AP® PHYSICS B (Form 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) 2 points

For a correct expression of conservation of momentum — 1 point

$m_w v_w = m_s v_s$

$v_s = \dfrac{m_w v_w}{m_s} = \dfrac{(70\ \text{kg})(0.55\ \text{m/s})}{35\ \text{kg}}$

For the correct final answer — 1 point

$v_s = 1.1\ \text{m/s}$

(b) 2 points

For correct use of the impulse–momentum relationship — 1 point

$F_{avg}\Delta t = m_s \Delta v_s$

$F_{avg} = \dfrac{m_s \Delta v_s}{\Delta t} = \dfrac{(35\ \text{kg})(1.1\ \text{m/s} - 0\ \text{m/s})}{0.60\ \text{s}}$

For the correct final answer — 1 point

$F_{avg} = 64\ \text{N}$

Alternate solution — *Alternate points*

For correct calculation of the average acceleration of the son during the push — *1 point*

$a_s = \dfrac{\Delta v_s}{\Delta t}$

$a_s = \dfrac{1.1\ \text{m/s}}{0.6\ \text{s}} = 1.83\ \text{m/s}^2$

For the correct final answer using Newton's second law — *1 point*

$F_{avg} = m_s a_s = (35\ \text{kg})(1.83\ \text{m/s}^2)$

$F_{avg} = 64\ \text{N}$

(c) 3 points

For indicating that the average force exerted on the mother by the son is equal in magnitude to that exerted on the son by the mother — 1 point

For indicating that the average force exerted on the mother by the son is opposite in direction to that exerted on the son by the mother — 1 point

For a correct justification invoking Newton's third law — 1 point

Question 1 (continued)

Distribution of points

(d) 3 points

For correctly finding the acceleration of the mother — 1 point

In the following solution, the positive direction for all quantities is to the right relative to the figure shown in the question.

$$\upsilon_{wf}{}^2 = \upsilon_{wi}{}^2 + 2a_w\Delta x_w$$

$$0 = (0.55\ \text{m/s})^2 + 2a_w(-7\ \text{m})$$

$$a_w = 0.022\ \text{m/s}^2$$

For recognizing that the accelerations of both the mother and the son are the same magnitude, since the acceleration is caused by friction — 1 point

$$F_{fric} = \mu N = \mu mg = ma$$

$$a = \mu g$$

$$|a_w| = |a_s|$$

$$a_s = -0.022\ \text{m/s}^2$$

For correctly finding the displacement of the son, with units — 1 point

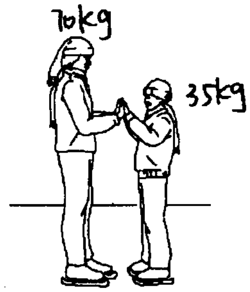
$$\upsilon_{sf}{}^2 = \upsilon_{si}{}^2 + 2a_s\Delta x_s$$

$$0 = (1.1\ \text{m/s})^2 + 2\left(-0.022\ \text{m/s}^2\right)\Delta x_s$$

$$\Delta x_s = 28\ \text{m}$$

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 lavender insert.



1. (10 points)

A 70 kg woman and her 35 kg son are standing at rest on an ice rink, as shown above. They push against each other for a time of 0.60 s, causing them to glide apart. The speed of the woman immediately after they separate is 0.55 m/s. Assume that during the push, friction is negligible compared with the forces the people exert on each other.

(a) Calculate the initial speed of the son after the push.

The momentum of the son and the mother is conserved

$m_m v_m + m_s v_s = m_m' v_m' + m_s' v_s'$

$v_m = v_s = 0$ m/s

$0 = 70kg \cdot (0.55 m/s) + 35 kg\ v_s'$

$v_s' = -1.1$ m/s

∴ The initial speed is 1.1 m/s

(b) Calculate the magnitude of the average force exerted on the son by the mother during the push.

impulse = change in momentum = average force × time

$F_{avg} \times 0.60 s = m_s' \cdot v_s' - m_s \cdot v_s$

$F_{avg} = \frac{(-1.1) \times 35kg - 0}{0.60 s}$

$= -64 N$

The direction of force is away from the mother

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(c) How do the magnitude and direction of the average force exerted on the mother by the son during the push compare with those of the average force exerted on the son by the mother? Justify your answer.

The magnitude of average force exerted on the mother by the son during the push is the same as the average force exerted on the son by the mother, but the direction of the two average force is opposite.
This is because the total momentum of the system which consists of the mother and the son is conserved, ~~thus~~ Since total momentum of the system is 0 at first, the total momentum after the push is also 0. Therefore the change of momentum of the mother and son must have the same magnitude, but opposite ~~different~~ direction. The time taken is the same, thus average force has the same amplitude but opposite direction

(d) After the initial push, the friction that the ice exerts cannot be considered negligible, and the mother comes to rest after moving a distance of 7.0 m across the ice. If their coefficients of friction are the same, how far does the son move after the push?

$f = \mu F_N = \mu mg = \mu \cdot 70kg \times 9.8 m/s^2$

~~$S = ut + \frac{1}{2}at^2$~~ $v^2 = u^2 + 2as$

~~$7.0m = 0.5$~~ $0 = (0.55 m/s)^2 + 2a \times 7.0m$

$a = -0.022 m/s^2$

$a = \frac{f}{m} = \frac{\mu \cdot 70kg \cdot 9.8 m/s^2}{70kg} = 0.022 m/s^2$

$\mu = 0.0022$

$f_s = \mu \cdot F_N = \mu \cdot m_s g$

$a = \frac{f_s}{m_s} = \mu \cdot g$

$v^2 = u^2 + 2as$

$0 = (1.1)^2 + 2 \times \mu \cdot 9.81 m/s^2 \times S$

$0 = (1.1 m/s)^2 + (2 \times 0.0022 \times 9.81 m/s^2) S$

$S = 28 m$

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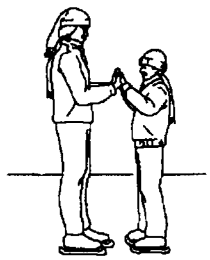
$mg\mu_k = 64 \cdot 7.0$



$\Delta x = 7.0$ m

1. (10 points)

A 70 kg woman and her 35 kg son are standing at rest on an ice rink, as shown above. They push against each other for a time of 0.60 s, causing them to glide apart. The speed of the woman immediately after they separate is 0.55 m/s. Assume that during the push, friction is negligible compared with the forces the people exert on each other.

(a) Calculate the initial speed of the son after the push.

$m_1 v_1 = m_2 v_2$

$70 \times 0.55 = 35 \times v_2$

$v_2 = 1.1$ m/s

(b) Calculate the magnitude of the average force exerted on the son by the mother during the push.

$F = ma = 35 \times a \qquad a = \frac{v}{t} = \frac{1.1 \text{ m/s}}{0.6 \text{ s}}$

$F = 35 \times \frac{1.1}{0.6} = 64$ N

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(c) How do the magnitude and direction of the average force exerted on the mother by the son during the push compare with those of the average force exerted on the son by the mother? Justify your answer.

According to the Newton's Law, the reactant force equals to the resultant force. Therefore, the force exerted by the mother is equal in magnitude but opposite in direction to the force exerted by the son.

(d) After the initial push, the friction that the ice exerts cannot be considered negligible, and the mother comes to rest after moving a distance of 7.0 m across the ice. If their coefficients of friction are the same, how far does the son move after the push?

mom:

$\Sigma F = F_k \cdot d - ma = 0$

$F_k \cdot d = ma$

$mg \cdot \mu k \cdot d = ma$

$70 \cdot 9.8 \cdot \mu k \cdot 7 = 64$

$\mu k = .013$

son:

$mg \cdot \mu k \cdot d = ma$

$35 \times 9.8 \times .013 \times d = 64$

$d = 14\,m$

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1. (10 points)

A 70 kg woman and her 35 kg son are standing at rest on an ice rink, as shown above. They push against each other for a time of 0.60 s, causing them to glide apart. The speed of the woman immediately after they separate is 0.55 m/s. Assume that during the push, friction is negligible compared with the forces the people exert on each other.

(a) Calculate the initial speed of the son after the push.

law of conservation of ~~moment~~ energy
$M = 70\,k \quad m = 35\,kg$

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

$\frac{1}{2}(70)(.55)^2 = \frac{1}{2}(35)v^2$

$\sqrt{\frac{70(.55)^2}{35}} = v = .778\,m/s$

(b) Calculate the magnitude of the average force exerted on the son by the mother during the push.

Force = m(a) time that it took to reach speed .778 m/s of the son is .6 s

m = 35 kg

$F = (35\,kg)(1.296\,m/s^2)$ $a = \frac{v}{t}$ $a = \frac{.778\,m/s}{.6\,s} = 1.296\,m/s^2$

$F = 45.15\,N$

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(c) How do the magnitude and direction of the average force exerted on the mother by the son during the push compare with those of the average force exerted on the son by the mother? Justify your answer.

F of mother on son = 415.15 N

The force of the son on the mother was greater than the force of the mother on the son

F = M(a)
M = 70 kg
F = 70 kg (.916 m/s²)
F = 64.167 N — F son on mother

V of mother = .55 m/s

a = V / t   t = .6 s

a = .55 m/s / .6

a = .916 m/s²

(d) After the initial push, the friction that the ice exerts cannot be considered negligible, and the mother comes to rest after moving a distance of 7.0 m across the ice. If their coefficients of friction are the same, how far does the son move after the push?

Work(F) = Work (on mother)   Work = F·d

g = 10 m/s²

F of mother (d) = d(M·g)(μ)   Normal force = g(M) = 700

(64.167)(7 m) = (7 m)(700)(μ)

64.167 N / 700 N = μ

.092 = μ

d = 7   d_b - distance by boy

d (F on mother − f_N μ) = d_b (F on boy − f_F)

7 (64.167 − μ

GO ON TO THE NEXT PAGE.

Question 1

Sample: B1A
Score: 10

Full credit was awarded for a set of very well-crafted responses to all parts. In part (c) the student uses a justification involving discussion of momentum instead of directly applying Newton's third law.

Sample: B1B
Score: 6

Full credit was awarded for parts (a) and (b). Part (c) received only 2 points because Newton's third law is not correctly described. The calculations in part (d) incorrectly assume that the forces on mother and son are of equal magnitude, and equal to the previously calculated value, so no credit was earned.

Sample: B1C
Score: 2

Part (a) incorrectly attempts to use conservation of energy to find the initial speed of the son, so no points were awarded. In part (b) the student received the full 2 points credit, since the impulse-momentum relationship is used correctly with the answer from part (a). No points were awarded for part (c), as the statement regarding force magnitude is incorrect, the direction is not indicated, and no mention is made of Newton's third law. No relevant work is performed in part (d).