AP® Physics B
2004 Sample Student Responses
Form B

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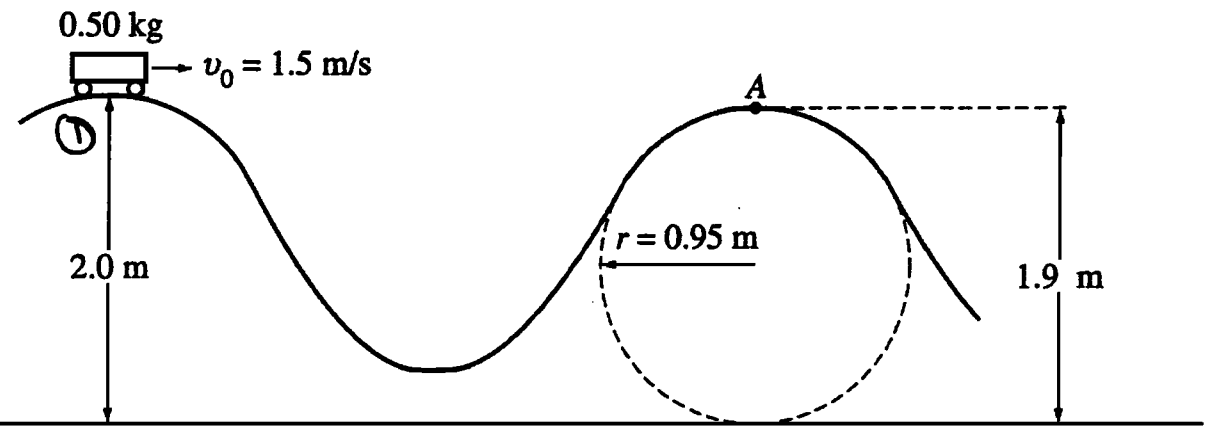
A1

PHYSICS B
SECTION II
Time—90 minutes
6 Questions

Directions: Answer all six questions, which are weighted according to the points indicated. The suggested time is about 17 minutes for answering each of questions 1-4, and about 11 minutes for answering each of questions 5-6. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part, NOT in the lavender insert.



1. (15 points)

A designer is working on a new roller coaster, and she begins by making a scale model. On this model, a car of total mass 0.50 kg moves with negligible friction along the track shown in the figure above. The car is given an initial speed $v_0 = 1.5$ m/s at the top of the first hill of height 2.0 m. Point A is located at a height of 1.9 m at the top of the second hill, the upper part of which is a circular arc of radius 0.95 m.

(a) Calculate the speed of the car at point A.

Conservation of mechanical energy,

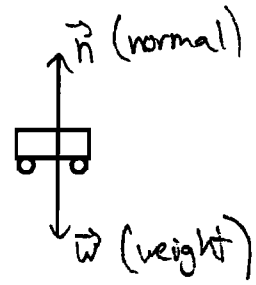
$K_1 + U_1 = K_2 + U_2$

$\frac{1}{2}mv_0^2 + mgh_1 = \frac{1}{2}mv_A^2 + mgh_2$

$\frac{1}{2}(1.5)^2 + (9.8)(2) = \frac{1}{2}v_A^2 + (9.8)(1.9)$

$v_A = 2.05$ m/s

(b) On the figure of the car below, draw and label vectors to represent the forces on the car at point A.



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(c) Calculate the magnitude of the force of the track on the car at point A.

At A : $\Sigma F_y = ma \Rightarrow N - W = 0$ $\quad \Sigma F_y = \frac{mv_A^2}{r} = mg - N$

$N = m\left(-\frac{v_A^2}{r} + g\right) = 0.5\left(-\frac{4.21}{0.95} + 9.8\right) = 2.68\,N$

(d) In order to stop the car at point A, some friction must be introduced. Calculate the work that must be done by the friction force in order to stop the car at point A.

$K_1 + U_1 = U_2 + E_{dissipated}$ $\quad E_{diss} = W_f$

$\frac{1}{2}(0.5)(1.5)^2 + (0.5)(9.8)(2) = (0.5)(9.8)(1.9) + W_f$

$W_f = 1.05\,J$ to the left

(e) Explain how to modify the track design to cause the car to lose contact with the track at point A before descending down the track. Justify your answer.

N should be zero $\Rightarrow$ $\Sigma F_y = \frac{mv_A^2}{r} = mg$

$v_A = 3.05\,m/s$

The car should start at a height $> 2m$

$\Rightarrow$ energy at position ① will be greater

$\Rightarrow$ energy at position ② will be greater

($\uparrow$ speed at A)

$\frac{1}{2}(0.5)(1.5)^2 + (0.5)(9.8)h' = \frac{1}{2}(0.5)(3.05)^2 + (0.5)(9.8)(1.9)$

$\Rightarrow h' = 2.26\,m$

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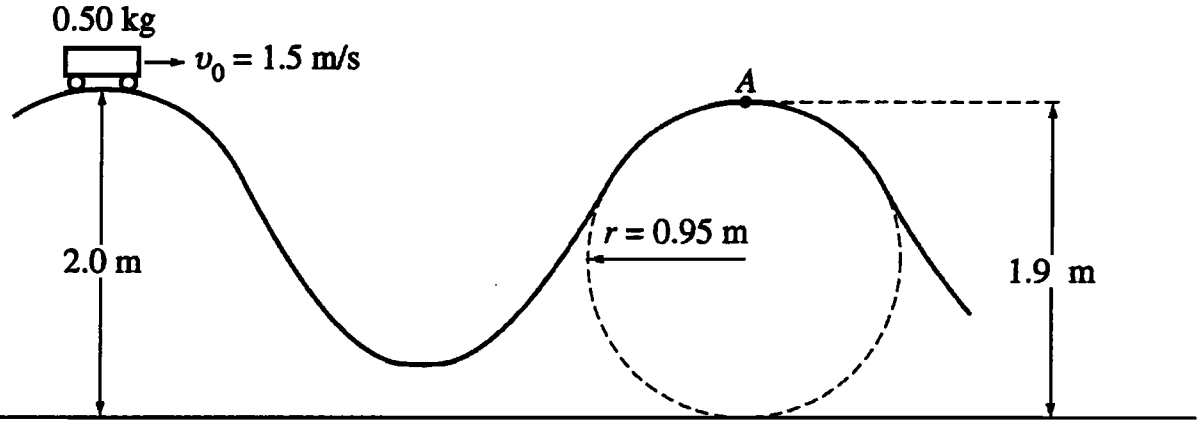

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A designer is working on a new roller coaster, and she begins by making a scale model. On this model, a car of total mass 0.50 kg moves with negligible friction along the track shown in the figure above. The car is given an initial speed $v_0 = 1.5$ m/s at the top of the first hill of height 2.0 m. Point A is located at a height of 1.9 m at the top of the second hill, the upper part of which is a circular arc of radius 0.95 m.

(a) Calculate the speed of the car at point A.

Total energy = $mgh_0 + \frac{1}{2}mv_0^2 = mgh_A + \frac{1}{2}mv_A^2$

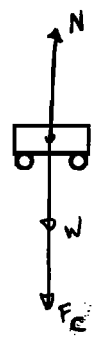
$(.5)(9.8)(2) + \frac{1}{2}(.5)(1.5)^2 = (.5)(9.8)(1.9) + \frac{1}{2}(.5)(v_A)^2$

$20.725 = 18.62 + \frac{1}{2}v_A^2$

$v_A^2 = 4.21$

$v_A \approx 2.052$ m/s

(b) On the figure of the car below, draw and label vectors to represent the forces on the car at point A.



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(c) Calculate the magnitude of the force of the track on the car at point *A*.

$N = W + F_c$

$N = mg + \frac{mv^2}{r}$

$= (.5)(9.8) + \frac{(.5)(2.052)^2}{.95}$

$= \boxed{7.116\ N}$

(d) In order to stop the car at point *A*, some friction must be introduced. Calculate the work that must be done by the friction force in order to stop the car at point *A*.

$W = \text{total energy} = (.5)(9.8)(2) + \frac{1}{2}(.5)(1.5)^2$

$= \boxed{10.3625\ J}$

$W = KE_A = \frac{1}{2}(.5)(2.052)^2 = \boxed{1.0525\ J}$

(e) Explain how to modify the track design to cause the car to lose contact with the track at point *A* before descending down the track. Justify your answer.

increase initial height or initial velocity so that the car has a higher kinetic energy at point A.

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