

AP[®] PHYSICS B
2007 SCORING GUIDELINES (Form B)

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

$$P_1 + \rho g y_1 + \frac{1}{2} \rho u_1^2 = P_2 + \rho g y_2 + \frac{1}{2} \rho u_2^2$$

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

$$u_1 = 0$$

$$\rho g (y_1 - y_2) = \frac{1}{2} \rho u_2^2$$

For a correct expression for the speed

$$u_2 = \sqrt{2g(y_1 - y_2)}$$

For correct substitutions

$$u_2 = \sqrt{2(9.8 \text{ m/s}^2)(0.70 \text{ m})}$$

For the correct answer, including units

$$u_2 = 3.7 \text{ m/s}$$

1 point

1 point

1 point

(b) 2 points

For any indication that the volume rate of flow is the area multiplied by the speed

Define the symbol V for the volume flow rate.

$$V = uA$$

For correct substitutions

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

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

1 point

1 point

(c) 2 points

For any indication that the volume is the volume rate multiplied by the time

$$V = Vt$$

For correct substitutions

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

$$V = 1.44 \times 10^{-3} \text{ m}^3$$

1 point

1 point

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Question 4 (continued)

		Distribution of points
(d)	3 points	
	For using the kinematic equation for distance as a function of time	1 point
	$y = y_0 + u_0t + \frac{1}{2}at^2$	
	Taking down as the positive direction, and using $a = g$ and $y = h$	
	$\frac{1}{2}gt^2 + u_0t - h = 0$	
	For solving the equation for t using the quadratic formula	1 point
	$t = \frac{-u_0 \pm \sqrt{u_0^2 + 2gh}}{g}$	
	For correct substitutions	1 point
	Using the + sign to avoid negative time	
	$t = \frac{-3.7 \text{ m/s} + \sqrt{(3.7 \text{ m/s})^2 + 2(9.8 \text{ m/s}^2)(0.25 \text{ m})}}{9.8 \text{ m/s}^2}$	
	$t = 0.062 \text{ s}$	
	<i>Alternate solution</i>	<i>Alternate points</i>
	<i>For using the kinematic equation relating speed, acceleration, and distance</i>	<i>1 point</i>
	$u^2 = u_0^2 + 2a(x - x_0)$	
	<i>For using the kinematic equation for speed as a function of time</i>	<i>1 point</i>
	$u = u_0 + at$	
	$t = \frac{u - u_0}{a}$	
	<i>Substituting for u from the initial equation into the above equation for t</i>	
	$t = \frac{\sqrt{u_0^2 + 2a(x - x_0)} - u_0}{a}$	
	<i>For correct substitutions</i>	<i>1 point</i>
	$t = \frac{\sqrt{(3.7 \text{ m/s})^2 + 2(9.8 \text{ m/s}^2)(0.25 \text{ m})} - 3.7 \text{ m/s}}{9.8 \text{ m/s}^2}$	
	$t = 0.062 \text{ s}$	