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 4

10 points total | **Distribution of points**

(a) 3 points

For a correct application of kinematics to the vertical motion — 1 point

$v_{yf}^2 = v_{y0}^2 - 2gh = 0$

$v_{y0}^2 = 2gh$

For correctly expressing the vertical component of the initial velocity — 1 point

$v_{y0} = v_0 \sin 50°$

For a correct solution — 1 point

$v_0 \sin 50° = \sqrt{2gh}$

$$v_0 = \frac{\sqrt{2gh}}{\sin 50°} = \frac{\sqrt{2\left(9.8\ \text{m/s}^2\right)(0.150\ \text{m})}}{\sin 50°}$$

$v_0 = 2.24\ \text{m/s}$ (or $2.26\ \text{m/s}$ using $g = 10\ \text{m/s}^2$)

(b) 2 points

For a correct expression for the volume flow rate, using an area of πr_0^2 — 1 point

Volume flow rate $= A_0 v_0 = \pi r_0^2 v_0$

For a correct solution with correct units, consistent with v_0 found in part (a) — 1 point

Volume flow rate $= \pi\left(4.00 \times 10^{-3}\ \text{m}\right)^2 (2.24\ \text{m/s})$

Volume flow rate $= 1.13 \times 10^{-4}\ \text{m}^3/\text{s}$ (or $1.14 \times 10^{-4}\ \text{m}^3/\text{s}$ using $g = 10\ \text{m/s}^2$)

Question 4 (continued)

Distribution of points

(c) 5 points

For a correct expression for the water velocity in the feeder pipe with substitutions consistent with previous work — 1 point

$A_0 \upsilon_0 = A_p \upsilon_p$

$\upsilon_p = \dfrac{A_0}{A_p}\upsilon_0 = \left(\dfrac{r_0}{r_p}\right)^2 \upsilon_0 = \left(\dfrac{4.00 \times 10^{-3}\ \text{m}}{7.00 \times 10^{-3}\ \text{m}}\right)^2 2.24\ \text{m/s}$

For a correctly calculated answer consistent with previous work — 1 point

$\upsilon_p = 0.731\ \text{m/s}$ (or $\upsilon_p = 0.738\ \text{m/s}$ using $g = 10\ \text{m/s}^2$)

For a correct expression of Bernoulli's equation — 1 point

$P_0 + \rho g h_0 + \frac{1}{2}\rho \upsilon_0^2 = P_p + \rho g h_p + \frac{1}{2}\rho \upsilon_p^2$

$P_p - P_0 = \rho g\left(h_0 - h_p\right) + \frac{1}{2}\rho\left(\upsilon_0^2 - \upsilon_p^2\right)$

For consistent/correct substitutions of heights and velocities — 1 point

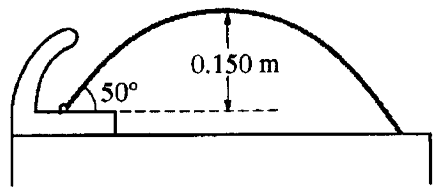
$P_p - P_0 = \left(1.0 \times 10^3\ \text{kg/m}^3\right)\left(9.8\ \text{m/s}^2\right)(3.00\ \text{m})$

$\qquad + \frac{1}{2}\left(1.0 \times 10^3\ \text{kg/m}^3\right)\left[(2.24\ \text{m/s})^2 - (0.731\ \text{m/s})^2\right]$

For correctly accounting for atmospheric pressure (with no obvious algebraic errors) leading to an answer — 1 point

P_0 is atmospheric pressure, and $P_p = P_0 + P_{gauge}$

$P_{gauge} = P_p - P_0 = 3.16 \times 10^4\ \text{Pa}$ (or $3.23 \times 10^4\ \text{Pa}$ using $g = 10\ \text{m/s}^2$)

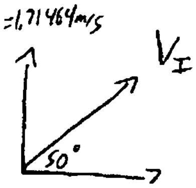


4. (10 points)

A drinking fountain projects water at an initial angle of 50° above the horizontal, and the water reaches a maximum height of 0.150 m above the point of exit. Assume air resistance is negligible.

(a) Calculate the speed at which the water leaves the fountain.

$v_0 = 1.71464 m/s$



$v^2 = v_0^2 + 2a\,\Delta x$

$0 = v_0^2 + 2(-9.8 m/s^2)(0.15 m)$

$v_0^2 = 2.94 m/s$

$v_0 = 1.71464 m/s$

$\sin 50° (v_I) = v_0 \qquad v_1 = \frac{v_0}{\sin 50°}$

$\frac{1.71464 m/s}{\sin 50°} = 2.238 m/s$

(b) The radius of the fountain's exit hole is 4.00×10^{-3} m . Calculate the volume rate of flow of the water.

$A = \pi r^2 = \pi(4.00 \times 10^{-3})^2 = 0.000050265 m^2$

$V = A(speed) = 0.000050265 m^2 (2.238 m/s) = 1.125 \times 10^{-4} m^3/s$

(c) The fountain is fed by a pipe that at one point has a radius of 7.00×10^{-3} m and is 3.00 m below the fountain's opening. The density of water is 1.0×10^3 kg/m^3 . Calculate the gauge pressure in the feeder pipe at this point.

$P + \rho g y + \frac{1}{2}\rho v^2 = P + \rho g y + \frac{1}{2}\rho v^2$

$P + 0 + \frac{1}{2}(1.0 \times 10^3 kg/m^3)(0.730775 m/s)^2 = 0 + 1.0 \times 10^3 kg/m^3 (9.8 m/s^2)(3 m) + \frac{1}{2}(1.0 \times 10^3 kg/m^3)(2.238 m/s)^2$

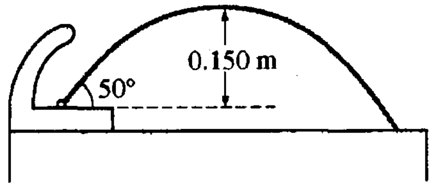
$A_1 v_1 = A_2 v_2$

$5.0265 \times 10^{-5} m^2 (2.238 m/s) = \pi (7.00 \times 10^{-3} m)^2 (v)$

$v = 0.730775 m/s$

$P = 31637.3 Pa$

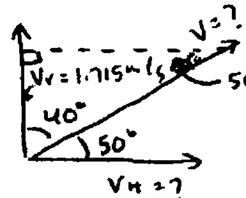
GO ON TO THE NEXT PAGE.



4. (10 points)

A drinking fountain projects water at an initial angle of 50° above the horizontal, and the water reaches a maximum height of 0.150 m above the point of exit. Assume air resistance is negligible.

(a) Calculate the speed at which the water leaves the fountain.



$(V_f)_v^2 = 2a(d_v) + (V_i)_v^2$

$0\ m^2/s^2 = 2(-9.8\ m/s^2)(.150\ m) + (V_i)_v^2$

$\sqrt{+2.94\ m^2/s^2} = \sqrt{(V_i)_v^2}$

$(V_i)_v = 1.71464282\ m/s$

$\frac{\sin 90°}{V} = \frac{\sin 50°}{1.714642820\ m/s}$ $\quad \frac{1.714642820\ m/s}{.7660444431} = \frac{(.7660444431)V}{.7660444431}$

$V = 2.2383\ m/s$ ⇒ speed water

(b) The radius of the fountain's exit hole is 4.00×10^{-3} m . Calculate the volume rate of flow of the water.

A_1V_1 = Volume Rate of flow $\quad A = \pi r^2$

$A = \pi(4\times10^{-3}m)^2$

$(5.0265\times10^{-5}m^2)(2.2383\ m/s)$ = Flow $\quad A = 5.0265\times10^{-5}m^2$

Volume rate of flow = $1.125\times10^{-4}\ m^3/s$

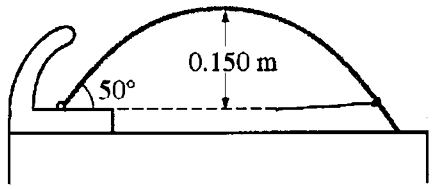
(c) The fountain is fed by a pipe that at one point has a radius of 7.00×10^{-3} m and is 3.00 m below the fountain's opening. The density of water is 1.0×10^3 kg/m^3 . Calculate the gauge pressure in the feeder pipe at this point.

$P = P_0 + \rho g h$

$P = 1atm + (1\times10^3 kg/m^3)(9.8\ m/s^2)(3m)$

$P = 1atm +$

GO ON TO THE NEXT PAGE.



4. (10 points)

A drinking fountain projects water at an initial angle of 50° above the horizontal, and the water reaches a maximum height of 0.150 m above the point of exit. Assume air resistance is negligible.

(a) Calculate the speed at which the water leaves the fountain.

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

$V = \sqrt{2gh}$

$V = \sqrt{2(10)\,0.150} = 1.73\ m/s$

(b) The radius of the fountain's exit hole is 4.00×10^{-3} m. Calculate the volume rate of flow of the water.

$A_1V_1 = A_2V_2$ $\quad A = \pi r^2 \quad A = \pi(4.\times 10^{-3} m)^2 = 5.027 \times 10^{-5}\ m^2$

$5.027 \times 10^{-5}\ m^2 \cdot 1.73\ m/s = 6.89 \times 10^{-5}\ m^3/s$

(c) The fountain is fed by a pipe that at one point has a radius of 7.00×10^{-3} m and is 3.00 m below the fountain's opening. The density of water is $1.0 \times 10^3\ kg/m^3$. Calculate the gauge pressure in the feeder pipe at this point.

$P - P_0 = \rho g h$

$P = \rho g h$

$P = 1 \times 10^3\ kg/m^3 \cdot 10\ m/s^2 \cdot 3\ m = 30{,}000\ N/m$

GO ON TO THE NEXT PAGE.

AP® PHYSICS B
2008 SCORING COMMENTARY

Question 4

Overview

This question tested students' knowledge of projectile motion, fluids, and the application of the Bernoulli equation.

Sample: B4A
Score: 10

Full credit was awarded for the calculations in all three parts.

Sample: B4B
Score: 5

The work in parts (a) and (b) is correct, and full credit was awarded for these parts. No relevant work is performed in part (c), so no points were awarded.

Sample: B4C
Score: 2

The vertical component of the velocity is correctly calculated, earning 1 point in part (a), but no additional work related to finding the total velocity is performed. In part (b) the answer to part (a) is substituted into the correct equation to find the flow rate, so 1 point was earned, but the solution point was lost due to a calculation error. No credit was awarded for part (c), as the full Bernoulli equation is not written out, nor is the continuity equation used.