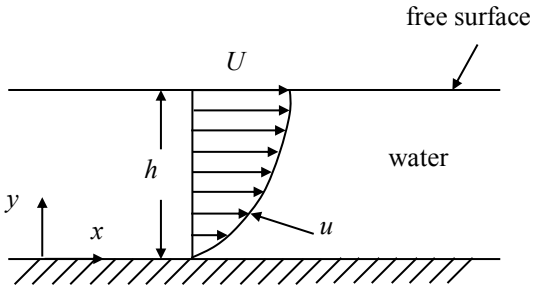
Determine the magnitude and direction of the shear stress that the water applies:

a. to the base

b. to the free surface




$$\frac{u}{U} = 2\left(\frac{y}{h}\right) - \left(\frac{y}{h}\right)$$

SOLUTION:

The shear stress, $\tau_{yx}$, acting on a Newtonian fluid is given by:

$$\tau_{yx} = \mu \frac{du}{dy} \tag{1}$$

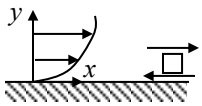
where

$$\frac{du}{dy} = U\left(2\frac{1}{h} - \frac{2y}{h^2}\right) \tag{2}$$

Evaluating the shear stress at the base and free surface gives:

base ($y = 0$): $\boxed{\tau_{yx}\Big|_{y=0} = \frac{2\mu U}{h}}$ (3)

This is the stress the wall exerts on the fluid. The fluid will exert an equal but opposite stress on the wall.




fluid element adjacent to the wall with positive $\tau_{yx}$ shown

free surface ($y = h$): $\boxed{\tau_{yx}\Big|_{y=h} = 0}$ (4)

The air at the free surface does not exert a stress on the water. Although in reality the air will exert a small shear stress on the water, assuming that the shear stress is negligible is reasonable in most engineering applications.