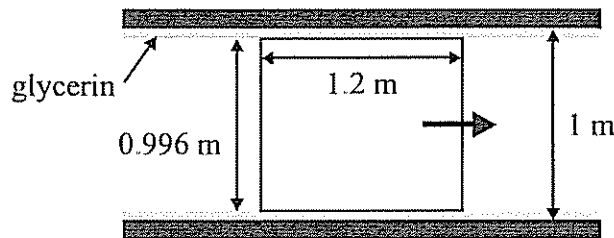
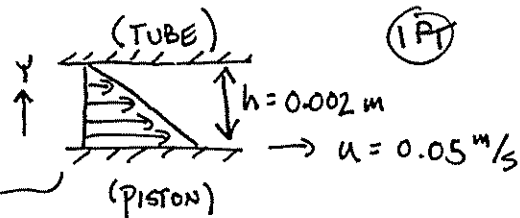


10 pts. Closed book.

Suppose you have a very long, hollow circular tube, with inner diameter 1 m. A solid cylindrical piston, with outer diameter 0.996 m and length 1.2 m, is centered in the tube. The gap between the piston and tube wall is filled with a layer of glycerin (dynamic viscosity  $1.0 \text{ N}\cdot\text{s}/\text{m}^2$ ) with constant thickness. What force would you need to apply to the piston to get it to slide in the tube at  $5 \text{ cm/s}$ ?



• GAP BETWEEN PISTON AND TUBE:



INTERFACE AREA

$$= 1.2 \text{ m} \cdot \pi \cdot 1 \text{ m}$$

$$= 3.77 \text{ m}^2$$

(COULD USE 0.996 m TOO)

(3)

$$\tau = \mu \cdot \left| \frac{du}{dy} \right| = 1.0 \frac{\text{N}\cdot\text{s}}{\text{m}^2} \cdot \frac{0.05 \text{ m/s}}{0.002 \text{ m}} = 25 \frac{\text{N}}{\text{m}^2}$$

(WORRY ABOUT DIRECTION LATER)

(2)

••  $F = \tau \cdot A = 25 \frac{\text{N}}{\text{m}^2} \cdot 3.77 \text{ m}^2 = \boxed{94.3 \text{ N}}$  (TO THE RIGHT AS DRAWN)

(3)