Question 3

15 points total   **Distribution of points**

(a)   3 points

        For a meaningful use of the correct expression for flow rate, Au (e.g., an attempt to   1 point
            substitute for volume and speed)
        For relating the flow rates at points A and B 1 point

$$A_A u_A = A_B u_B$$

$$u_A = A_B u_B / A_A = 0.50 \times 10^{-4} \text{ m}^2) \, 8.2 \text{ m/s}) / 1.0 \times 10^{-4} \text{ m}^2)$$

        For the correct answer   1 point

$$u_A = 4.1 \text{ m/s}$$

(b)   5 points

        For applying Bernoulli's equation to this situation   1 point

$$P_A + rgy_A + \frac{1}{2} ru_A^2 = P_B + rgy_B + \frac{1}{2} ru_B^2$$

$$P_A = P_B + rg(y_B - y_A) + \frac{1}{2} r\left(u_B^2 - u_A^2\right)$$

        For using atmospheric pressure $1.0 \times 10^5 \text{ Pa}$) for the pressure at point B 1 point

        For correctly substituting values for y_A and y_B 1 point
        For correctly substituting values for u_A and u_B consistent with the work in part (a)   1 point

$$P_A = \left(1.0 \times 10^5 \text{ Pa} + \left(1000 \text{ kg/m}^3 \left(9.8 \text{ m/s}^2\right) \, 0.50 \text{ m} - 0\right)\right.$$

$$+ \frac{1}{2}\left(1000 \text{ kg/m}^3\right)\left([8.2 \text{ m/s}]^2 - [4.1 \text{ m/s}]^2\right)$$

        For correct units for the answer   1 point

$$P_A = 1.3 \times 10^5 \text{ N/m}^2 \text{ (or Pa)}$$

(c)   2 points

        For correctly relating the initial speed and the maximum height   1 point

$$u^2 = u_0{}^2 + 2a(x - x_0) \quad \text{OR} \quad \frac{1}{2} mu^2 \quad mgh$$

$$u_B^2 = 2gh$$

$$h = u_B^2 / 2g = (8.2 \text{ m/s})^2 / 2 \, 9.8 \text{ m/s}^2)$$

        For the correct answer with correct units   1 point
        $h \quad 3.4 \text{ m}$

<div align="right">**Distribution of points**</div>

(d)   5 points

> For correctly analyzing the vertical motion with constant acceleration, to find the time   1 point
>   for the water to reach maximum height

$u = u_0 + at$

$0 = u_{By} + gt$

$u_{By} \quad gt$

For the correct vertical component of speed   1 point

$u_{By} = u_B \sin q$

$t = u_{By}/g = u_B \sin q/g$

For correctly analyzing the horizontal motion with constant speed   1 point

$x = u_{Bx} \, 2t)$

For the correct horizontal component of speed   1 point

$u_{Bx} = u_B \cos q$

$x = u_B \cos q(2u_B \sin q/g) = 2u_B^2 \cos q \sin q/g$

$x = 2(8.2 \text{ m/s})^2 \cos 60° \sin 60° / 9.8 \text{ m/s}^2)$

For the correct answer with units   1 point

$x \quad 5.9 \text{ m} \ (\text{or } 5.8 \text{ m using } g - 10 \text{ m/s}^2)$