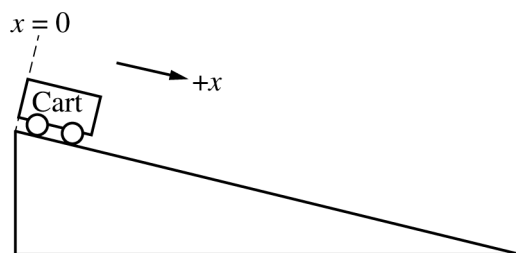Begin your response to **QUESTION 2** on this page.

$x = 0$

Cart

$+x$

2. (12 points, suggested time 25 minutes)

(a) Students conduct an experiment to determine the acceleration a of a cart. The cart is released from rest at the top of the ramp at time $t = 0$ and moves down the ramp. The x-axis is defined to be parallel to the ramp with its origin at the top, as shown in the figure. The students collect the data shown in the following table.

|	Position x (m)	Time t (s)	
	0.06	0.39	
	0.14	0.59	
	0.24	0.77	
	0.37	0.96	
	0.55	1.20	

i. Indicate which quantities could be graphed to yield a straight line whose slope could be used to determine the acceleration a of the cart. You may use the remaining columns in the table, as needed, to record any quantities (including units) that are not already in the table.

Vertical axis: _____   Horizontal axis: _____

GO ON TO THE NEXT PAGE.

Continue your response to **QUESTION 2** on this page.

ii. On the following grid, plot the appropriate quantities to create a graph that can be used to determine the acceleration a of the cart as it rolls down the ramp. Clearly scale and label all axes (including units), as appropriate. Draw a straight line that best represents the data.
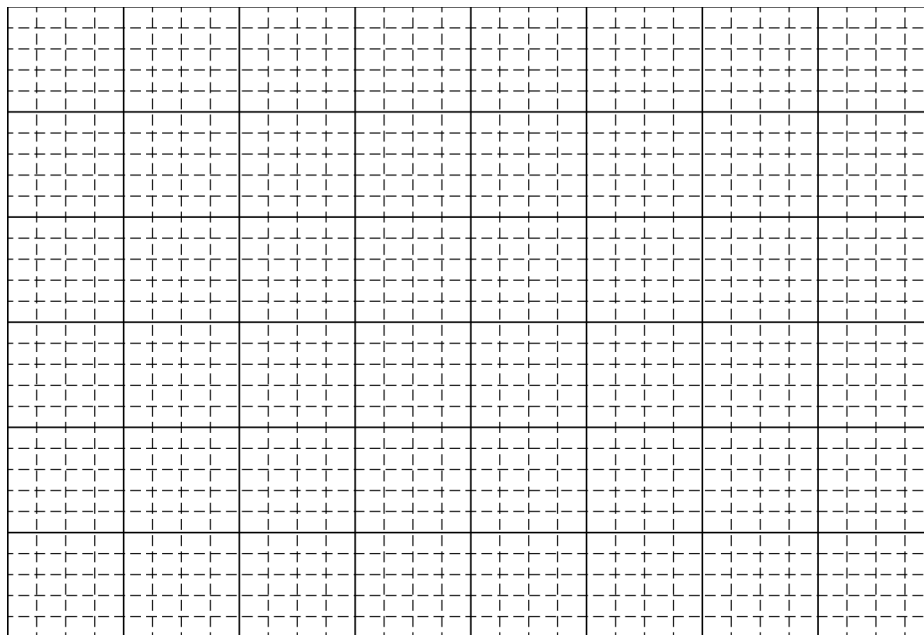
iii. Using the line you drew in part (a)(ii), calculate an experimental value for the acceleration a of the cart as it rolls down the ramp.

(b) The students are asked to determine an experimental value for the acceleration due to gravity g_{exp} using their data.

i. What additional quantities do the students need to measure in order to calculate g_{exp} from a ?

ii. Write an expression for the value of g_{exp} in terms of a.
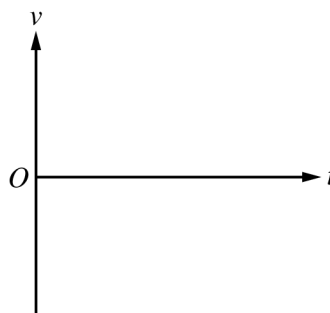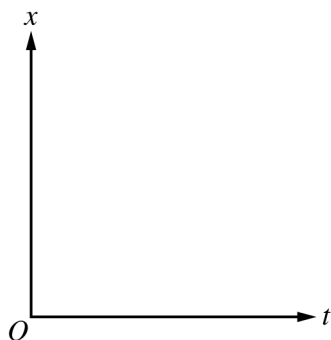
GO ON TO THE NEXT PAGE.

Continue your response to **QUESTION 2** on this page.

(c) The students calculate the value of g_{exp} to be significantly lower than the accepted value of 9.8 m/s^2.

i. What is a physical reason, other than friction or air resistance, that could lead to a significant difference in the experimentally determined value of g_{exp} ?

ii. Briefly explain how the physical reason you identified in part (c)(i) would lead to the decrease in the experimentally determined value of g_{exp} .
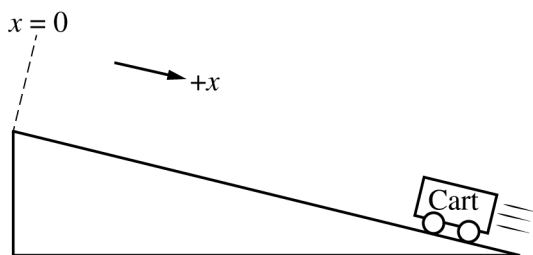
The students want to confirm that the acceleration is the same whether the cart rolls up or down the ramp. The students start the cart at the bottom and give the cart a quick push so that it rolls up the ramp and momentarily comes to rest. The x-axis is still defined to be parallel to the ramp with the origin at the top.

(d) On the following graphs, sketch the position x and velocity v as functions of time t that correspond to the scenario shown while the cart moves up the ramp.

GO ON TO THE NEXT PAGE.

Question 2: Experimental Design   12 points

|		
(a)(i)	For indicating two quantities that, when graphed together, produce a straight line whose slope can be used to determine the acceleration a	**1 point**

Example Response

Vertical Axis : _____*Position*_____   Horizontal Axis : _____*Time squared*_____

| Position x (m)	Time t (s)	Time squared t^2 $\left(s^2\right)$
0.06	0.39	0.15
0.14	0.59	0.35
0.24	0.77	0.59
0.37	0.96	0.92
0.55	1.20	1.44

(a)(ii)	The axes have a linear scale and are identified (labels **OR** units) so that when graphed correctly, the data will span more than half of the horizontal and vertical axes	**1 point**
	For plotting at least 4 of the data points correctly	**1 point**
	For drawing a best-fit line that approximates the trend of the data	**1 point**

Example Response
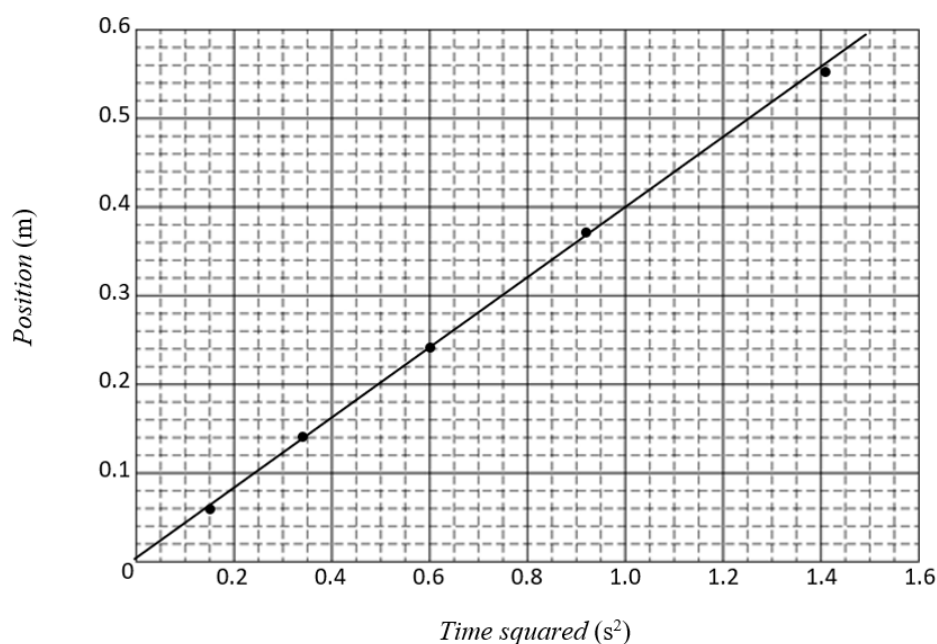
Scoring Note: The following are alternate example graphs with the points the response would earn.

Graph	Points
	Earns 2 points
	Earns 1 point
	Earns 1 point
	Earns 1 point
	Earns 0 points
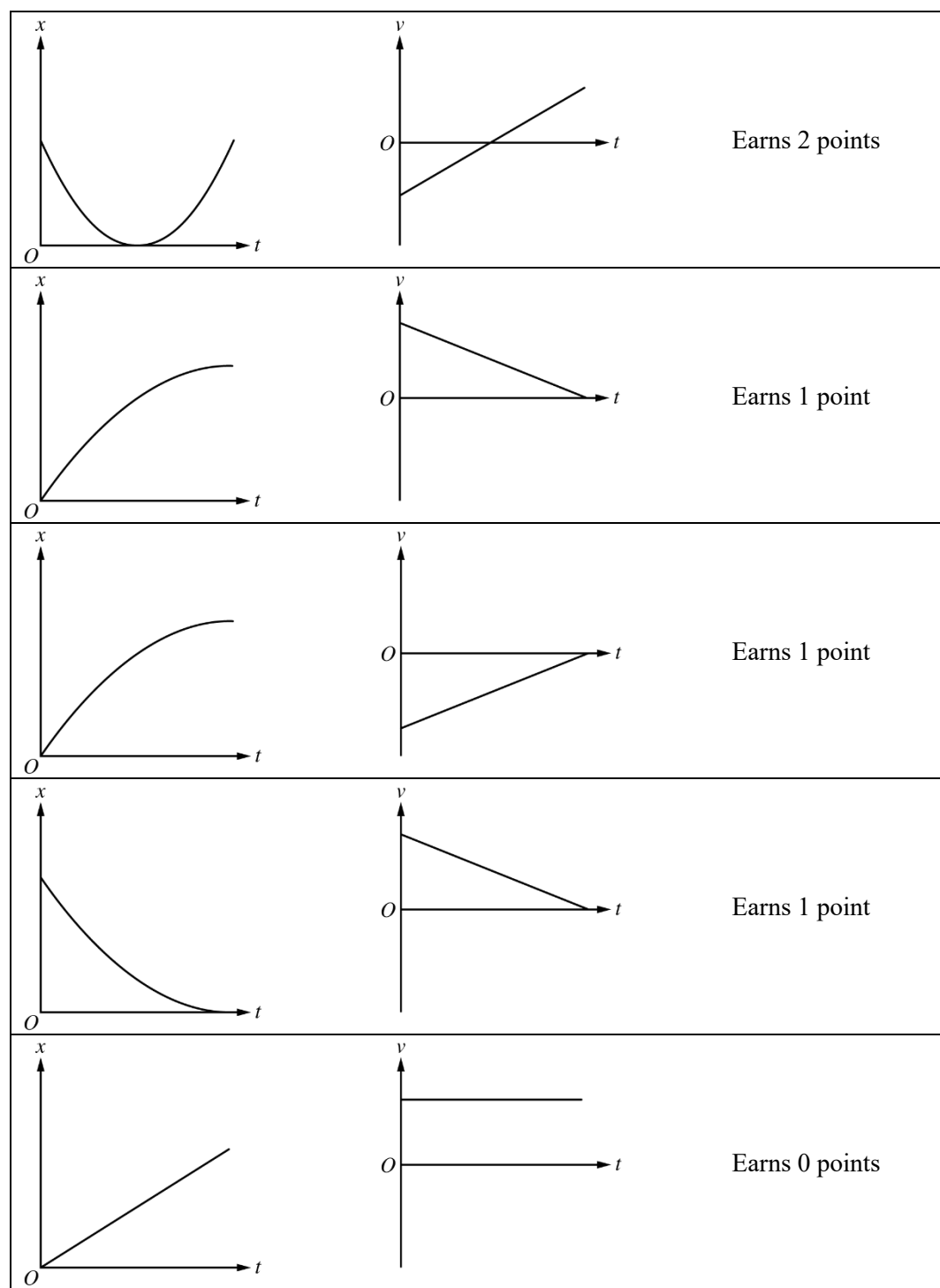
Total for part (d)   2 points

Total for question 2 12 points