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 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 2

15 points total — **Distribution of points**

(a) 4 points

For a correct application of Newton's 2nd law for the two-block system — 1 point

$F = (m_A + m_B)a$

Note: Newton's 2nd law may be applied to each block separately to produce an equivalent solution.

For a correct determination of the acceleration — 1 point

$$a = \frac{F}{(m_A + m_B)} = \frac{4.0\ \text{N}}{(2.0\ \text{kg} + 8.0\ \text{kg})}$$

$a = 0.40\ \text{m/s}^2$

For correct substitution of the acceleration into Newton's 2nd law for one of the blocks — 1 point

$F_{spring} = m_A a$ (or $F - F_{spring} = m_B a$)

For the correct solution (consistent with the value of the acceleration found above) — 1 point

$F_{spring} = (2.0\ \text{kg})(0.40\ \text{m/s}^2)$ (or $F_{spring} = 4.0\ \text{N} - (8.0\ \text{kg})(0.40\ \text{m/s}^2)$)

$F_{spring} = 0.80\ \text{N}$

Note: A correct free-body diagram for each block could earn 1 point each.

(b) 2 points

For a correct expression relating spring force to extension — 1 point

$F_{spring} = kx$

For the correct solution using the spring force from part (a) — 1 point

$$x = \frac{F_{spring}}{k} = \frac{0.80\ \text{N}}{80\ \text{N/m}}$$

$x = 0.010\ \text{m}$

(c) 3 points

For correctly indicating that the acceleration will be the same as before — 1 point

For a correct justification (only if the previous point was awarded) — 2 points

Examples:

- Explaining that in both cases there is a 4.0 N force pulling a combined mass of 10 kg, and hence the acceleration will be the same in the two cases. (Note: One point was awarded when the student noted that either the net force acting on the system of two blocks or the mass of the system is unchanged. For full credit, the student must have noted that both the force and mass are the same in the two cases.)
- Applying Newton's 2nd law to each block and calculating an acceleration with the same value as in part (a).

Question 2 (continued)

	Distribution of points
(d) 3 points	
For correctly indicating that the spring extension is greater than in part (b)	1 point
For a correct justification (only if the previous point was awarded)	2 points

Examples:

- The spring force on the 8.0 kg block produces the same acceleration as the spring force on the 2.0 kg block in part (a); hence the spring force is greater than in part (a) so the extension is greater.
- Applying Newton's 2nd law to show that the new spring extension is 0.040 m.

Notes:

- A partial justification worth a single point may note that the spring is pulling on a larger mass than before, or may note that the force exerted by the spring is larger than before (without explaining why this force is larger).
- Students who answered part (c) by saying that the acceleration is greater could earn 2 points here by noting that the force exerted by the spring on block B must be larger in order to give the larger mass a greater acceleration.

(e) 3 points	
For indicating that, after block A impacts the wall, mechanical energy is conserved	1 point
For correctly applying conservation of energy, equating the energy immediately after block A hits the wall to the energy when the spring is at maximum compression	1 point

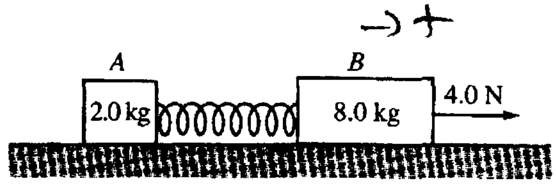
$$K_{before} + U_{before} = K_{after} + U_{after}$$

$$\frac{1}{2}m_B\upsilon^2 + 0 = 0 + \frac{1}{2}kx^2$$

For the correct solution — 1 point

$$x = \sqrt{\frac{m_B\upsilon^2}{k}} = \sqrt{\frac{(8.0\ \text{kg})(0.50\ \text{m/s})^2}{80\ \text{N/m}}}$$

$$x = 0.16\ \text{m}$$



2. (15 points)

Block A of mass 2.0 kg and block B of mass 8.0 kg are connected as shown above by a spring of spring constant 80 N/m and negligible mass. The system is being pulled to the right across a horizontal frictionless surface by a horizontal force of 4.0 N, as shown, with both blocks experiencing equal constant acceleration.

(a) Calculate the force that the spring exerts on the 2.0 kg block.

$K = 80\ N/m$

$\Sigma F = ma$

$4N = (8kg + 2kg)a$

$\frac{4N}{10kg} = \frac{(10kg)a}{10kg}$

$a = .4\ m/s^2$

$\Sigma F = ma$

$F = (2kg)(.4\ m/s^2)$

$F = 0.8N$

(b) Calculate the extension of the spring.

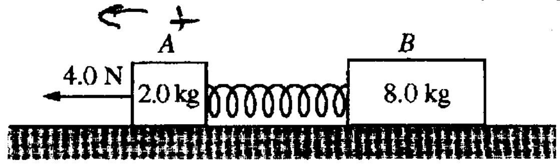
$F_s = -Kx$

$\frac{.08N}{80N/m} = \frac{80N/m\ x}{80N/m}$

$x = .001m$

GO ON TO THE NEXT PAGE.

The system is now pulled to the left, as shown below, with both blocks again experiencing equal constant acceleration.



(c) Is the magnitude of the acceleration greater than, less than, or the same as before?

____ Greater ____ Less ✓ ____ The same

Justify your answer.

$\Sigma F = ma$
$F = (m_1 + m_2)a$
$4N = (2kg + 8kg)a$
$\frac{4N}{10kg} = \frac{(10kg)a}{10kg}$
$a = 0.4\ m/s^2$

The same force is acting on the same weight, therefore same acceleration.

(d) Is the amount the spring has stretched greater than, less than, or the same as before?

✓ Greater ____ Less ____ The same

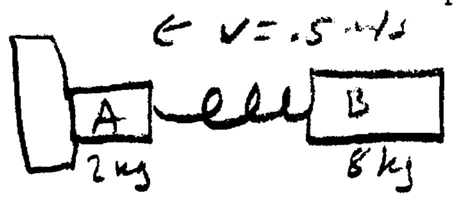
Justify your answer.

$F_s = kx$
$\frac{3.2N}{80N/m} = \frac{80N/m\, x}{80N/m}$
$x = .04\ m$

$\Sigma F = ma$
$F = (8kg)(.4 m/s^2)$
$F = 3.2N$

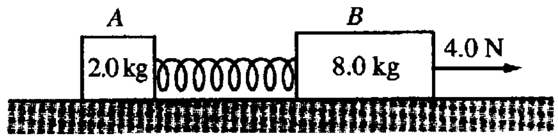
There is a greater mass at the end of the spring therefore the spring would stretch more.

(e) In a new situation, the blocks and spring are moving together at a constant speed of 0.50 m/s to the left. Block *A* then hits and sticks to a wall. Calculate the maximum compression of the spring.



$KE = U_s$
$\frac{1}{2}mv^2 = \frac{1}{2}kx^2$
$\frac{(10kg)(.5m/s)^2}{80N/m} = \frac{(80N/m)x^2}{80N/m}$
$\sqrt{x^2} = \sqrt{.03125}$
$x = 0.177\ m$

GO ON TO THE NEXT PAGE.



2. (15 points)

Block *A* of mass 2.0 kg and block *B* of mass 8.0 kg are connected as shown above by a spring of spring constant 80 N/m and negligible mass. The system is being pulled to the right across a horizontal frictionless surface by a horizontal force of 4.0 N, as shown, with both blocks experiencing equal constant acceleration.

(a) Calculate the force that the spring exerts on the 2.0 kg block.

$F_B = ma$

$4N = 8kg\,a$

$a = 0.5 m/s^2$

$F_s = ma$

$F_s = (2.0\ kg)(0.5 m/s^2)$

$F_{S\to A} = 1N$

(b) Calculate the extension of the spring.

$F = -kx$

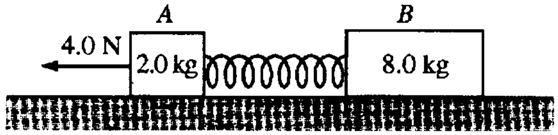
$1N = -80 N/m\, x$

$x = -0.0125$

$x = 0.0125$ stretched

GO ON TO THE NEXT PAGE.

The system is now pulled to the left, as shown below, with both blocks again experiencing equal constant acceleration.



(c) Is the magnitude of the acceleration greater than, less than, or the same as before?

✓ Greater ____ Less ____ The same

Justify your answer.

$F_A = ma$

$4N = (2kg)a$

$a = 2 m/s^2$

(d) Is the amount the spring has stretched greater than, less than, or the same as before?

✓ Greater ____ Less ____ The same

Justify your answer.

$F_s = ma$

$F_s = (8 kg)(2 m/s^2)$

$F_s = 16 N$

$16 = -80x$

$x = 0.2 m$ stretched

$0.2m > 0.0125m$

(e) In a new situation, the blocks and spring are moving together at a constant speed of 0.50 m/s to the left. Block *A* then hits and sticks to a wall. Calculate the maximum compression of the spring.

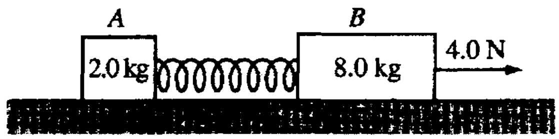
$\frac{1}{2}mv^2 = \frac{1}{2}kx^2$

$\frac{1}{2}10(0.50)^2 = \frac{1}{2}80x^2$

$1.25 = 40x^2$

$x = 0.177 m$

GO ON TO THE NEXT PAGE.



2. (15 points)

Block *A* of mass 2.0 kg and block *B* of mass 8.0 kg are connected as shown above by a spring of spring constant 80 N/m and negligible mass. The system is being pulled to the right across a horizontal frictionless surface by a horizontal force of 4.0 N, as shown, with both blocks experiencing equal constant acceleration.

(a) Calculate the force that the spring exerts on the 2.0 kg block.

$m_A = 2.0kg$
$m_B = 8.0kg$
$k = 80N/m$
$F = 4.0N$

$F = ma$
$4.0N = 8.0kg \cdot a$
$a = .5m/s^2$

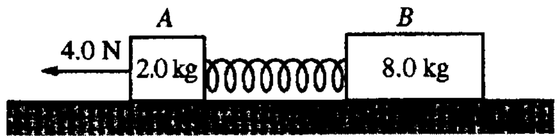
$F = ma$
$= 2.0kg \cdot .5m/s^2$
$= 1N$

(b) Calculate the extension of the spring.

$F = kx$
$4.0N = 80N/m \cdot x$
$x = .05 m$

GO ON TO THE NEXT PAGE.

The system is now pulled to the left, as shown below, with both blocks again experiencing equal constant acceleration.



(c) Is the magnitude of the acceleration greater than, less than, or the same as before?

X Greater ____ Less ____ The same

Justify your answer.

It is greater because the force is being applied to the smaller box first, by the equation F=ma, 4.0N=2.0kg·a, acceleration will be 2.0m/s², much larger than the previous .5 m/s².

(d) Is the amount the spring has stretched greater than, less than, or the same as before?

X Greater ____ Less ____ The same

Justify your answer.

It will be greater because Block A will have to move farther before enough force will be applied to the much larger Block B.

(e) In a new situation, the blocks and spring are moving together at a constant speed of 0.50 m/s to the left. Block *A* then hits and sticks to a wall. Calculate the maximum compression of the spring.

$V_i = -.50 m/s$ (−) = left
(+) = right

$V_{fA} = 0$

$m_1V_1 + m_2V_2 = m_1V_{f1} + m_2V_{f2}$

$(2.0kg)(-.5m/s) + (8.0kg)(-.50m/s) = (2.0kg \cdot 0m/s) + 8kg$

$V_{f2} = -.625 m/s$
or
$.625 m/s$ left

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

$(\frac{1}{2})(8.0kg)(-.625 m/s) = (\frac{1}{2})(80N/m)(x^2)$

$x = .25m$

GO ON TO THE NEXT PAGE.

Question 2

Overview

Students were given a system of two blocks connected by a spring, moving on a frictionless surface under the influence of a constant force applied to one block. The two blocks had the same acceleration. This question tested students' ability to appropriately define a system when applying Newton's second law, as they were asked to calculate the force exerted by the spring and the stretch in the spring. Students were then asked to analyze the same system when the same force is applied to the other block. They were to decide how (if at all) the acceleration and extension of the spring differed from before, and they had to justify their answers. Again, the key was to apply Newton's second law to the appropriate system. Finally, in a section that was independent of previous parts of the problem, students had to apply conservation of energy to find the compression in the spring after one of the blocks underwent a completely inelastic collision with a wall, given the initial velocity of the blocks.

Sample: B2A
Score: 13

The calculations in part (a) are performed correctly, and were awarded full credit. In part (b) the student correctly attempts to use the spring force equation, but a substitution error leads to an incorrect solution, which led to the loss of 1 point. The choices in parts (c) and (d) are correct, with correct mathematical justifications; full credit was awarded for these parts. Conservation of energy is correctly applied in part (e), but the incorrect substitution of the mass led to the loss of the solution point.

Sample: B2B
Score: 9

In part (a) the calculation of the acceleration is incorrect, but the result is substituted into a correct Newton's law expression, obtaining an answer consistent with the acceleration used; 2 points were awarded. Full credit was earned in part (b), as the result from part (a) is correctly used to determine the displacement. The choice in part (c) is incorrect, so no credit was awarded. Full credit was awarded for a correct choice and mathematical justification in part (d). Conservation of energy is implied in part (e), with the relevant forms of energy correctly included, but the incorrect substitution of the mass led to the loss of the solution point.

Sample: B2C
Score: 6

In part (a) the calculation of the acceleration is incorrect, but the result is substituted into a correct Newton's law expression, obtaining an answer consistent with the acceleration used; 2 points were awarded. The correct relationship is used in part (b), which earned 1 point, but the answer is inconsistent with the result obtained in part (a). The choice in part (c) is incorrect, so no points were awarded. One point was awarded in part (d) for the correct choice, but the justification is incorrect, so no additional points were given. Conservation of energy is indicated in part (e), with the relevant forms of energy included, but the initial velocity of block *B* used is incorrect, which led to the loss of the solution point.