AP® PHYSICS B
2008 SCORING GUIDELINES

General Notes About 2008 AP Physics Scoring Guidelines

1. The solutions contain the most common method of solving the free-response questions and the allocation of points for this solution. Some also contain a common alternate solution. Other methods of solution also receive appropriate credit for correct work.

2. Generally, double penalty for errors is avoided. For example, if an incorrect answer to part (a) is correctly substituted into an otherwise correct solution to part (b), full credit will usually be awarded. One exception to this may be cases when the numerical answer to a later part should be easily recognized as wrong, e.g., a speed faster than the speed of light in vacuum.

3. Implicit statements of concepts normally receive credit. For example, if use of the equation expressing a particular concept is worth 1 point, and a student's solution contains the application of that equation to the problem but the student does not write the basic equation, the point is still awarded. However, when students are asked to derive an expression it is normally expected that they will begin by writing one or more fundamental equations, such as those given on the AP Physics exam equation sheet. For a description of the use of such terms as "derive" and "calculate" on the exams, and what is expected for each, see "The Free-Response Sections—Student Presentation" in the *AP Physics Course Description*.

4. The scoring guidelines typically show numerical results using the value $g = 9.8\ \text{m/s}^2$, but use of $10\ \text{m/s}^2$ is of course also acceptable. Solutions usually show numerical answers using both values when they are significantly different.

5. Strict rules regarding significant digits are usually not applied to numerical answers. However, in some cases answers containing too many digits may be penalized. In general, two to four significant digits are acceptable. Numerical answers that differ from the published answer due to differences in rounding throughout the question typically receive full credit. Exceptions to these guidelines usually occur when rounding makes a difference in obtaining a reasonable answer. For example, suppose a solution requires subtracting two numbers that should have five significant figures and that differ starting with the fourth digit (e.g., 20.295 and 20.278). Rounding to three digits will lose the accuracy required to determine the difference in the numbers, and some credit may be lost.

Question 1

10 points total | **Distribution of points**

(a) 4 points

For the correct value of t_1, the time car *A* is accelerating — 1 point

$v_f = v_i + at_1$

$t_1 = (v_f - v_i)/a = (5.0\ \text{m/s} - 2.0\ \text{m/s})/(1.5\ \text{m/s})$

$t_1 = 2.0\ \text{s}$

For a correct value of x_1, the distance car *A* travels while accelerating — 1 point

$x_1 = v_i t_1 + \frac{1}{2}at_1^2$

$x_1 = (2.0\ \text{m/s})(2.0\ \text{s}) + \frac{1}{2}(1.5\ \text{m/s}^2)(2.0\ \text{s})^2$

$x_1 = 7.0\ \text{m}$

Note: The equation $v_f^2 = v_i^2 + 2ax_1$ could also be used.

For a correct value of $(x - x_1)$, the distance car *A* travels at constant velocity — 1 point

$(x - x_1) = (15.0\ \text{m} - 7.0\ \text{m}) = 8.0\ \text{m}$

For correctly calculating t_2, the time car *A* travels at constant velocity — 1 point

$x = x_1 + v_f t_2$

$t_2 = (x - x_1)/v_f = (15.0\ \text{m} - 7.0\ \text{m})/5.0\ \text{m/s}$

$t_2 = 1.6\ \text{s}$

$t_{tot} = t_1 + t_2 = 2.0\ \text{s} + 1.6\ \text{s}$

$t_{tot} = 3.6\ \text{s}$

(b)

(i) 2 points

For any clear statement that momentum is conserved — 1 point

$m_A v_{Ai} = m_A v_{Af} + m_B v_B$

$$v_{Af} = \frac{m_A v_{Ai} - m_B v_B}{m_A} = \frac{(250\ \text{kg})(5.0\ \text{m/s}) - (200\ \text{kg})(4.8\ \text{m/s})}{250\ \text{kg}}$$

For a correct answer — 1 point

$v_{Af} = 1.2\ \text{m/s}$

(ii) 1 point

For indicating a direction of car *A* after the collision that is consistent with the calculation of v_{Af} — 1 point

Note: A correct calculation yields a direction to the right.

Question 1 (continued)

	Distribution of points
(c) 3 points	
For correctly indicating that the collision is <u>not</u> elastic	1 point
For a statement that kinetic energy is not conserved	1 point
For clearly showing that $K_f < K_i$, implying the collision is non-elastic	1 point

$$K_i = \frac{1}{2}m_A v_{Ai}^2 = \frac{1}{2}(250\ \text{kg})(5.0\ \text{m/s})^2$$

$$K_i = 3125\ \text{J}$$

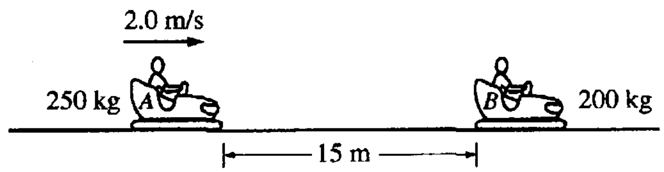
$$K_f = \frac{1}{2}m_A v_{Af}^2 + \frac{1}{2}m_B v_B = \frac{1}{2}(250\ \text{kg})(1.2\ \text{m/s})^2 + \frac{1}{2}(200\ \text{kg})(4.8\ \text{m/s})^2$$

$$K_f = 2484\ \text{J}$$

Note: Two points were awarded for checking "yes" with a clear, correct explanation that it is a partially elastic collision.

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 11 minutes for answering Questions 1 and 4-7 and about 17 minutes for answering each of Questions 2 and 3. 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 green insert.



1. (10 points)

Several students are riding in bumper cars at an amusement park. The combined mass of car *A* and its occupants is 250 kg. The combined mass of car *B* and its occupants is 200 kg. Car *A* is 15 m away from car *B* and moving to the right at 2.0 m/s, as shown, when the driver decides to bump into car *B*, which is at rest.

(a) Car *A* accelerates at $1.5\ m/s^2$ to a speed of $5.0\ m/s$ and then continues at constant velocity until it strikes car *B*. Calculate the total time for car *A* to travel the 15 m.

$a = 1.5\,m/s^2$
$v_1 = 2.0\,m/s$
$v_f = 5.0\,m/s$
$t = ?$

$a = \frac{\Delta v}{t} = \frac{(v_f - v_1)}{t} = \frac{(5\,m/s - 2\,m/s)}{t}$

$1.5\,m/s^2 = \frac{3\,m/s}{t}$

$t = 2s$

$d = \frac{1}{2}at^2$
$d = \frac{1}{2}(1.5\,m/s^2)(2s)^2$
$d = 3$ meters

$V = 5\,m/s$
$d = 12\,m$
↓
total distance - accelerated distance

$v = \frac{d}{t} \quad t = \frac{d}{v} = \frac{12m}{5\,m/s} = 2.4sec$

total time = 2sec + 2.4 sec = 4.4 sec
↑ acceleration time ↑ constant velocity time.

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(b) After the collision, car B moves to the right at a speed of 4.8 m/s. B1A2

i. Calculate the speed of car A after the collision.

Conservation of momentum

momentum before = momentum after

$m_A = 250kg$ $\quad m_A V_A = m_A V_{final} + m_B V_B$

$V_A = 5 m/s$ $\quad (250kg)(5m/s) = (250kg)(V_{final}) + (200kg)(4.8m/s)$

$m_B = 200kg$ $\quad V_{final} = 1.16 m/s$

$V_B = 4.8 m/s$

ii. Indicate the direction of motion of car A after the collision.

____ To the left __✓__ To the right ____ None; car A is at rest.

(c) Is this an elastic collision?

____ Yes __✓__ No

Justify your answer.

This is not an elastic collision because kinetic energy is not conserved.

Before the collision, the kinetic energy was

$K = \frac{1}{2} m_A v^2$

$= \frac{1}{2}(250kg)(5m/s)^2$

$= 3,125$ Joules because only m_A has kinetic energy

After the collision, the kinetic energy is

$K = \frac{1}{2} m_A v^2 + \frac{1}{2} m_B v^2$ because both m_A and m_B have kinetic energy

$K = \frac{1}{2}(250kg)(1.16m/s)^2 + \frac{1}{2}(200kg)(4.8m/s)^2$

$K = 2,472.2$ Joules

Thus, kinetic energy was lost during the collision proving the collision is not elastic.

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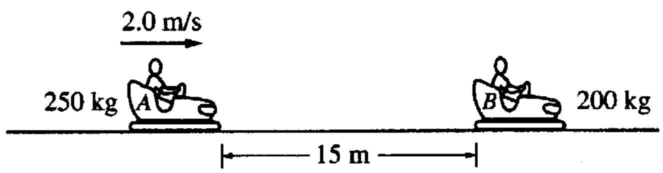

$M_A = 250$ kg
$M_B = 200$ kg
$d = 15$ m
$V_A = 2\ \frac{m}{s}$
$A_A = 1.5\ \frac{m}{s^2}$

1. (10 points)

Several students are riding in bumper cars at an amusement park. The combined mass of car *A* and its occupants is 250 kg. The combined mass of car *B* and its occupants is 200 kg. Car *A* is 15 m away from car *B* and moving to the right at 2.0 m/s, as shown, when the driver decides to bump into car *B*, which is at rest.

(a) Car *A* accelerates at $1.5\ \text{m/s}^2$ to a speed of $5.0\ \text{m/s}$ and then continues at constant velocity until it strikes car *B*. Calculate the total time for car *A* to travel the 15 m.

$V^2 = V_0^2 + 2a(x - x_0)$
$5^2 = 2^2 + 2(1.5)(x - 0)$
$25 = 4 + 3(x)$
$21 = 3x$
$7\text{ m} = x$ ← accelerates 7 m

$x = \bar{V} t$
$t = \frac{x}{\bar{V}}$
$t = \frac{7\text{ m}}{3.25\ \frac{m}{s}}$
$t = 2.15$ s

$x = \bar{V} t$
$\frac{x}{\bar{V}} = t$
$\frac{8\text{ m}}{5\ \frac{m}{s}} = t$
$1.6\text{ s} = t$

$t_{total} = t_{accelerating} + t_{after}$
$t = 2.15\text{ s} + 1.6\text{ s}$
$t = 3.75$ s

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(b) After the collision, car B moves to the right at a speed of 4.8 m/s.

i. Calculate the speed of car A after the collision.

$$M_1 V_1 + \cancel{M_2 V_2} = M_1 V_1' + M_2 V_2'$$
$$(250\,kg)(5\,\tfrac{m}{s}) = (250\,kg)V_1' + (200\,kg)(4.8\,\tfrac{m}{s})$$
$$1250 = 250 V_1' + 960$$
$$-960 \qquad\qquad -960$$
$$\frac{290}{250} = \frac{250 V_1'}{250}$$
$$\boxed{1.16\,\tfrac{m}{s} = V_1'}$$

ii. Indicate the direction of motion of car A after the collision.

____ To the left ✓ To the right ____ None; car A is at rest.

(c) Is this an elastic collision?

✓ Yes [scribbled out] No

Justify your answer.

The two bodies kept their shape and did not stick to each other.

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B1C

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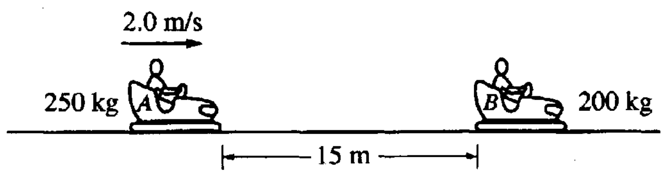

1. (10 points)

Several students are riding in bumper cars at an amusement park. The combined mass of car *A* and its occupants is 250 kg. The combined mass of car *B* and its occupants is 200 kg. Car *A* is 15 m away from car *B* and moving to the right at 2.0 m/s, as shown, when the driver decides to bump into car *B*, which is at rest.

(a) Car *A* accelerates at 1.5 m/s^2 to a speed of 5.0 m/s and then continues at constant velocity until it strikes car *B*. Calculate the total time for car *A* to travel the 15 m.

	x	y
a	1.5	-9.8
V_i	2	
V_f	5	
d		
t		

$F_{net} = ma = (250)(1.5)$

$V = \frac{d}{t}$

$5 = \frac{15}{t}$

$t = 3$ seconds

✓

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(b) After the collision, car *B* moves to the right at a speed of 4.8 m/s.

i. Calculate the speed of car *A* after the collision.

conservation of momentum

$m_A v_A + m_B v_B = m_A v_A' + m_B v_B'$

$(250)(5) + 0 = (250)(v_A') + (200)(4.8)$

$1250 = 250 v_A' + 960$

$-960 \qquad -960$

$\frac{290}{250} = \frac{250 v_A'}{250}$

$v_A' = 1.16 \text{ m/s}$

ii. Indicate the direction of motion of car *A* after the collision.

X To the left ____ To the right ____ None; car *A* is at rest.

(c) Is this an elastic collision?

X Yes ____ No

Justify your answer.

It is elastic because momentum is conserved, the two objects do not stay together after the collision and only some kinetic energy is lost.

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Question 1

Overview

This question was intended to test students' ability to analyze a one-dimensional mechanics problem that involved motion with constant-velocity and constant-acceleration stages and that utilized momentum conservation in collisions.

Sample: B1A
Score: 9

The calculation of the time car *A* spends accelerating is performed correctly, but the distance traveled during that time fails to include the car's initial velocity; 1 point was deducted as a result. This incorrect distance is used properly in the concluding steps of part (a), so the final 2 points were awarded for that part. The remainder of the problem earned full credit.

Sample: B1B
Score: 6

The time car *A* spends accelerating is calculated incorrectly, so 1 point was deducted. The remainder of parts (a) and (b) are correct and were awarded full credit. No points were awarded for part (c), as the incorrect choice is selected, and the justification is generally invalid.

Sample: B1C
Score: 2

No attempt is made to distinguish between the accelerating and constant-velocity portions of the motion in part (a); the calculation is instead incorrectly performed assuming a constant velocity throughout the motion. No points were awarded for that part. Conservation of momentum is correctly applied in part (b)(i), where 2 points were awarded, but the direction of motion chosen is incorrect. No points were awarded for part (c), as the collision is incorrectly characterized as elastic, and the justification includes incorrect statements regarding the nature of elastic collisions.