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

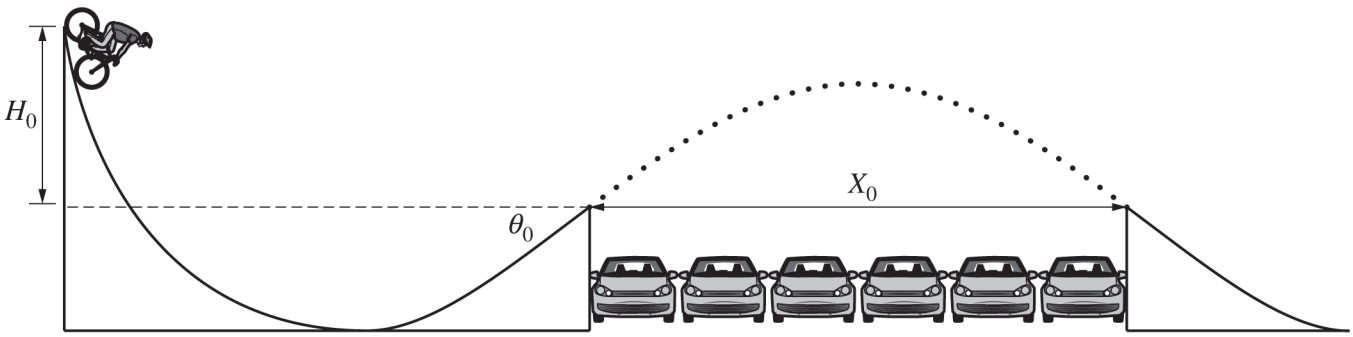
PHYSICS 1

SECTION II

Time—1 hour and 30 minutes

5 Questions

Directions: Questions 1, 4, and 5 are short free-response questions that require about 13 minutes each to answer and are worth 7 points each. Questions 2 and 3 are long free-response questions that require about 25 minutes each to answer and are worth 12 points each. Show your work for each part in the space provided after that part.



Note: Figure not drawn to scale.

1. (7 points, suggested time 13 minutes)

A stunt cyclist builds a ramp that will allow the cyclist to coast down the ramp and jump over several parked cars, as shown above. To test the ramp, the cyclist starts from rest at the top of the ramp, then leaves the ramp, jumps over six cars, and lands on a second ramp.

H_0 is the vertical distance between the top of the first ramp and the launch point.
θ_0 is the angle of the ramp at the launch point from the horizontal.
X_0 is the horizontal distance traveled while the cyclist and bicycle are in the air.
m_0 is the combined mass of the stunt cyclist and bicycle.

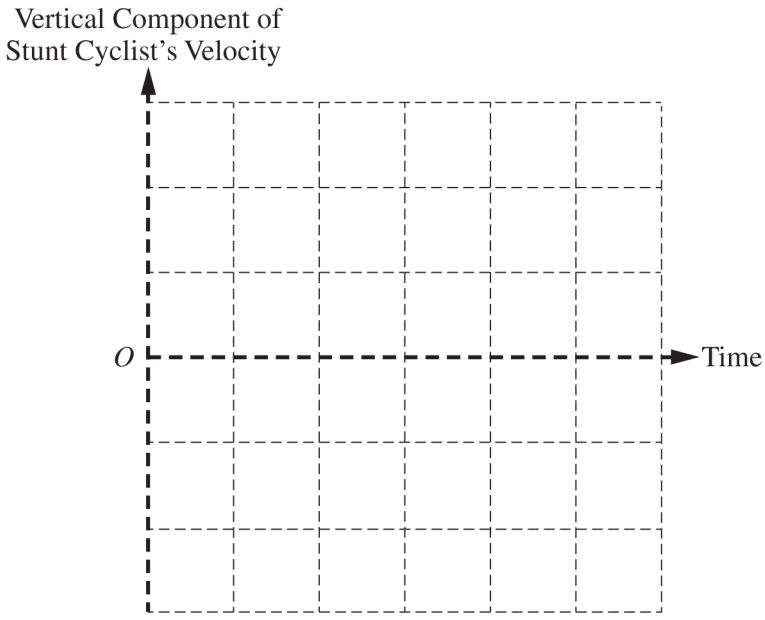
(a) Derive an expression for the distance X_0 in terms of H_0, θ_0, m_0, and physical constants, as appropriate.

GO ON TO THE NEXT PAGE.

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

(b) If the vertical distance between the top of the first ramp and the launch point were $2H_0$ instead of H_0, with no other changes to the first ramp, what is the maximum number of cars that the stunt cyclist could jump over? Justify your answer, using the expression you derived in part (a).

(c) On the axes below, sketch a graph of the vertical component of the stunt cyclist's velocity as a function of time from immediately after the cyclist leaves the ramp to immediately before the cyclist lands on the second ramp. On the vertical axis, clearly indicate the initial and final vertical velocity components in terms of H_0, θ_0, m_0, and physical constants, as appropriate. Take the positive direction to be upward.



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Question 1: Short Answer — 7 points

(a)

For using conservation of energy to find the speed v of the bicycle as it leaves the ramp — **1 point**

For using kinematics, vertical components, attempting to find the time the bicycle is in the air — **1 point**

For a correct expression for X_0 in terms of given quantities — **1 point**

Example response for part (a)

$E_{top} = E_{bottom}$

$m_0 g H_0 = \frac{1}{2} m_0 v^2$

$v = \sqrt{2gH_0}$

$v_{fy} = v_{iy} + at$

$-v\sin\theta = v\sin\theta - gt$

$-2v\sin\theta = -gt$

$2\sin\theta_0\sqrt{2gH_0} = gt$

$t = \frac{2\sin\theta_0\sqrt{2gH_0}}{g}$

$X_0 = v_x t$

$X_0 = \cos\theta_0\sqrt{2gH_0}\,\frac{2\sin\theta_0\sqrt{2gH_0}}{g}$

$X_0 = 4H_0\cos\theta_0\sin\theta_0$

Scoring Note:

Using the range equation to get $X_0 = 2H_0\sin 2\theta_0$ is sufficient to earn the second and third points.

Total for part (a) — 3 points

(b)

Correct answer: 12 cars

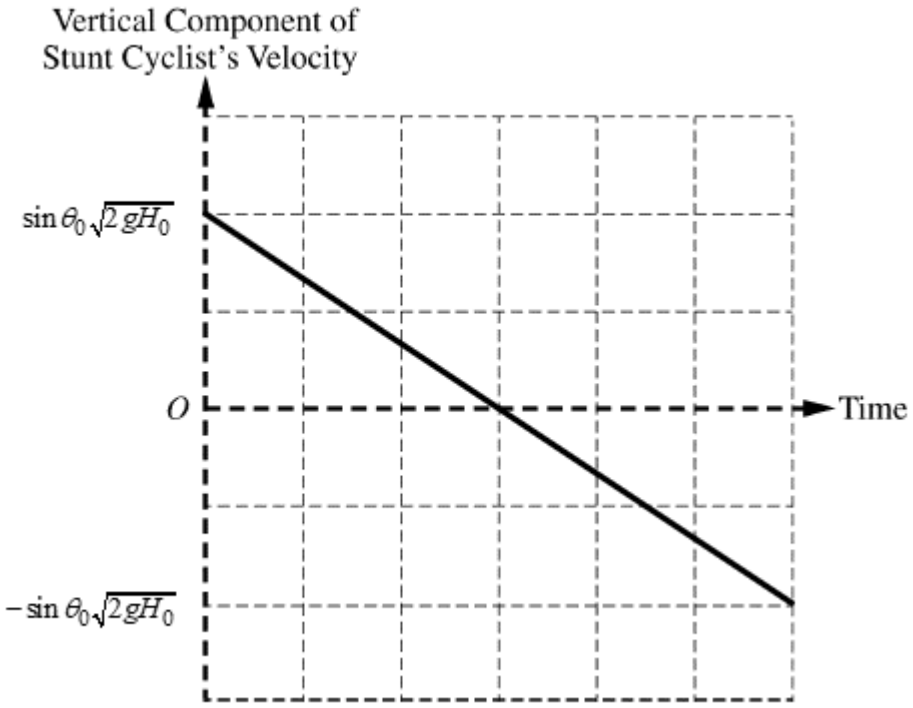
For an answer and justification that attempts to use the functional dependence of the horizontal distance on the initial height — **1 point**

For an answer consistent with the expression derived in part (a) — **1 point**

Total for part (b) — 2 points

(c)	For a linear graph with a constant negative slope	**1 point**
	For a graph that starts at v_y and ends at $-v_y$, using only allowed variables	**1 point**

Example response for part (c)



Total for part (c) 2 points

Total for Question 1 7 points