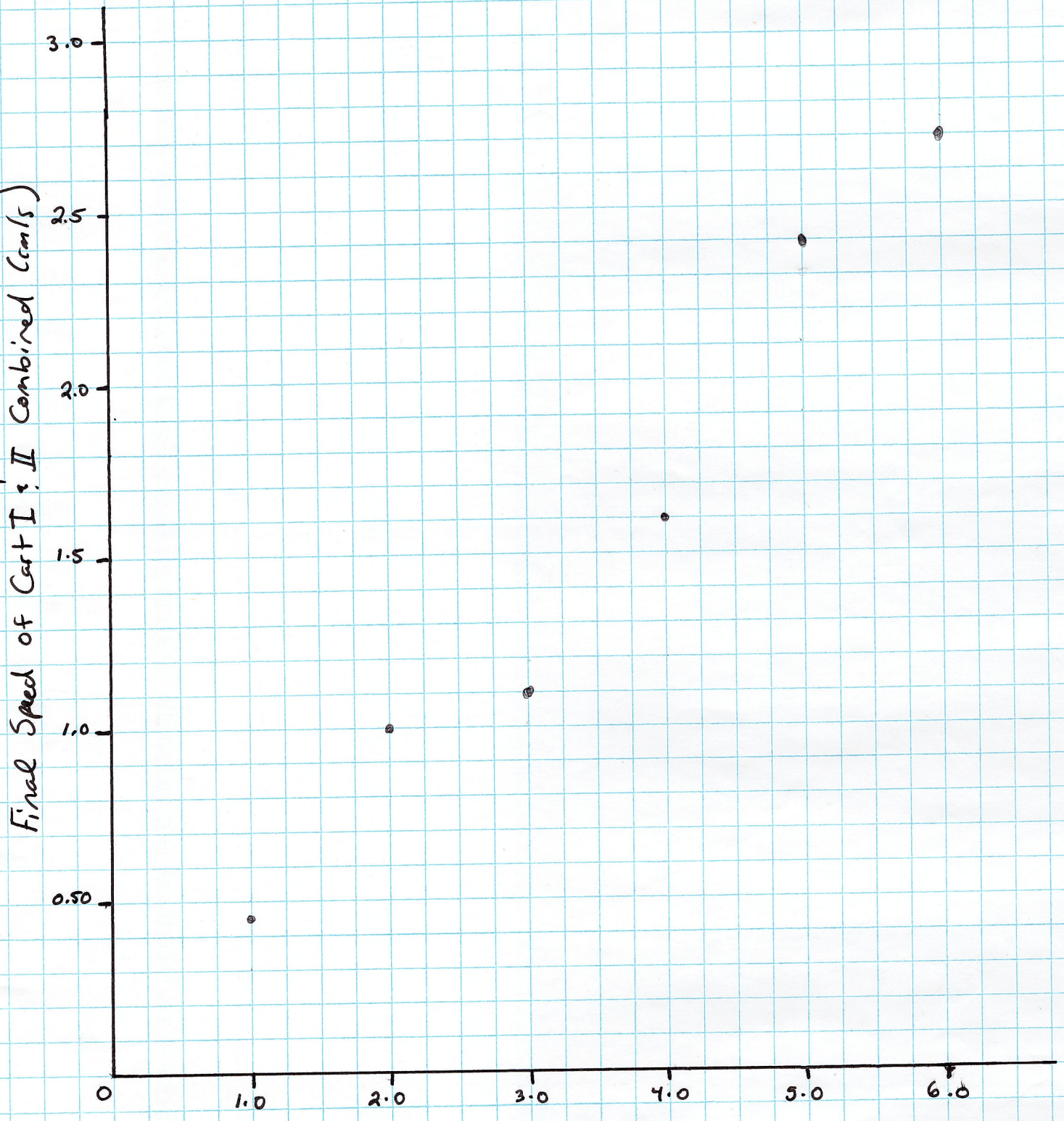
$$b = \frac{v_2}{2} \quad \therefore \quad v_2 = 2b$$

$v_2 = 2(0.23\ cm/s)$

$v_2 = -0.46\ cm/s$

$v_2 = 0.46\ cm/s$, opposite direction of cart I

Final Speeds of Combined Carts vs. Initial Speed of Cart I



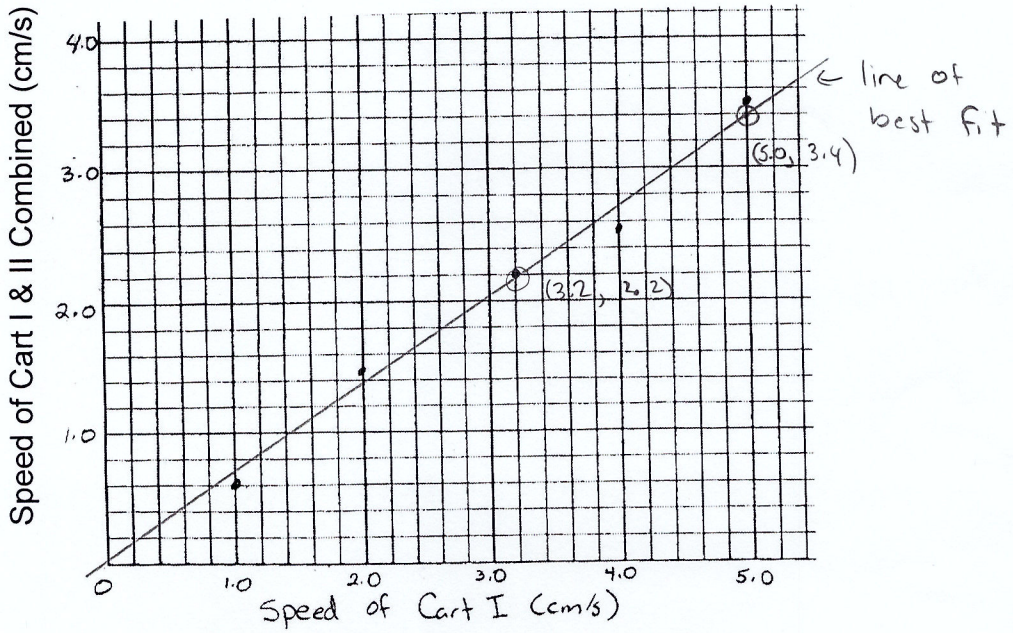
Graphing linear Momentum Practice Problem

A student is performing an experiment that is related to momentum. The student used a two cart system where two carts collide and stick together after the collision. Cart I has a mass of 1.54kg and the speed of the cart I is changed each trial. Cart I will collide with cart II which is initially at rest. The student the measures both the initial speed of cart I before the collision, and the speed of carts I and II combined after the collision.

The following graph shows the speed of carts I and II locked together after the collision vs. the initial speed of cart 1 before the collision.

Use the slope of the graph to calculate the mass of the cart II.

Speed of Cart I & II Combined vs. the Speed of Cart I



After

Before

Before

I

$m_1 = 1.54$

$v_1 = x$

$P_1 = m_1 v_1$

II

$m_2 = ?$

$v_2 = 0$

$P_2 = 0$

After

I II

$m = m_1 + m_2$

$v' = y$

$P' = (m_1 + m_2) v'$

$$\Sigma P = \Sigma P'$$

$$m_1 v_1 + 0 = (m_1 + m_2) v'$$

$\therefore \quad v_1 = x$

$v' = y$

$$m_1 v_1 = (m_1 + m_2) v'$$

$$\frac{m_1 v_1}{(m_1 + m_2)} = v'$$

$$y = m x + b$$

$$v' = \left(\frac{m_1}{m_1 + m_2}\right) v_1 + 0$$

$$\text{slope} = \frac{m_1}{(m_1 + m_2)}$$

$$0.6945\ldots = \frac{1.54\,\text{kg}}{(1.54\,\text{kg} + m_2)}$$

$$1.54\,\text{kg} + m_2 = \frac{1.54\,\text{kg}}{0.6945\ldots}$$

$$1.54\,\text{kg} + m_2 = 2.217\ldots$$

$$m_2 = 0.677\,\text{kg}$$

$$\boxed{m_2 = 0.68\,\text{kg}}$$

Graphing Calculator

$y = ax + b$

$a = 0.6945\ldots$

$b = -0.05\overline{15}$

By hand

$$\text{slope} = \frac{3.4 - 2.2}{5.0 - 3.2} = \frac{1.2}{1.8} = 0.\overline{6}$$

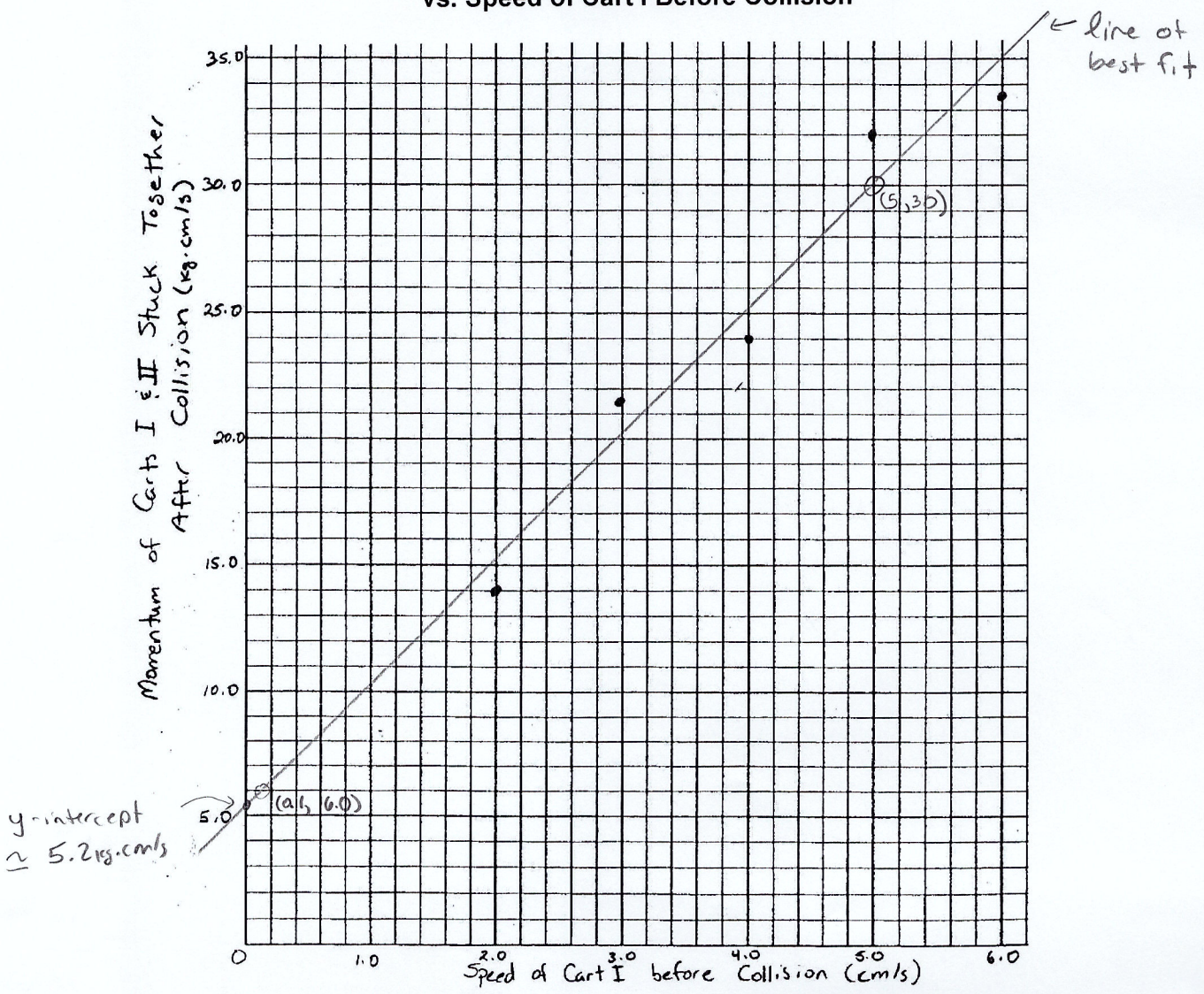
PROBLEM #2

A student performs an experiment which consists of two carts colliding into each other. The student collides cart I into cart II, which are both heading in the same direction. Cart II always starts out at the same velocity before the collision, therefore cart II always has the same momentum before the collision. The student varies the momentum of cart I before the collision by varying the speed of cart I. The student ensures that the collision is always linear and that carts I and II stick together after the collision.

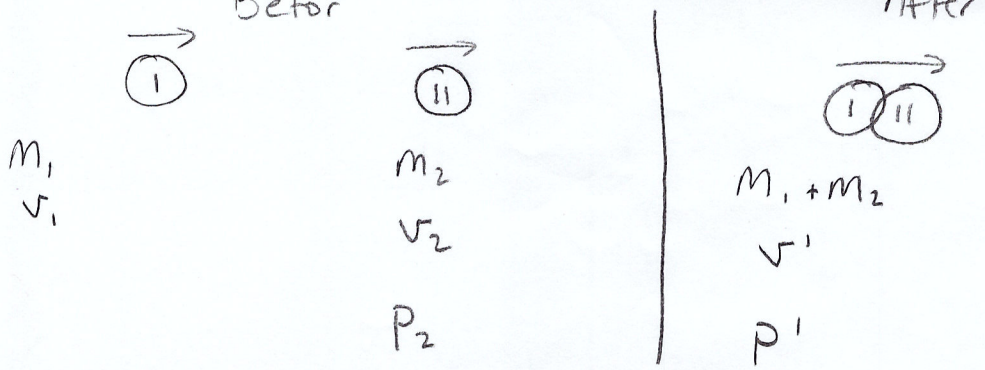
The following graph shows the momentum of carts I and II stuck together after the collision vs. the speed of cart I before the collision.

a. Use the slope of the graph to calculate the mass of cart I. (Part of your work should show how the physics formula fits into *y=mx+b)!*
b. Use the graph to determine the momentum of cart II before the collision.

Momentum of Carts I & II Stuck Together After Collision vs. Speed of Cart I Before Collision



a.)



$$\sum P = \sum P'$$

$$m_1 v_1 + P_2 = P'$$

but $y = P'$

$x = v_1$

$$\therefore \quad P' = m_1 v_1 + P_2$$

$$\downarrow \quad = \quad \downarrow \; \downarrow \quad \downarrow$$

$$y \quad = \quad m \; x \; + \; b$$

slope $= m_1$

$\therefore$ $\boxed{m_1 \simeq 4.9 \text{ kg}}$

b.) $\boxed{P_2 = 5.2 \text{ kg cm/s}}$

on Calculator

$y = ax + b$

$a = 4.95$

$b = 5.2$

by hand

$$\text{slope} = \frac{(30 - 6.0)}{(5 - 0.1)} = \frac{24}{4.9} = 4.89795\ldots$$