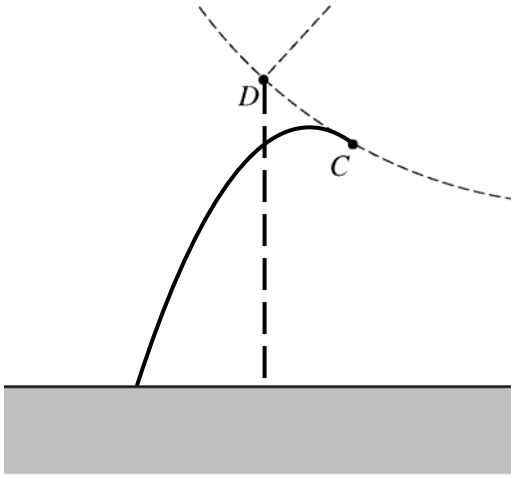
AP® PHYSICS B
2014 SCORING GUIDELINES

Question 1

15 points total **Distribution of points**

(a) 3 points



For showing a parabolic path from point C that is tangent to the arc at C 1 point
For a maximum height of the parabolic path that is lower than point D 1 point
For showing the person traveling straight downward from point D 1 point
Note: the two paths may, but need not, cross each other.

(b) 2 points

For using the gravitational potential energy equation 1 point

$\Delta U_g = mgh = (50\text{ kg})\left(9.8\text{ m/s}^2\right)(4.1\text{ m})$

For a correct answer 1 point

$\Delta U_g = 2010\text{ J}$ (or 2050 J using $g = 10\text{ m/s}^2$)

(c) 3 points

For using an expression of conservation of energy 1 point

$U_{g1} = U_{g2} + K_2$

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

For correctly substituting values 1 point

$gh_1 = gh_2 + \frac{1}{2}v^2$

$v = \sqrt{2g(h_1 - h_2)}$

$v = \sqrt{2\left(9.8\text{ m/s}^2\right)(4.1\text{ m} - 2.4\text{ m})}$

For a correct answer 1 point

$v = 5.8\text{ m/s}$

Question 1 (continued)

Distribution of points

(d) 3 points

For using a correct expression to solve for the time of fall 1 point

$\Delta y = v_0 t + \frac{1}{2} a t^2$

For correctly solving for the time of fall 1 point

$\Delta y = \frac{1}{2} a t^2$

$t = \sqrt{\frac{2\Delta y}{a}}$

$t = \sqrt{\frac{2(2.4\text{ m})}{(9.8\text{ m/s}^2)}}$

$t = 0.70\text{ s}$ (or 0.69 s using $g = 10\text{ m/s}^2$)

In the horizontal direction, the acceleration is zero.

$R = v_x t$

For substituting the speed from part (c) into the constant-velocity equation for horizontal motion 1 point

$R = (5.8\text{ m/s})(0.70\text{ s})$

$R = 4.1\text{ m}$ (or 4.0 m using either unrounded speed of 5.77 m/s or $g = 10\text{ m/s}^2$)

Units 1 point

For correct units in the calculated answers to parts (b), (c), and (d) 1 point

(e) 3 points

For selecting "$p_C < p_B$" 1 point

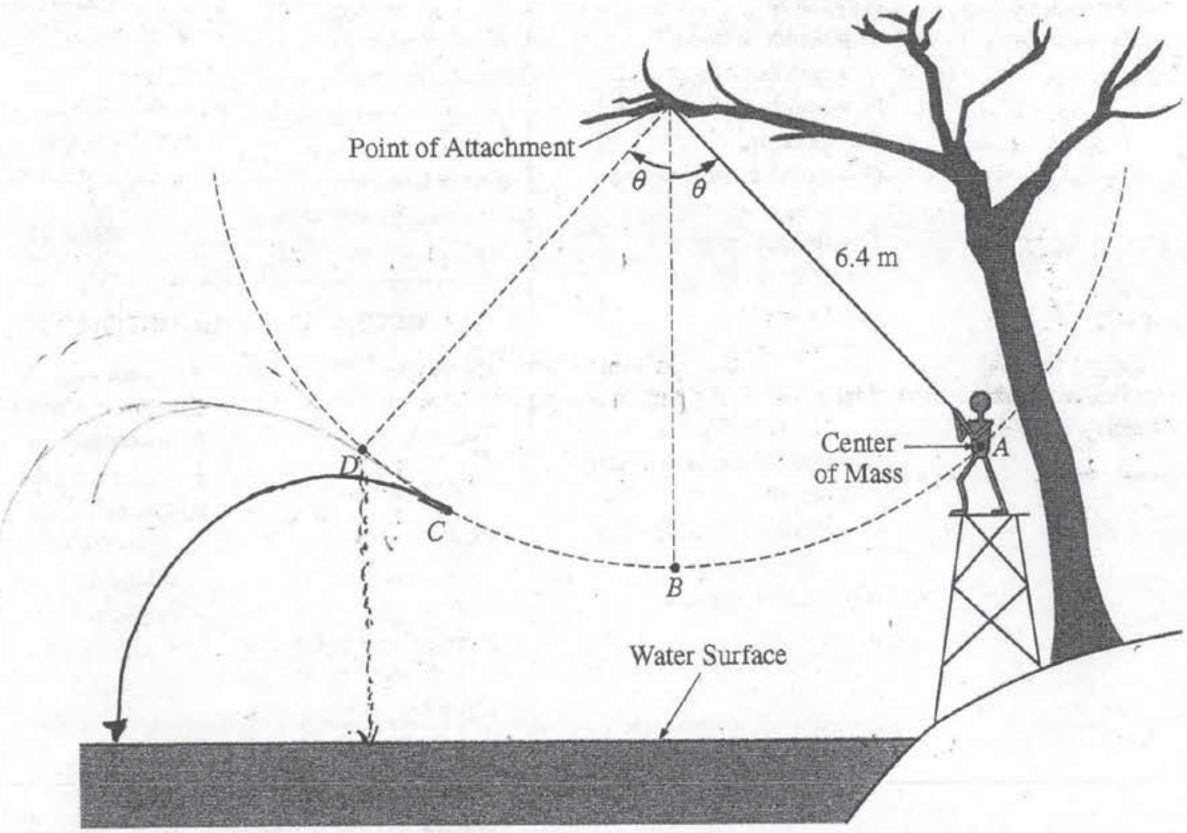
For any indication that the speed at C is less than the speed at B 1 point

For an explanation of why the speed decreases from B to C, which includes the following or equivalent statements: 1 point

by conservation of energy: U increases as the person moves from B to C, therefore K decreases, resulting in a decrease in speed
OR
gravitational force opposes motion as the person moves from B to C, which results in a negative acceleration and a decrease in speed
OR
by the impulse-momentum theorem: momentum decreases because the force of gravity provides impulse opposing the motion of the person

PHYSICS B
SECTION II
Time—90 minutes
7 Questions

Directions: Answer all seven questions, which are weighted according to the points indicated. The suggested times are about 17 minutes for answering each of Questions 1 and 5, and about 11 minutes for answering each of Questions 2-4 and 6-7. The parts within a question may not have equal weight. Show all your work in this booklet in the spaces provided after each part.



1. (15 points)

Starting from rest at point *A*, a 50 kg person swings along a circular arc from a rope attached to a tree branch over a lake, as shown in the figure above. Point *D* is at the same height as point *A*. The distance from the point of attachment to the center of mass of the person is 6.4 m. Ignore air resistance and the mass and elasticity of the rope.

(a) The person swings two times, each time letting go of the rope at a different point.

i. On the first swing, the person lets go of the rope when first arriving at point *C*. Draw a solid line to represent the trajectory of the center of mass after the person releases the rope.

ii. A second time, the person lets go of the rope at point *D*. Draw a dashed line to represent the trajectory of the center of mass after the person releases the rope.

GO ON TO THE NEXT PAGE.

(b) The center of mass of the person standing on the platform is at point A, 4.1 m above the surface of the water. Calculate the gravitational potential energy when the person is at point A relative to when the person is at the surface of the water.

$U_{grav} = mgh = (50)(10)(4.1) = 2050\ J$

(c) The center of mass of the person at point B, the lowest point along the arc, is 2.4 m above the surface of the water. Calculate the person's speed at point B.

Conservation of energy:

$\frac{1}{2}mv_1^2 + mgh_1 = \frac{1}{2}mv_2^2 + mgh_2$

$\Rightarrow 0 + 2050 = \frac{1}{2}(50)v^2 + (50)(10)(2.4) \Rightarrow v = 5.83\ m/s$

(d) Suppose that the person swings from the rope a third time, letting go of the rope at point B. Calculate R, the horizontal distance moved from where the person releases the rope at point B to where the person hits the water.

Airtime before reaching water: $h = \frac{1}{2}gt^2$

$2.4 = \frac{1}{2}(10)t^2 \Rightarrow t = 0.693\ s$

$\Delta s_x = v_x t$

$\Delta s_x = (5.83)(0.693) = 4.04\ m$

(e) If the person does not let go of the rope, how does the magnitude of the person's momentum p_C at point C compare with the magnitude of the person's momentum p_B at point B ?

___ $p_C > p_B$ ✓ $p_C < p_B$ ___ $p_C = p_B$

Provide a physical explanation to justify your answer.

Momentum is proportional to velocity. The maximum velocity is achieved at point B. Mechanical Energy is constant and the sum of Kinetic and Potential Energy. Potential Energy is lowest at point B, as height is lowest. Thus Kinetic Energy and momentum is maximised.

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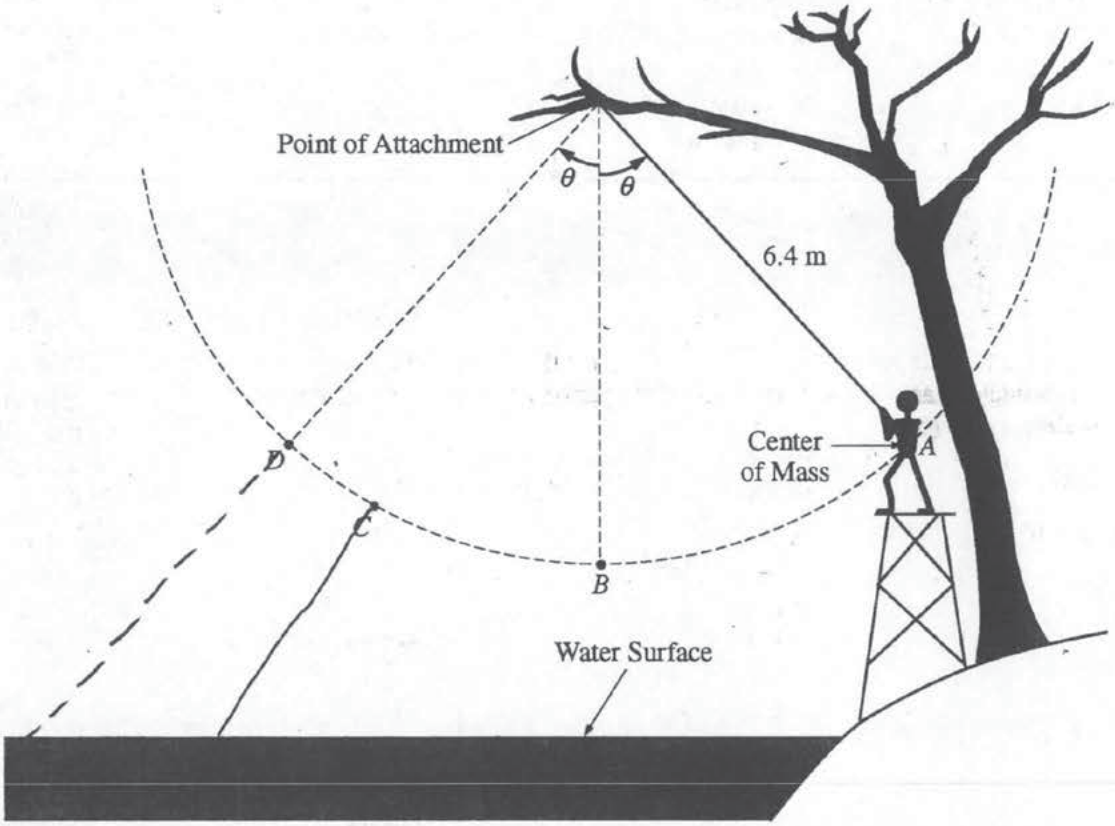

1. (15 points)

Starting from rest at point *A*, a 50 kg person swings along a circular arc from a rope attached to a tree branch over a lake, as shown in the figure above. Point *D* is at the same height as point *A*. The distance from the point of attachment to the center of mass of the person is 6.4 m. Ignore air resistance and the mass and elasticity of the rope.

(a) The person swings two times, each time letting go of the rope at a different point.

i. On the first swing, the person lets go of the rope when first arriving at point *C*. Draw a solid line to represent the trajectory of the center of mass after the person releases the rope.

ii. A second time, the person lets go of the rope at point *D*. Draw a dashed line to represent the trajectory of the center of mass after the person releases the rope.

GO ON TO THE NEXT PAGE.

(b) The center of mass of the person standing on the platform is at point A, 4.1 m above the surface of the water. Calculate the gravitational potential energy when the person is at point A relative to when the person is at the surface of the water.

$U_g = PE_g = mgh$

$U_g = (50\text{kg})(9.8\text{m/s}^2)(4.1\text{m}) = \boxed{2009\text{ J}}$

(c) The center of mass of the person at point B, the lowest point along the arc, is 2.4 m above the surface of the water. Calculate the person's speed at point B.

$KE = PE_g$

$\frac{1}{2}mv^2 = mgh$

$\frac{1}{2}(50\text{kg})v^2 = (50\text{kg})(9.8\text{m/s}^2)(2.4\text{m})$

$v^2 = \frac{(50\text{kg})(9.8\text{m/s}^2)(2\text{m})}{\frac{1}{2}(50\text{kg})} = \boxed{6.859\text{ m/s}}$

(d) Suppose that the person swings from the rope a third time, letting go of the rope at point B. Calculate R, the horizontal distance moved from where the person releases the rope at point B to where the person hits the water.

~~$d = v_i t + \frac{1}{2}at^2$~~

v	v_f	v_i	a	t
0	6.859 m/s	?	-9.8m/s^2	

$v_f^2 = v_i^2 + 2ad$

$0 = (6.859\text{m/s})^2 + 2(-9.8\text{m/s}^2)R$

~~$\frac{1}{2}mv^2 = mgh$~~

~~6.859^2~~

$47.04 = 2(-9.8\text{m/s}^2)R$

$\boxed{R = 2.4\text{ meters}}$

(e) If the person does not let go of the rope, how does the magnitude of the person's momentum p_C at point C compare with the magnitude of the person's momentum p_B at point B ?

X $p_C > p_B$ ~~$p_C < p_B$~~ ___ $p_C = p_B$

Provide a physical explanation to justify your answer.

$p = mv$ ~~The~~ The water's surface is the point of reference, so as the person goes from B to C, the position above the water will increase, and if bigger velocity means more momentum since KE=PE, when $h_C > h_B$, $V_C > V_B$ so $P_C > P_B$.

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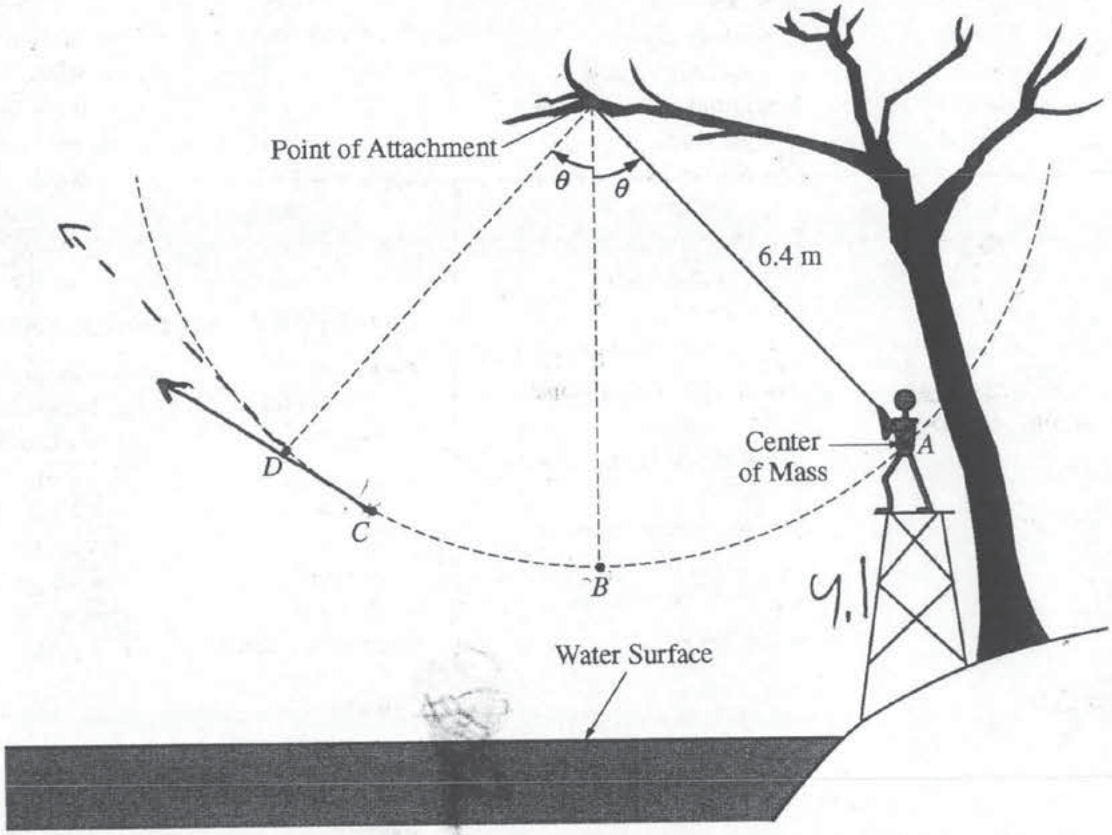

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(b) The center of mass of the person standing on the platform is at point A, 4.1 m above the surface of the water. Calculate the gravitational potential energy when the person is at point A relative to when the person is at the surface of the water.

$PE = mgh$

$PE = (50)(10)(4.1) = 2050\ J$

(c) The center of mass of the person at point B, the lowest point along the arc, is 2.4 m above the surface of the water. Calculate the person's speed at point B.

$PE = KE$

$2mgh = \frac{1}{2}mv^2$

$\frac{2mgh}{m} = \frac{mv^2}{m}$

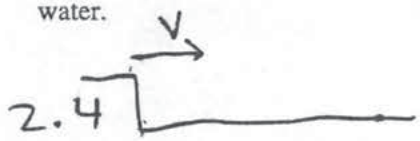
$\sqrt{v^2} = \sqrt{2gh}$

$v = \sqrt{2gh}$

$v = \sqrt{2(10)(2.4)}$

$v = \sqrt{48} = 6.92\ m/s$

(d) Suppose that the person swings from the rope a third time, letting go of the rope at point B. Calculate R, the horizontal distance moved from where the person releases the rope at point B to where the person hits the water.



$\Delta y = 0 + -5(t)^2$

$\frac{-2.4}{-5} = \frac{-5t^2}{-5}$

$\sqrt{.48} = \sqrt{t^2}$

$t = .69$

$D = Vt$

$R = (6.92)\cdot(.69)$

$R = 4.77\ m$

(e) If the person does not let go of the rope, how does the magnitude of the person's momentum p_C at point C compare with the magnitude of the person's momentum p_B at point B?

___ $p_C > p_B$ ✓ $p_C < p_B$ ___ $p_C = p_B$

Provide a physical explanation to justify your answer.

Point b has the fasters velocity, anything after point b is lower so since $mv = p$ when $v < 6.9$ then $p_b > p_c$

$P_b = mv_b \quad P_b = 50 \cdot 6.9 = 345$

$P_c = mv_c \quad P_c = 50 \cdot 6.0 = 300$

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AP® PHYSICS B
2014 SCORING COMMENTARY

Question 1

Overview

The intent of this question was to assess student understanding of projectile motion, mechanical energy including its transformation and conservation, kinematics, and momentum.

Sample : B1 A
Score: 15

This full-credit response uses $g = 10\ \mathrm{m/s^2}$. Note that in part (c) the answer to (b) was used instead of calculating a difference in heights.

Sample : B1 B
Score: 9

Both trajectories in part (a) are incorrect, so no points were earned. Part (b) earned full credit. The substitutions were incorrect and an incorrect velocity was obtained in part (c). Part (d) earned full credit for correct work using the incorrect velocity from part (c). The units point was also earned. Part (e) earned only 2 points, because there was no explanation for why the speed is greatest at point *B*.

Sample : B1 C
Score: 4

Both trajectories in part (a) are incorrect, so no points were earned. Part (b) earned full credit. Part (c) earned 1 point for using an expression for conservation of energy. Part (d) uses an incorrect kinematic approach, and part (e) has the wrong choice selected, so neither earned any points. The units point was also earned.