# AP® PHYSICS B (Form B)
# 2007 SCORING GUIDELINES

## General Notes About 2007 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 one 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 and 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

Applying Bernoulli's equation
For example, taking point 1 to be at the top of the liquid and point 2 at the hole

$$P_1 + \rho g y_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g y_2 + \frac{1}{2}\rho v_2^2$$

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

$$v_1 = 0$$

$$\rho g(y_1 - y_2) = \frac{1}{2}\rho v_2^2$$

For a correct expression for the speed — 1 point

$$v_2 = \sqrt{2g(y_1 - y_2)}$$

For correct substitutions — 1 point

$$v_2 = \sqrt{2\left(9.8\ \text{m/s}^2\right)(0.70\ \text{m})}$$

For the correct answer, including units — 1 point

$$v_2 = 3.7\ \text{m/s}$$

(b) 2 points

For any indication that the volume rate of flow is the area multiplied by the speed — 1 point
Define the symbol $\mathcal{V}$ for the volume flow rate.

$$\mathcal{V} = vA$$

For correct substitutions — 1 point

$$\mathcal{V} = (3.7\ \text{m})\pi(0.0010\ \text{m})^2$$

$$\mathcal{V} = 1.2 \times 10^{-5}\ \text{m}^3/\text{s}$$

(c) 2 points

For any indication that the volume is the volume rate multiplied by the time — 1 point

$$V = \mathcal{V}t$$

For correct substitutions — 1 point

$$V = \left(1.2 \times 10^{-5}\ \text{m}^3/\text{s}\right)(2\ \text{min})(60\ \text{s/min})$$

$$V = 1.4 \times 10^{-3}\ \text{m}^3$$

**Question 4 (continued)**

**Distribution of points**

(d) 3 points

For using the kinematic equation for distance as a function of time — 1 point

$y = y_0 + \upsilon_0 t + \frac{1}{2}at^2$

Taking down as the positive direction, and using $a = g$ and $y = h$

$\frac{1}{2}gt^2 + \upsilon_0 t - h = 0$

For solving the equation for *t* using the quadratic formula — 1 point

$t = \dfrac{-\upsilon_0 \pm \sqrt{\upsilon_0{}^2 + 2gh}}{g}$

For correct substitutions — 1 point

Using the + sign to avoid negative time

$t = \dfrac{-3.7\ \text{m/s} + \sqrt{(3.7\ \text{m/s})^2 + 2\left(9.8\ \text{m/s}^2\right)(0.25\ \text{m})}}{9.8\ \text{m/s}^2}$

$t = 0.062\ \text{s}$

*Alternate solution* — *Alternate points*

*For using the kinematic equation relating speed, acceleration, and distance* — *1 point*

$\upsilon^2 = \upsilon_0^2 + 2a(x - x_0)$

*For using the kinematic equation for speed as a function of time* — *1 point*

$\upsilon = \upsilon_0 + at$

$t = \dfrac{\upsilon - \upsilon_0}{a}$

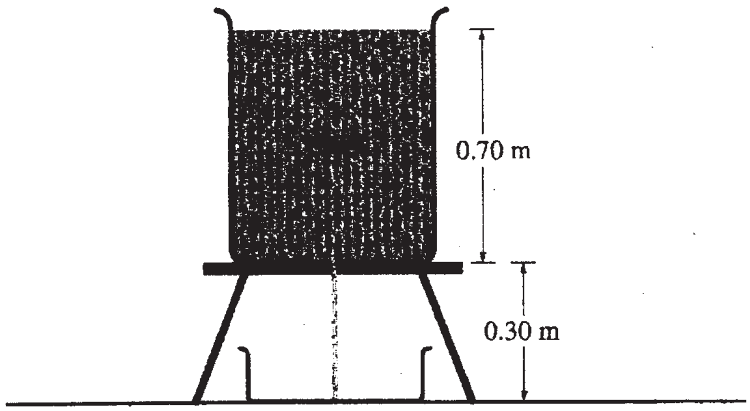
*Substituting for* $\upsilon$ *from the initial equation into the above equation for t*

$t = \dfrac{\sqrt{\upsilon_0^2 + 2a(x - x_0)} - \upsilon_0}{a}$

*For correct substitutions* — *1 point*

$t = \dfrac{\sqrt{(3.7\ \text{m/s})^2 + 2\left(9.8\ \text{m/s}^2\right)(0.25\ \text{m})} - 3.7\ \text{m/s}}{9.8\ \text{m/s}^2}$

$t = 0.062\ \text{s}$




4. (10 points)

A cylindrical tank containing water of density 1000 $kg/m^3$ is filled to a height of 0.70 m and placed on a stand as shown in the cross section above. A hole of radius 0.0010 m in the bottom of the tank is opened. Water then flows through the hole and through an opening in the stand and is collected in a tray 0.30 m below the hole. At the same time, water is added to the tank at an appropriate rate so that the water level in the tank remains constant.

(a) Calculate the speed at which the water flows out from the hole.

$P + \rho g y_1 + \frac{1}{2}\rho v_1^2 = P + \rho g y_2 + \frac{1}{2}\rho v_2^2$

$\rho g y_1 = \rho g y_2 + \frac{1}{2}\rho v_2^2$

$(9.8)(7) = (9.8)(0) + \frac{1}{2}v_2^2$

$v = 11.71$ m/s

(b) Calculate the volume rate at which water flows out from the hole.

$R = A_1 V_1$

$R = (\pi r^2)(v_1)$

$R = (\pi(.001)^2)(11.71)$

$R = 3.68 \times 10^{-5}$ V/s

GO ON TO THE NEXT PAGE.

(c) Calculate the volume of water collected in the tray in $t = 2.0$ minutes.

2 min = 120s

$(120)(3.68\times10^{-5})$

.0044

(d) Calculate the time it takes for a given droplet of water to fall 0.25 m from the hole.

$V_0 = 11.71$
$V = 11.92$
$y_0 = .25$
$y = 0$
$a = -9.8$
$t = ?$

$V^2 = V_0^2 + 2a(y - y_0)$
$V^2 = (11.71)^2 + 2(-9.8)(-.25)$
$V = 11.92$ m/s

$V = V_0 + at$
$11.92 = 11.71 + (-9.8)t$
$t = .021$ s

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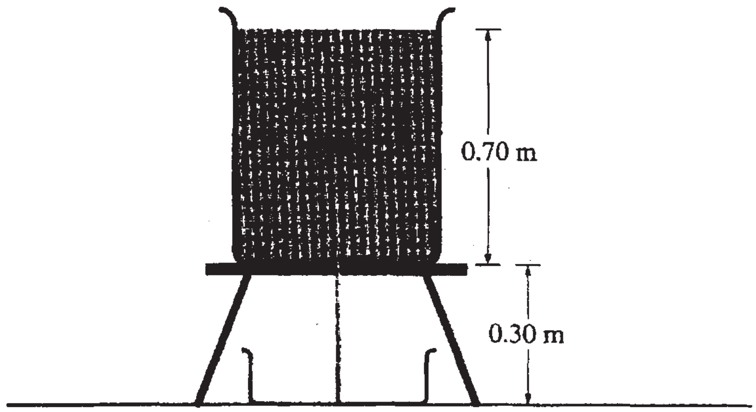



4. (10 points)

A cylindrical tank containing water of density $1000\ \text{kg/m}^3$ is filled to a height of 0.70 m and placed on a stand as shown in the cross section above. A hole of radius 0.0010 m in the bottom of the tank is opened. Water then flows through the hole and through an opening in the stand and is collected in a tray 0.30 m below the hole. At the same time, water is added to the tank at an appropriate rate so that the water level in the tank remains constant.

(a) Calculate the speed at which the water flows out from the hole.

$P = \rho g h$

$V = 5.24\ \text{m/s}$

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

$gh + gy = \frac{1}{2}\rho V^2$

$4gh = V^2$

$2\sqrt{gh} = V$

(b) Calculate the volume rate at which water flows out from the hole.

$\pi r^2 = 0.00314 \times 524$

$= 0.0165\ \text{m}^3/\text{s}$

GO ON TO THE NEXT PAGE.

(c) Calculate the volume of water collected in the tray in $t = 2.0$ minutes.

$0.0165 \times 2 \times 60.$

$= 1.975 \ m^3.$

(d) Calculate the time it takes for a given droplet of water to fall 0.25 m from the hole.

$V^2 = V_0^2 + 2a(D)$

$V^2 = (5.24)^2 + 2 \times 9.81(0.25)$

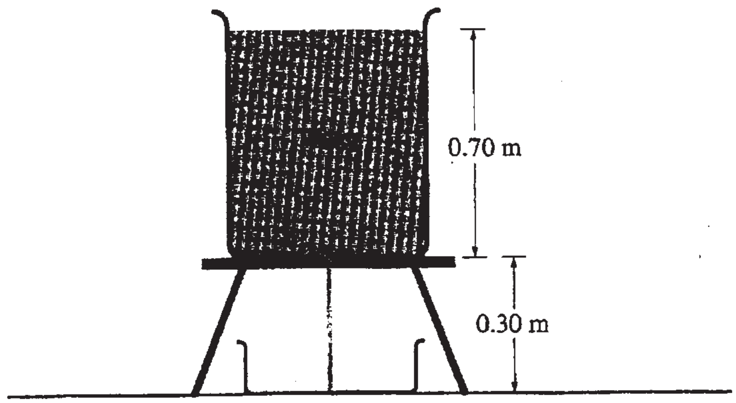
$V^2 = 32.3626.$

$V = 5.689.$

$V = V_0 + a.t$

$5.689 = 5.24 + 9.81t,$

$t = 0.046(5).$

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(a) Calculate the speed at which the water flows out from the hole.

$P_1 + \rho_1 g y_1 + \frac{1}{2}\rho_1 v^2 = P_2 + \rho g y_2 + \frac{1}{2}\rho v^2$

$\rho_1 g y_1 = \rho g y_2 + \frac{1}{2}\rho v^2$

$g y_1 = g y_2 + \frac{1}{2}v^2$

$.7g - .3g = \frac{1}{2}v^2$

$(.4)(9.8) = \frac{1}{2}v^2$

$3.92 = \frac{1}{2}v^2$

$7.84 = v^2$

$2.8\ m/s = v$

(b) Calculate the volume rate at which water flows out from the hole.

$r = 0.0010$

~~$V = \pi r^2$~~

~~$V = \pi (0.001)$~~

~~$V = 2.49 \times 10^{-6}\ m^3$~~

~~$V \cdot v = V_{rate}$~~

$A = \pi r^2$

$A = (\pi)(0.001)^2$

$A = 3.14159 \times 10^{-6}$

$A \cdot v = V_{rate}$

$8.796 \times 10^{-6}\ m^3/s$

GO ON TO THE NEXT PAGE.

(c) Calculate the volume of water collected in the tray in $t = 2.0$ minutes.

$\frac{V_{rate}}{120s} = 1.0556 \times 10^{-3} m^3$

(d) Calculate the time it takes for a given droplet of water to fall 0.25 m from the hole.

$\frac{.25}{2.8 m/s} = 0.0893 sec$

## Question 4

**Sample: B4A**
**Score: 8**

Part (a) received only 1 point for correctly using Bernoulli's equation to derive an expression for speed. The value 7 m was substituted for the height of the water instead of 0.7 m, so the other points were lost. The rest of the work received full credit. Although the units are left off the answer in part (c), the 2 points were awarded for the correct relation and correct substitutions, so no credit was lost.

**Sample: B4B**
**Score: 5**

Although the relationship derived in part (a) is close, it is not correct, so no credit was given. No credit was given for part (b) either; although the student appears to have multiplied the area by the speed, the equation is not correct as written, and the radius appears not to have been squared in the calculation of the area. However, full credit was given to parts (c) and (d); the equations and methods of solution are correct, and the substitutions are consistent with previous incorrect values.

**Sample: B4C**
**Score: 3**

Part (a) received 1 point for a correct expression for the speed. The only other points awarded for this response were the 2 points for part (b), in which the incorrect answer to part (a) is correctly substituted into the correct relationship.