Begin your response to **QUESTION 1** on this page.

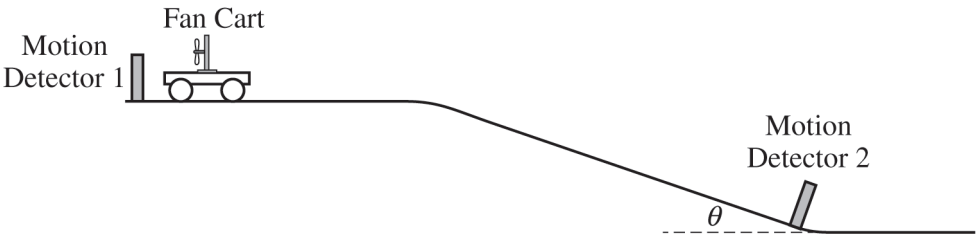
PHYSICS C: MECHANICS

SECTION II

Time—45 minutes

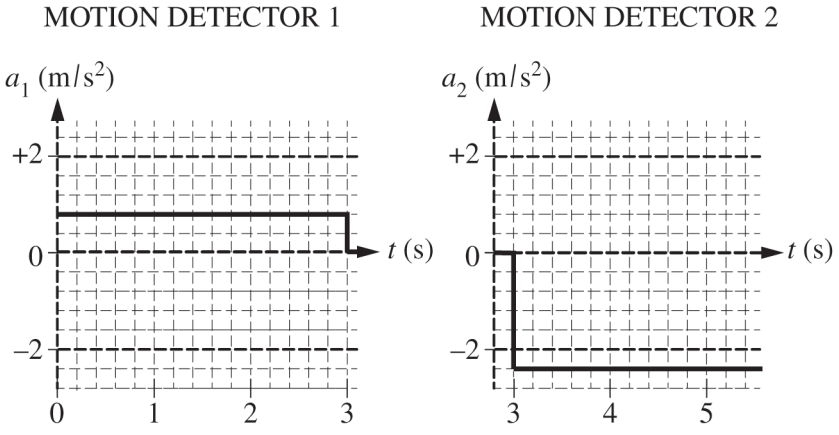
3 Questions

Directions: Answer all three questions. The suggested time is about 15 minutes for answering each of the questions, which are worth 15 points each. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part.



Note: Figure not drawn to scale.

1. A 0.50 kg fan cart is placed on a level, horizontal track of negligible friction, as shown. The fan is turned on, and the fan cart is released from rest and moves to the right. The cart travels along the horizontal track and then down an incline. Motion detector 1 measures the acceleration a of the cart from time $t = 0$ to $t = 3$ s. At $t = 3$ s, the cart makes a smooth transition to the incline, and motion detector 2 measures the acceleration of the cart after $t = 3$ s. The fan exerts the same magnitude of force on the cart during the entire motion. The graphs below show a as functions of t. For each motion detector, the positive direction is away from the detector.



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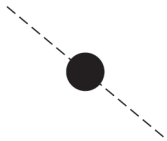
Continue your response to **QUESTION 1** on this page.

(a) On the dots below that represent the cart at two different locations, draw and label the forces (not components) that act on the cart at each location. Each force must be represented by a distinct arrow starting on, and pointing away from, the dot.

Cart on Horizontal Track

Cart on Incline



(b) Calculate the magnitude of the net force exerted on the fan cart when it is on the horizontal track.

(c) Calculate the angle θ of the incline.

(d) Suppose careful measurement determines the angle of the incline to be 3° larger than that calculated in part (c). Consider the following explanation.

"The scale used to measure the mass of the fan cart was not calibrated properly before the measurement, and this could account for the observed difference in the angle."

Does the explanation sufficiently account for the observed discrepancy?

_____ Yes _____ No

Justify your answer.

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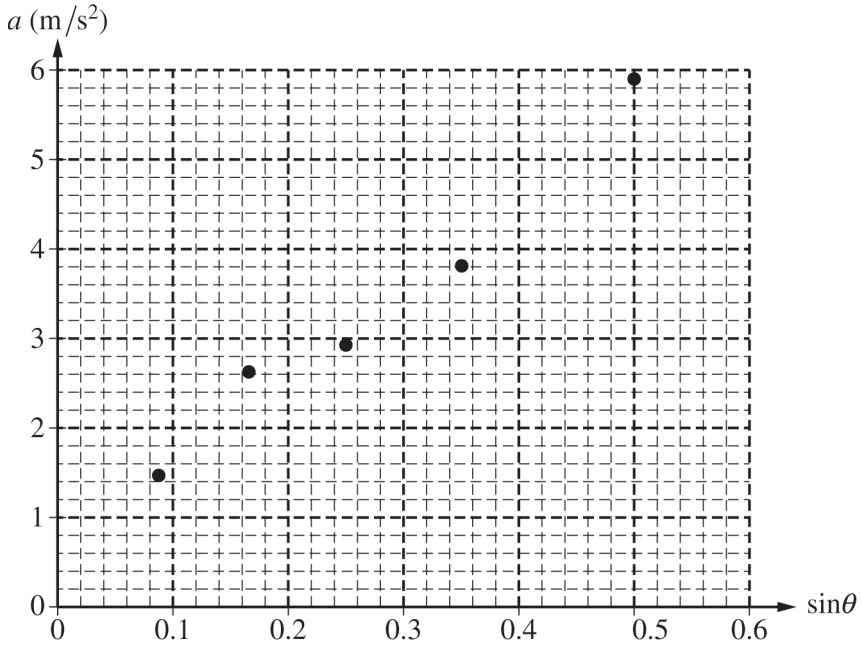
Continue your response to **QUESTION 1** on this page.

The experiment is repeated for several trials, each with a different angle for the incline. The acceleration of the cart down the incline is measured for each angle. The graph below shows the plot of the acceleration a of the cart as a function of the sine of the angle $\sin\theta$.



(e)

i. Draw a best-fit line for the data.

ii. Using the straight line, calculate an experimental value for the acceleration due to gravity g.

(f) If the cart were replaced with a second cart of mass 1.0 kg that has a fan that exerts the same magnitude of force as the original fan, explain how the graph given in part (e) would change.

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Question 1: Free-Response Question — 15 points

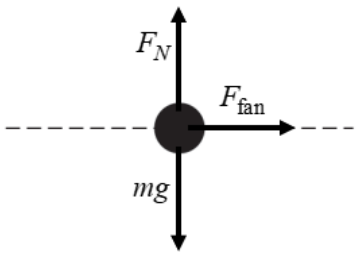
(a)

For correctly drawing and labeling all the forces on the cart on the flat surface	**1 point**
For correctly drawing and labeling the weight of the cart on the incline	**1 point**
For correctly drawing and labeling the normal force on the cart on the incline	**1 point**
For correctly drawing and labeling the force of the fan on the cart on the incline	**1 point**

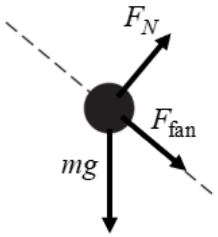
Scoring note: A maximum of three points can be earned if there are any extraneous vectors.

Example responses for part (a)

Cart on Horizontal Track



Cart on Incline



Scoring note: Examples of appropriate labels for the force due to gravity include: F_{G}, F_{g}, F_{grav}, W, mg, Mg, "grav force," "F Earth on cart," "F on cart by Earth," $F_{\text{Earth on cart}}$, $F_{\text{E,Cart}}$, $F_{\text{Cart,E}}$. The labels G or g are not appropriate labels for the force due to gravity. F_n, F_N, N, "normal force," "ground force," or similar labels may be used for the normal force.

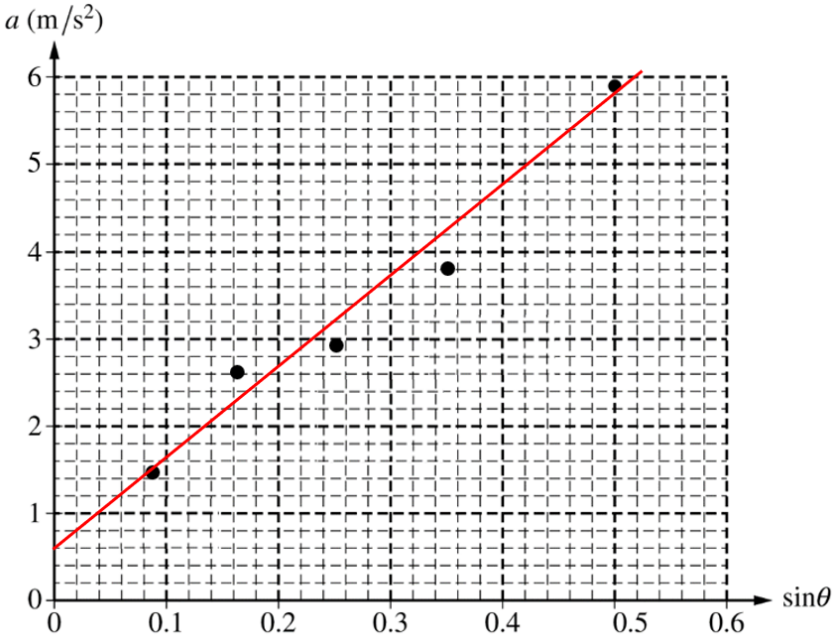
Total for part (a) 4 points

(b)

For correctly applying Newton's second law for the cart on the flat surface $F_{\text{fan}} = m_{\text{cart}} a_1$	**1 point**
For the correct answer with units $F_{\text{fan}} = (0.50\ \text{kg})\left(0.8\ \text{m/s}^2\right) = 0.40\ \text{N}$	**1 point**

Total for part (b) 2 points

(e) **i.** For drawing an appropriate best-fit line **1 point**



ii. For correctly calculating slope using two points from the best-fit line **1 point**

$$\text{slope} = \frac{\Delta y}{\Delta x} = \frac{(5-1)\left(\text{m/s}^2\right)}{(0.42-0.04)} = 10.52\ \text{m/s}^2$$

For correctly using an expression that relates the slope to the acceleration due to gravity **1 point**

$$F_{\text{net}} = F_{\text{fan}} + mg\sin\theta = ma$$
$$\therefore a = g\sin\theta + \frac{F_{\text{fan}}}{m}$$

$$\text{from } y = mx + b$$
$$a = (\text{slope})\sin\theta + (y\text{-intercept})$$
$$\therefore \text{slope} = g = 10.52\ \text{m/s}^2$$

Total for part (e) **3 points**

(f) For a correct explanation **1 point**

Example response for part (f)

The mass of the cart is in the denominator of the y-intercept, so increasing the mass decreases the y-intercept without changing the rest of the graph. So the new line of data is predicted to be parallel to and below the original line.

Total for question 1 **15 points**