AP® Physics B
2001 Sample Student Responses

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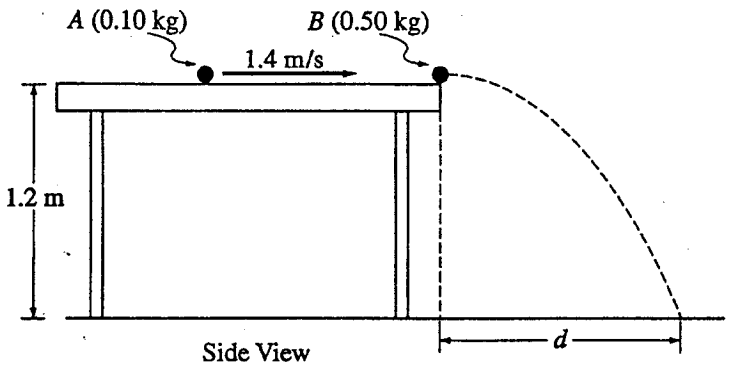

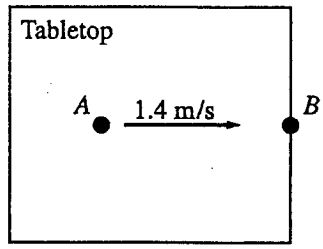

Note: Figures not drawn to scale.

2. (15 points)

An incident ball A of mass 0.10 kg is sliding at 1.4 m/s on the horizontal tabletop of negligible friction shown above. It makes a head-on collision with a target ball B of mass 0.50 kg at rest at the edge of the table. As a result of the collision, the incident ball rebounds, sliding backwards at 0.70 m/s immediately after the collision.

(a) Calculate the speed of the 0.50 kg target ball immediately after the collision.

Conservation of Momentum

$\Delta \vec{p}_{system} = 0$

$\vec{p} = m \cdot \vec{v}$

$\vec{p}_{initial} = m_A \cdot \vec{v}_{o_A} + m_B \cdot \vec{v}_{o_B} = (.10)(1.4) + (.50)(0) = .14 = \vec{p}_{final} = m_A \cdot \vec{v}_{f_A} + m_B \cdot \vec{v}_{f_B} = (.10)(-.70) + (.50)\vec{v}_{f_B}$

Therefore, $(.10)(-.70) + (.50) \cdot \vec{v}_{f_B} = .14$

$-.07 + .5\vec{v}_{f_B} = .14$

$.5\vec{v}_{f_B} = .21$

$\vec{v}_{f_B} = .42$ m/s to the right / forwards

$v_{final\ of\ B} = .42$ m/s

The tabletop is 1.20 m above a level, horizontal floor. The target ball is projected horizontally and initially strikes the floor at a horizontal displacement d from the point of collision.

(b) Calculate the horizontal displacement d.

① $a_y = g = -9.8\ m/s^2$

② $y = -1.2$ m

③ $m_B = .50$ kg

④ $v_{o_y} = 0$ m/s

⑤ $a_x = 0\ m/s^2$

⑥ $v_{o_x} = .42$ m/s

$y = v_{o_y} \cdot t + \frac{1}{2} a_y \cdot t^2$

$(-1.2) = 0 + \frac{1}{2}(-9.8)t^2$

$-1.2 = -4.9t^2$

$.2449 = t^2$

$t^2 = .244897959\overline{2}$

$t = \sqrt{.2448979592}$

$t = .4948716593$

$d = v_{o_x} \cdot t + \frac{1}{2} a_x \cdot t^2$

$d = (.42)(.495) + \frac{1}{2}(0)(.495)^2$

$d = (.42)(.495) + 0$

$d = .207846096\overline{9}$

$\vec{d} = .208$ m in the positive x direction

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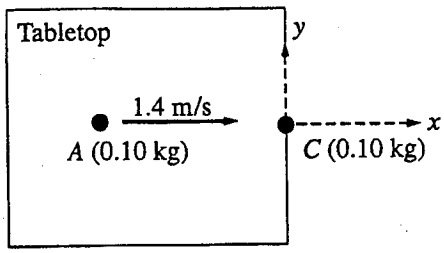
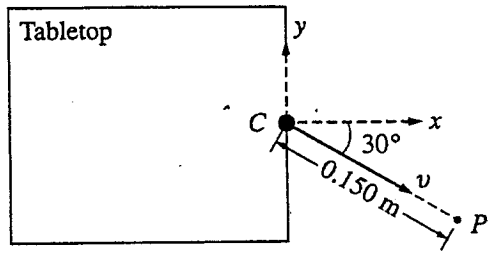


Top View
Before Collision



Top View
After Collision

In another experiment on the same table, the target ball B is replaced by target ball C of mass 0.10 kg. The incident ball A again slides at 1.4 m/s, as shown above left, but this time makes a glancing collision with the target ball C that is at rest at the edge of the table. The target ball C strikes the floor at point P, which is at a horizontal displacement of 0.15 m from the point of the collision, and at a horizontal angle of 30° from the $+x$-axis, as shown above right.

(c) Calculate the speed v of the target ball C immediately after the collision.

① $t = .495$ s
② $d = .150$ m
③ $v_{0C} = ?$
④ $a_C = 0$

$d = v_{0C} \cdot t + \frac{1}{2} a_C \cdot t^2$

$(.150) = v_{0C}(.495) + \frac{1}{2}(0)(.495)^2$

$0 + .495\, v_{0C} = .150$

$v_{0C} = .3031088413$ m/s

$v_{\text{after collision of } C} = .30$ m/s

(d) Calculate the y-component of incident ball A's momentum immediately after the collision.

$v_{y \text{ of } C} = v_{\text{of } C} \cdot \sin\theta$

$v_{y \text{ of } C} = (.30) \cdot \sin 30° = (.30) \cdot \frac{1}{2} = .15$ m/s

Conservation of Momentum

$m_A = .10$ kg
$v_{0A_y} = 0$ m/s
$v_{0C_y} = ?$ m/s
$v_{fA_y} =$?
$m_C = .10$ kg
$v_{fC_y} = -.15$ m/s

$\vec{p}_{\text{initial}_y} = \vec{p}_{\text{final}_y}$

$m_A \cdot v_{0A_y} + m_C \cdot v_{0C_y} = m_A \cdot v_{fA_y} + m_C \cdot v_{fC_y}$

$(.10)(0) + (.10)(0) = (.10)(v_{fA_y}) + (.10)(-.15)$

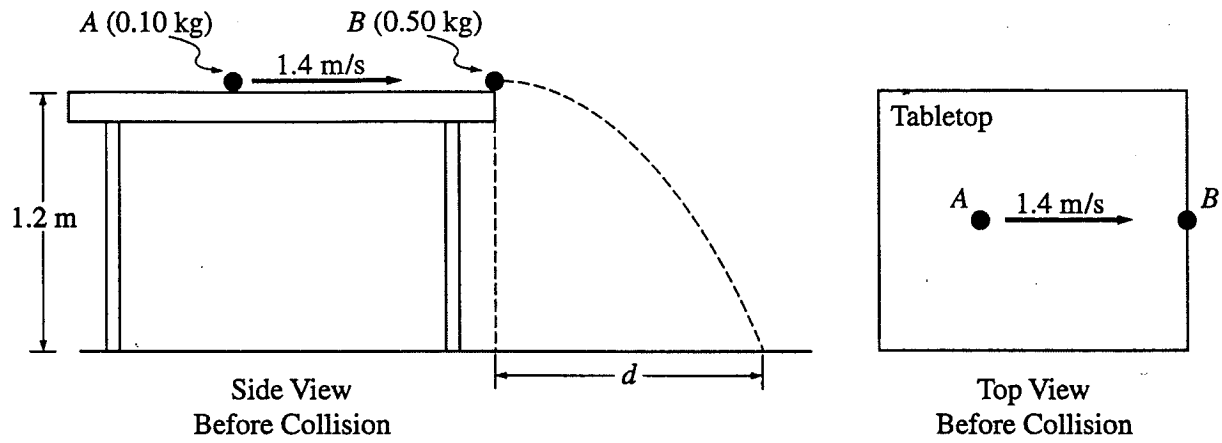
$0 = .10 \cdot v_{fA_y} - .015$

$.10 \cdot v_{fA_y} = .015$

$v_{fA_y} = .15$ m/s

$\vec{p}_{fA_y} = m_A \cdot v_{fA_y} = (.10)(.15) = .015$ kg·m/s

$\vec{p}_{y\text{-component of } A} = .015$ kg·m/s in the positive y-direction (TOP VIEW)



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2. (15 points)

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(a) Calculate the speed of the 0.50 kg target ball immediately after the collision.

$$m_1v_1 + m_2v_2 = m_1'v_1' + m_2'v_2'$$

$$(.1\text{ kg})(1.4\text{ m/s}) = (.1\text{ kg})(-.7\text{ m/s}) + (.5\text{ kg})(v)$$

$$v = 4\text{ m/s}$$

The tabletop is 1.20 m above a level, horizontal floor. The target ball is projected horizontally and initially strikes the floor at a horizontal displacement d from the point of collision.

(b) Calculate the horizontal displacement d.

$$h = v_0t + \tfrac{1}{2}at^2$$

$$1.2\text{m} = \tfrac{1}{2}(9.8\text{ m/s})t^2$$

$$t = .49\text{ s}$$

$$d = v_0t + \tfrac{1}{2}at^2$$

$$d = 4(.49)$$

$$d = 1.98\text{ m}$$

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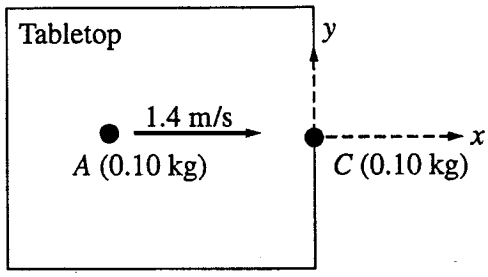

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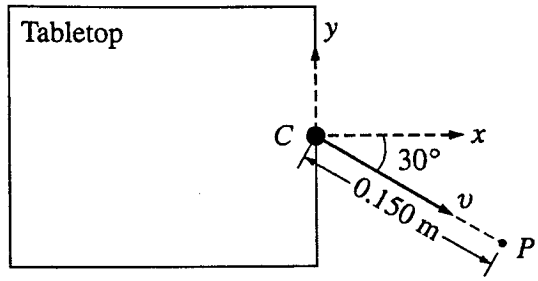

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(c) Calculate the speed v of the target ball C immediately after the collision.

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

$.15 = v_0 (.49)$

$v_0 = .3 \text{ m/s}$

(d) Calculate the y-component of incident ball A's momentum immediately after the collision.

$\sin(30) \cdot .3 \text{m/s} = v_y$

$v_y = .015$

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