1.63

1.63 A 25-mm-diameter shaft is pulled through a cylindrical bearing as shown in Fig. P1.63 The lubricant that fills the 0.3-mm gap between the shaft and bearing is an oil having a kinematic viscosity of 8.0×10^{-4} m²/s and a specific gravity of 0.91. Determine the force P required to pull the shaft at a velocity of 3 m/s. Assume the velocity distribution in the gap is linear.

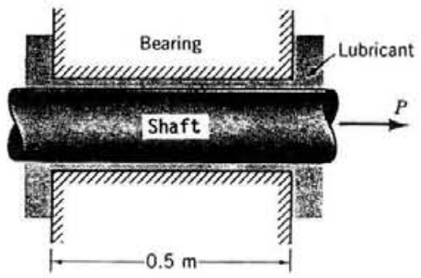
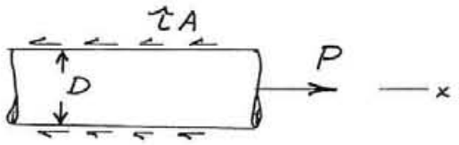


FIGURE P1.63



$\Sigma F_x = 0$

Thus, $P = \tau A$

where $A = \pi D \times (\text{shaft length in bearing}) = \pi D \ell$

and $\tau = \mu \dfrac{(\text{velocity of shaft})}{(\text{gap width})} = \mu \dfrac{V}{b}$

so that

$$P = \left(\mu \frac{V}{b}\right)(\pi D \ell)$$

Since $\mu = \nu\rho = \nu\,(SG)(\rho_{H_2O\,@\,4^\circ C})$,

$$P = \frac{\left(8.0\times10^{-4}\,\frac{m^2}{s}\right)\left(0.91\times10^{3}\,\frac{kg}{m^3}\right)\left(3\,\frac{m}{s}\right)(\pi)(0.025m)(0.5m)}{(0.0003m)}$$

$$= \underline{\underline{286\ N}}$$