



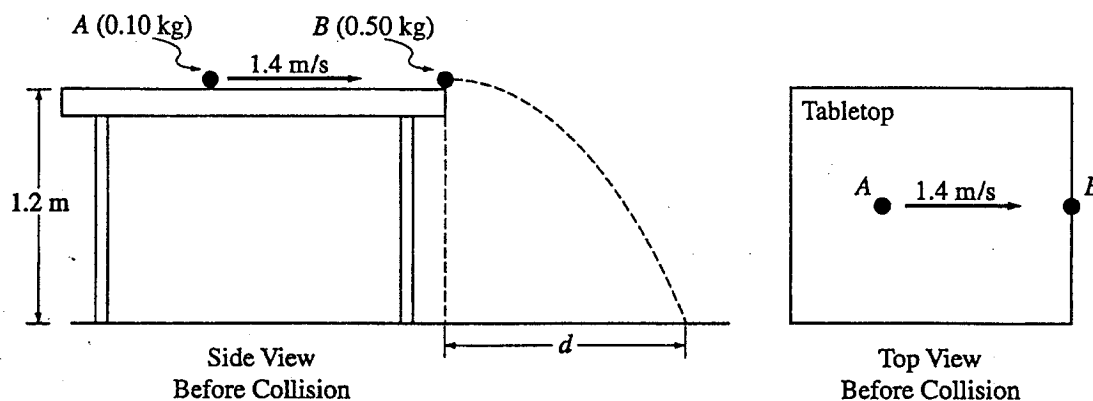
AP[®] Physics B 2001 Sample Student Responses

The materials included in these files are intended for non-commercial use by AP teachers for course and exam preparation; permission for any other use must be sought from the Advanced Placement Program. Teachers may reproduce them, in whole or in part, in limited quantities, for face-to-face teaching purposes but may not mass distribute the materials, electronically or otherwise. These materials and any copies made of them may not be resold, and the copyright notices must be retained as they appear here. This permission does not apply to any third-party copyrights contained herein.

These materials were produced by Educational Testing Service (ETS), which develops and administers the examinations of the Advanced Placement Program for the College Board. The College Board and Educational Testing Service (ETS) are dedicated to the principle of equal opportunity, and their programs, services, and employment policies are guided by that principle.

The College Board is a national nonprofit membership association dedicated to preparing, inspiring, and connecting students to college and opportunity. Founded in 1900, the association is composed of more than 3,900 schools, colleges, universities, and other educational organizations. Each year, the College Board serves over three million students and their parents, 22,000 high schools, and 3,500 colleges, through major programs and services in college admission, guidance, assessment, financial aid, enrollment, and teaching and learning. Among its best-known programs are the SAT[®], the PSAT/NMSQT[™], the Advanced Placement Program[®] (AP[®]), and Pacesetter[®]. The College Board is committed to the principles of equity and excellence, and that commitment is embodied in all of its programs, services, activities, and concerns.

Copyright © 2001 by College Entrance Examination Board. All rights reserved. College Board, Advanced Placement Program, AP, and the acorn logo are registered trademarks of the College Entrance Examination Board.



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

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

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

$$\vec{p}_{\text{initial}} = m_A \cdot \vec{v}_{0A} + m_B \cdot \vec{v}_{0B} = (0.10)(1.4) + (0.50)(0) = .14 = \vec{p}_{\text{final}} = m_A \cdot \vec{v}_{fA} + m_B \cdot \vec{v}_{fB} = (0.10)(-0.70) + (0.50)\vec{v}_{fB}$$

Therefore, $(0.10)(-0.70) + (0.50) \cdot \vec{v}_{fB} = .14$

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

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

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

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

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 .

$$1. a_y = g = -9.8 \text{ m/s}^2 \quad y = v_{0y} \cdot t + \frac{1}{2} a_y \cdot t^2$$

$$2. y = -1.2 \text{ m} \quad (-1.2) = 0 + \frac{1}{2} (-9.8) t^2$$

$$3. m_B = .50 \text{ kg} \quad -1.2 = -4.9 t^2$$

$$4. v_{0y} = 0 \text{ m/s} \quad .2449 = t^2$$

$$5. a_x = 0 \text{ m/s}^2 \quad t = \sqrt{.2448979592}$$

$$6. v_{0x} = .42 \text{ m/s} \quad t = .4948716543$$

$$d = v_{0x} \cdot t + \frac{1}{2} a_x \cdot t^2$$

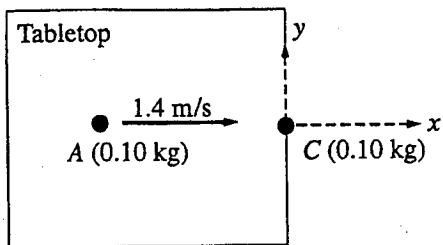
$$d = (.42)(.495) + \frac{1}{2} (0) (.495)^2$$

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

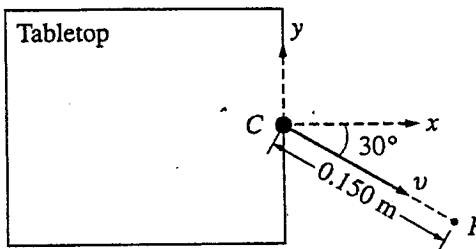
$$d = .2078460964$$

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

GO ON TO THE NEXT PAGE.



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.

$$\begin{aligned} \textcircled{1} t &= .495\text{ s} & d &= v_{0c} \cdot t + \frac{1}{2} a_c \cdot t^2 \\ \textcircled{2} d &= .150\text{ m} & (.150) &= v_{0c} (.495) + \frac{1}{2} (0) (.495)^2 \\ \textcircled{3} v_{0c} &= ? & 0 + .495 v_{0c} &= .150 \\ \textcircled{4} a_c &= 0 & v_{0c} &= .3031088413\text{ m/s} \end{aligned}$$

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

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

$$\begin{aligned} v_{y \text{ of } C} &= v_{\text{of } C} \cdot \sin \theta \\ v_{y \text{ of } C} &= (.30) \cdot \sin 30^\circ = (.30) \cdot \frac{1}{2} = .15\text{ m/s} \\ v_{y \text{ of } A} &= (-.30) \cdot \sin 30^\circ = (-.30) \cdot \frac{1}{2} = -.15\text{ m/s} \end{aligned}$$

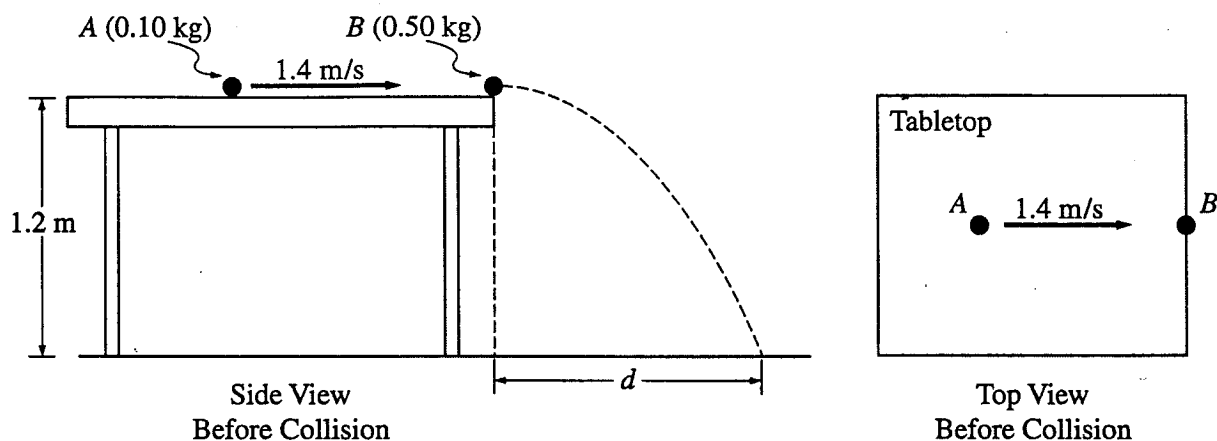
Conservation of Momentum

$$\begin{aligned} m_A &= .10\text{ kg} \\ v_{0Ay} &= 0\text{ m/s} \\ v_{0Cy} &= 0\text{ m/s} \\ v_{fAy} &= ? \\ m_C &= .10\text{ kg} \\ v_{fCy} &= -.15\text{ m/s} \end{aligned}$$

$$\begin{aligned} \vec{p}_{\text{initial } y} &= \vec{p}_{\text{final } y} \\ m_A \cdot v_{0Ay} + m_C \cdot v_{0Cy} &= m_A \cdot v_{fAy} + m_C \cdot v_{fCy} \\ (.10)(0) + (.10)(0) &= (.10)(v_{fAy}) + (.10)(-.15) \\ 0 &= .10 \cdot v_{fAy} + -.015 \\ .10 \cdot v_{fAy} &= .015 \\ v_{fAy} &= .15\text{ m/s} \end{aligned}$$

$$\begin{aligned} v_{fAy} &= .15\text{ m/s} \\ \vec{p}_{fAy} &= m_A \cdot v_{fAy} = (.10)(.15) = .015\text{ m}^2/\text{s} \\ \vec{p}_{y\text{-component of } A} &= .015\text{ m}^2/\text{s} \text{ in the positive } y\text{-direction (TOP VIEW)} \end{aligned}$$

GO ON TO THE NEXT PAGE.



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.

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

$$(0.1 \text{ kg})(1.4 \text{ m/s}) = (0.1 \text{ kg})(-0.7 \text{ m/s}) + (0.5 \text{ kg})(v)$$

$$v = 4.1 \text{ m/s}$$

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 .

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

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

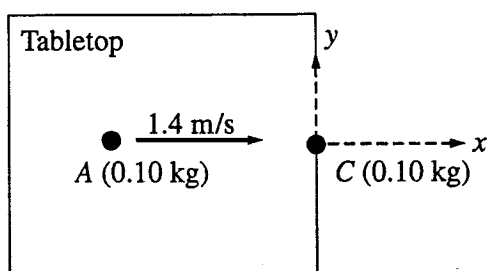
$$t = 0.49 \text{ s}$$

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

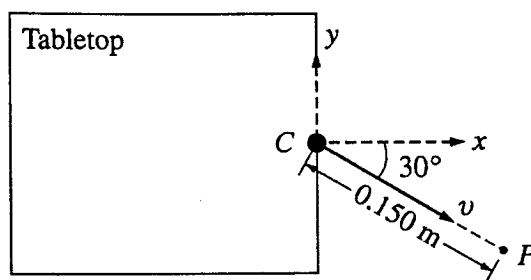
$$d = 4.1 (0.49)$$

$$d = 2.01 \text{ m}$$

GO ON TO THE NEXT PAGE.



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.

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

$$.15 = v_0 (.49)$$

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

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

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

$$y_v = .015$$

GO ON TO THE NEXT PAGE.