

33.3 A residential gutter with a rectangular cross section transports 2gpm during peak rainfall. The channel is 6 inches wide and is pitched such that the height of the flowing water is 2 inches. Assuming 60°F rainwater, what is the friction factor for the gutter?

- A. 0.01
- B. 0.02
- C. 0.04
- D. 0.08

Often times when asked to find the friction factor is it appropriate to use the Darcy Equation, which is fairly accurate over a wide range of turbulent and laminar flow situations. However, if the flow is determined to be laminar, it may be more convenient to use the equation where f is specified directly as a function of the Reynolds number. This formula is shown on the **Moody Diagram** as $f = \frac{64}{Re}$ where $Re < 2000$.

For open channel flow, find the **Hydraulic Diameter**, using the formula.

$$D_h = \frac{4A}{P_{wetted}} = \frac{(4)(6in)(2in)}{[(2)(2in) + 6in]} = \frac{48in^2}{10in} = 4.8in \left(\frac{1ft}{12in} \right) = 0.4ft$$

Find the velocity of the water flow by using the volume flow rate and the cross-sectional area of the flow.

$$Q = vA \rightarrow v = \frac{Q}{A} = \frac{\left(2 \frac{gallons}{min}\right) \left(\frac{1min}{60sec}\right) \left(\frac{1ft^3}{7.48gallons}\right)}{[(6in)(2in)] \left(\frac{1ft^2}{144in^2}\right)} = 0.0535 \frac{ft}{sec}$$

Lookup the kinematic viscosity @60°F by searching **Properties of Water**.

$$\nu = 1.217 \times 10^{-5} \frac{ft^2}{sec}$$

Calculate the **Reynolds Number** and conclude the flow is laminar.

$$Re = \frac{vD}{\nu} = \frac{\left(0.0535 \frac{ft}{sec}\right) (0.4ft)}{\left(1.217 \times 10^{-5} \frac{ft^2}{sec}\right)} = 1758 < 2000 \text{ (laminar)}$$

Calculate the friction factor for laminar flow.

$$f = \frac{64}{Re} = \frac{64}{1758} = 0.036$$

Answer C