37.47 Waste water flows to a common drain from 3 upstream sources. The pipes have inside diameters of $1in$, $2in$, and $3in$. The velocity in each upstream pipe is $3\frac{ft}{s}$. If the main drain downstream is sized such that the velocity in is not to exceed $2\frac{ft}{s}$, what is the minimum diameter?

A. $3in$

B. $4in$

C. $5in$

D. $6in$

Calculate the volume flow rate through the drain by finding the sum of the volume flow rate from each of the 3 sources. Use the relation that volume flow rate is the product of velocity and area for each source. Area is a function of the inside diameter. Label the sources as 1, 2, and 3, and the drain as 4.

$$Q_4 = Q_1 + Q_2 + Q_3$$

$$Q_4 = V_1 A_1 + V_2 A_2 + V_3 A_3$$

Substitute known velocities and diameters. Convert in to ft.

$$Q_4 = \left(3\frac{ft}{s}\right)\left(\frac{\pi}{4}\right)\left(\frac{1in}{\left(\frac{12in}{ft}\right)}\right)^2 + \left(3\frac{ft}{s}\right)\left(\frac{\pi}{4}\right)\left(\frac{2in}{\left(\frac{12in}{ft}\right)}\right)^2 + \left(3\frac{ft}{s}\right)\left(\frac{\pi}{4}\right)\left(\frac{3in}{\left(\frac{12in}{ft}\right)}\right)^2 = 0.229\frac{ft^3}{s}$$

Solve for the area of the drain.

$$Q_4 = V_4 A_4$$

$$A_4 = \frac{Q_4}{V_4} = \frac{0.229\frac{ft^3}{s}}{2\frac{ft}{s}} = 0.1145 ft^2$$

Calculate the diameter of the drain. Convert to in.

$$A_4 = \frac{\pi}{4} D_4^2$$

$$D_4 = \sqrt{\frac{4}{\pi} A_4} = 0.38ft\left(\frac{12in}{ft}\right) = 4.6in$$

Answer C