33.38 **$60°F$ water flows horizontally in a $1in$ pipe, then branches into (2) $\frac{3}{4}in$ pipes, one which continues horizontally and one which turns up at a 45 degree angle. The velocity in each branch after splitting is $8\frac{ft}{s}$. All piping is standard weight steel. What is the vertical force required to secure the pipe assembly at the location of the branch?**

A. $0.04lb_f$

B. $0.2lb_f$

C. $1.3lb_f$

D. $7.4lb_f$

Only the Propulsive Force of the branch that turns up on a 45 degree angle produces force in verticle direction. Horizontal support will also be required, but is not the concern of this problem. The formula for the force of a stream of an incompressible fluid is given below for SI units.

$$F = Q\rho v$$

For US customary units, g_c must be included in the denominator to make the units work. If the problem was stated in SI units the formula above would be valid.

$$F = \frac{Q\rho v}{g_c}$$

Using Trigonometry, find the vertical component of the velocity of the 45 degree branch.

$$v_y = v \cdot sin\,(45) = \left(8\frac{ft}{s}\right) sin\,(45) = 5.66\frac{ft}{s}$$

Use the Schedule 40 Steel Pipe table to look up the internal area of the $\frac{3}{4}in$ pipe.

$$A = 0.533in^2$$

In the force equation, substitute for Q since velocity and area are known, and solve for F.

$$Q = vA$$

$$F = \frac{\rho v^2 A}{g_c}$$

$$F = \frac{\left(62.4\frac{lb_m}{ft^3}\right)\left(5.66\frac{ft}{s}\right)^2 (0.533in^2)\left(\frac{1ft^2}{144in^2}\right)}{32.2\frac{lb_m \cdot ft}{lb_f \cdot s^2}} = 0.23lb_f$$

Answer B