40.5 A pump designed to operate at $100gpm$ and $50ft$ of head is determined to be oversized. The pump's impeller diameter is decreased by 20%. What is the resulting pressure developed by the pump after this change?

A. $26ft$

B. $32ft$

C. $40ft$

D. $50ft$

Lookup Pump Affinity Laws in the reference handbook and choose the formula where head pressure changes as a function of Impeller Diameter Change:

$$\frac{h_2}{h_1} = \left(\frac{D_2}{D_1}\right)^2 \to h_2 = h_1 \left(\frac{D_2}{D_1}\right)^2$$

where h_1, the head pressure provided by the pump before the impeller diameter change, is known, and h_2 is to be determined. The actual diameter is unknown, but the 20% reduction implies the ratio of the diameters as such:

$$D_2 = (1 - .2)\, D_1 \to \frac{D_2}{D_1} = .8$$

The volume flow rate, Q, will also change; however, that is extra information and does not impact the pressure.

Substitute and solve for h_2:

$$h_2 = h_1 \left(\frac{D_2}{D_1}\right)^2 = (50ft)\,(.8)^2 = 32ft$$

Answer B

40.6 A residential gutter with a rectangular cross section transports $2gpm$ during peak rainfall. The channel is $6in$ wide and is pitched such that the height of the flowing water is $2in$. 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: $f = \frac{64}{Re}$ where $Re < 2000$.

For open channel flow, find the hydraulic diameter via the formula below. Note the use of the hydraulic diameter and not the equivalent diameter which is reserved for closed rectangular ducts.

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

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

$$Q = vA \rightarrow v = \frac{Q}{A} = \frac{\left(2\frac{gallons}{min}\right)\left(\frac{1min}{60sec}\right)\left(\frac{1ft^3}{7.48gallons}\right)}{[(6in)(2in)]\left(\frac{1ft^2}{144in^2}\right)} = .0535\frac{ft}{sec}$$

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.

$$Re = \frac{vD}{\nu} = \frac{\left(.0535\frac{ft}{sec}\right)(.4ft)}{\left(1.217 \times 10^{-5}\frac{ft^2}{sec}\right)} = 1758 < 2000\,(laminar)$$

Calculate the friction factor for laminar flow:

$$f = \frac{64}{Re} = \frac{64}{1758} = .036$$

Answer C