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 4

10 points total | **Distribution of points**

(a) 3 points

For a correct expression for the volume flow rate I_V — 1 point

$I_V = A\upsilon$

For a correct substitution for area (only if the first point was awarded) — 1 point

$A = \pi r^2$

$I_V = \pi r^2 \upsilon = (3.14)(0.015\ \text{m})^2 (6.0\ \text{m/s})$

For the correct answer — 1 point

$I_V = 4.2 \times 10^{-3}\ \text{m}^3/\text{s}$

(b) 3 points

For a correct application of Bernoulli's equation to point 1 in the feeder pipe below ground and point 2 at the surface where the water emerges — 1 point

$P_1 + \rho g y_1 + \frac{1}{2}\rho \upsilon_1^2 = P_2 + \rho g y_2 + \frac{1}{2}\rho \upsilon_2^2$

$P_1 = P_{abs}$ and $P_2 = P_{atm}$

$P_{abs} = P_{atm} + \rho g (y_2 - y_1) + \frac{1}{2}\rho\left(\upsilon_2^2 - \upsilon_1^2\right)$

For the correct use of the equation of continuity to find υ_1 — 1 point

$A_1 \upsilon_1 = A_2 \upsilon_2$

$\upsilon_1 = \frac{\upsilon_2 A_2}{A_1} = \frac{\upsilon_2 \pi r_2^2}{\pi r_1^2} = \frac{(6.0\ \text{m/s})(0.015\ \text{m})^2}{(0.025\ \text{m})^2} = 2.2\ \text{m/s}$

$\upsilon_2^2 - \upsilon_1^2 = (6.0\ \text{m/s})^2 - (2.2\ \text{m/s})^2 = 31\ \text{m}^2/\text{s}^2$

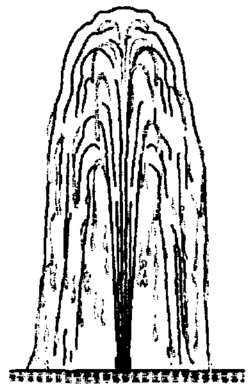
$P_{abs} = 1.0 \times 10^5\ \text{Pa} + \left(10^3\ \text{kg/m}^3\right)\left(9.8\ \text{m/s}^2\right)(2.5\ \text{m}) + \frac{1}{2}\left(10^3\ \text{kg/m}^3\right)\left(31\ \text{m}^2/\text{s}^2\right)$

For the correct answer with units — 1 point

$P_{abs} = 1.4 \times 10^5\ \text{Pa}$

Question 4 (continued)

	Distribution of points
(c) 4 points	
For correct use of kinematics or conservation of energy or Torricelli's theorem to find the exit speed, with correct substitution of values	1 point
$\upsilon_2{}^2 = 2gh$	
$\upsilon_2 = \sqrt{2gh} = \sqrt{2\left(9.8\ \text{m/s}^2\right)(4.0\ \text{m})}$	
For the correct answer for the exit speed	1 point
$\upsilon_2 = 8.9\ \text{m/s}$	
For correct use of the equation of continuity to find r_{new}, with correct substitution of values	1 point
$A\upsilon = A_{\text{new}}\upsilon_{\text{new}}$	
$\pi r^2\upsilon = \pi r_{\text{new}}^2\upsilon_{\text{new}}$	
$r_{\text{new}}^2 = r^2\dfrac{\upsilon}{\upsilon_{\text{new}}} = (0.015\ \text{m})^2\dfrac{(6.0\ \text{m/s})}{(8.9\ \text{m/s})}$	
For the correct answer with units, consistent with the new exit speed found above	1 point
$r_2 = 1.2 \times 10^{-2}\ \text{m}$	



4. (10 points)

A fountain with an opening of radius 0.015 m shoots a stream of water vertically from ground level at 6.0 m/s. The density of water is $1000\ \text{kg/m}^3$.

(a) Calculate the volume rate of flow of water.

$V_{flow} = Av$

$V_{flow} = (\pi(0.015m)^2)(6.0m/s)$

$V_{flow} = 4.2 \times 10^{-3}\ m^3/s$

(b) The fountain is fed by a pipe that at one point has a radius of 0.025 m and is 2.5 m below the fountain's opening. Calculate the absolute pressure in the pipe at this point.

$A_1 v_1 = A_2 V_2$

$4.2 \times 10^{-3} m^3/s = (\pi(0.025m)^2)V_2$

$V_2 = 2.16 m/s$

$P + \rho g y + \frac{1}{2}\rho v^2 = P_2 + \rho g y_2 + \frac{1}{2}\rho v^2$ (with $y_2 = 0$)

$P + (1000 kg/m^3)(9.8 m/s^2)(-2.5m) + \frac{1}{2}(1000 kg/m^3)(2.16m/s)^2 = (1.01 \times 10^5 Pa) + \frac{1}{2}(1000 kg/m^3)(6.0m/s)^2$

$P = 1.4 \times 10^5\ Pa$

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(c) The fountain owner wants to launch the water 4.0 m into the air with the same volume flow rate. A nozzle can be attached to change the size of the opening. Calculate the radius needed on this new nozzle.

$v^2 = v_0^2 + 2ad$

$0 = v_0^2 + 2(-9.81 m/s^2)(4.0 m)$

$v_0 = 8.9 m/s$

$V_{flow} = Av$

$(4.2 \times 10^{-3} m^3/s) = A(8.9 m/s)$

$A = 4.7 \times 10^{-4} m^2$

$A = \pi r^2$

$4.7 \times 10^{-4} m^2 = \pi r^2$

$r = 1.23 \times 10^{-2} m$

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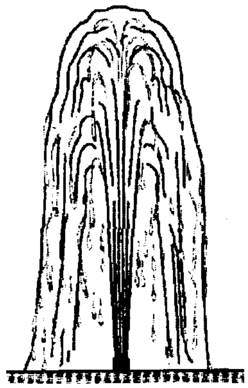

4. (10 points)

A fountain with an opening of radius 0.015 m shoots a stream of water vertically from ground level at 6.0 m/s. The density of water is 1000 kg/m^3.

(a) Calculate the volume rate of flow of water.

Speed × volume = $6\frac{m}{s} \cdot \pi(0.015)^2\ m^2$

$= 0.0042\ m^3/s$

RATE $= 4.24 \times 10^{-3}\ m^3/s$

(b) The fountain is fed by a pipe that at one point has a radius of 0.025 m and is 2.5 m below the fountain's opening. Calculate the absolute pressure in the pipe at this point.

$P = dgh = 1000 \times 10 \times 2.5 = 25000\ pa$ (due to depth)

$P = \frac{F}{A} = \frac{mg}{A} = \frac{dVg}{A} = \frac{d(hA)g}{A} = dgh$

GO ON TO THE NEXT PAGE.

(c) The fountain owner wants to launch the water 4.0 m into the air with the same volume flow rate. A nozzle can be attached to change the size of the opening. Calculate the radius needed on this new nozzle.

$A_1 v_1 = A_2 v_2$

$\pi (0.0015)^2 \cdot 6 = A_2\, 8.85$

$A_2 = 4.79 \times 10^{-6}\ m^2$

$A_2 = \pi r^2 = 4.79 \times 10^{-6}$

$r = 0.0012 m$

$\frac{1}{2} m V^2 = m g h$

$V^2 = 2gh$

$V = \sqrt{2 \times 9.8 \times 4}$

$V = 8.85$

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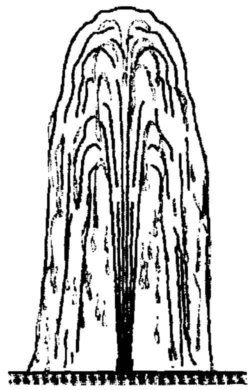

4. (10 points)

A fountain with an opening of radius 0.015 m shoots a stream of water vertically from ground level at 6.0 m/s. The density of water is 1000 kg/m^3.

(a) Calculate the volume rate of flow of water.

$\frac{V}{t} = A \cdot v = \pi r^2 \cdot v = \pi(.015)^2 \cdot 6 = .00135\pi = \boxed{.0042\ m^3/s}$

(b) The fountain is fed by a pipe that at one point has a radius of 0.025 m and is 2.5 m below the fountain's opening. Calculate the absolute pressure in the pipe at this point.

$P = \frac{F}{A} = \frac{mg}{A} = \frac{\pi r^2 \cdot h \cdot d \cdot g}{\pi r^2}$

$= h \cdot d \cdot g = (2.5)(1000)(9.8)$

$P = 24500\ N/m^2$

$= \boxed{24.5\ kN/m^2}$

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B4C

(c) The fountain owner wants to launch the water 4.0 m into the air with the same volume flow rate. A nozzle can be attached to change the size of the opening. Calculate the radius needed on this new nozzle.

$\frac{V}{t} = Av = \pi r^2 \cdot v = (.015)^2 \pi \cdot v$

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Question 4

Sample: B4A
Score: 10

The calculations in all three parts are correct, so full credit was given for each.

Sample: B4B
Score: 7

Part (a) received the full 3 points for a correct solution. Part (b) does not make use of the full Bernoulli's equation, as required by the nature of the problem, nor is the equation of continuity used, so no points were awarded for this part. Part (c) received full credit.

Sample: B4C
Score: 3

Full credit was awarded for part (a). No additional credit was awarded for this problem. Part (b) uses neither the full Bernoulli's equation nor the continuity equation. Part (c) shows no relevant work.