FLUID PROPERTIES

3. Variation of viscosity with temperature for liquids

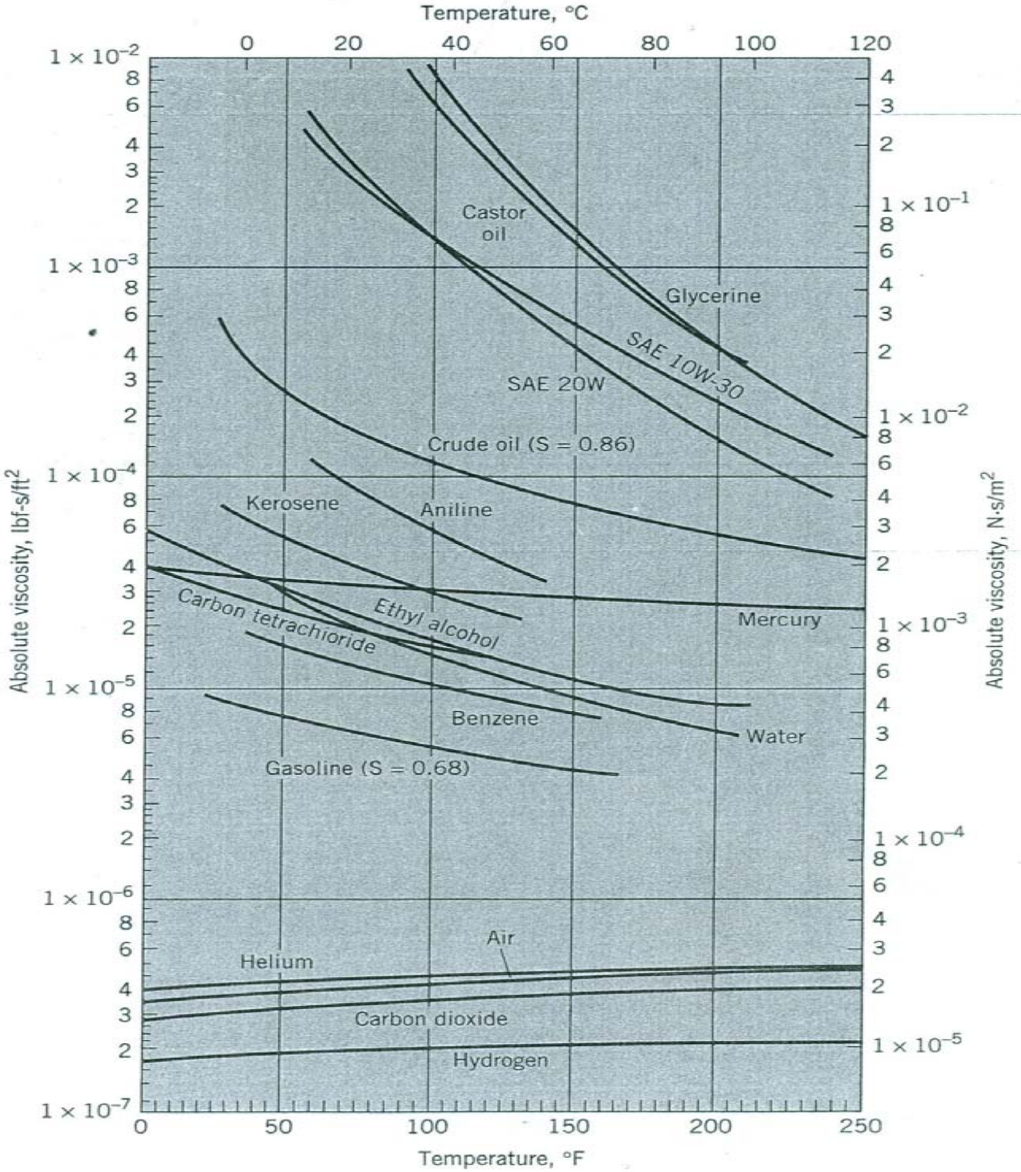
$$\mu = Ce^{b/T}$$

The variation of ***Dynamic Viscosity*** for fluids with temperature is given in **(Fig. A.2)** in the Appendix of the text book.

Figure (A-2) on Page (A-9)

FIGURE A.2

Absolute viscosities of certain gases and liquids [Adapted from Fluid Mechanics, *5th ed., by V. L. Streeter. Copyright © 1971, McGraw-Hill Book Company, New York. Used with permission of the McGraw-Hill Book Company.]*



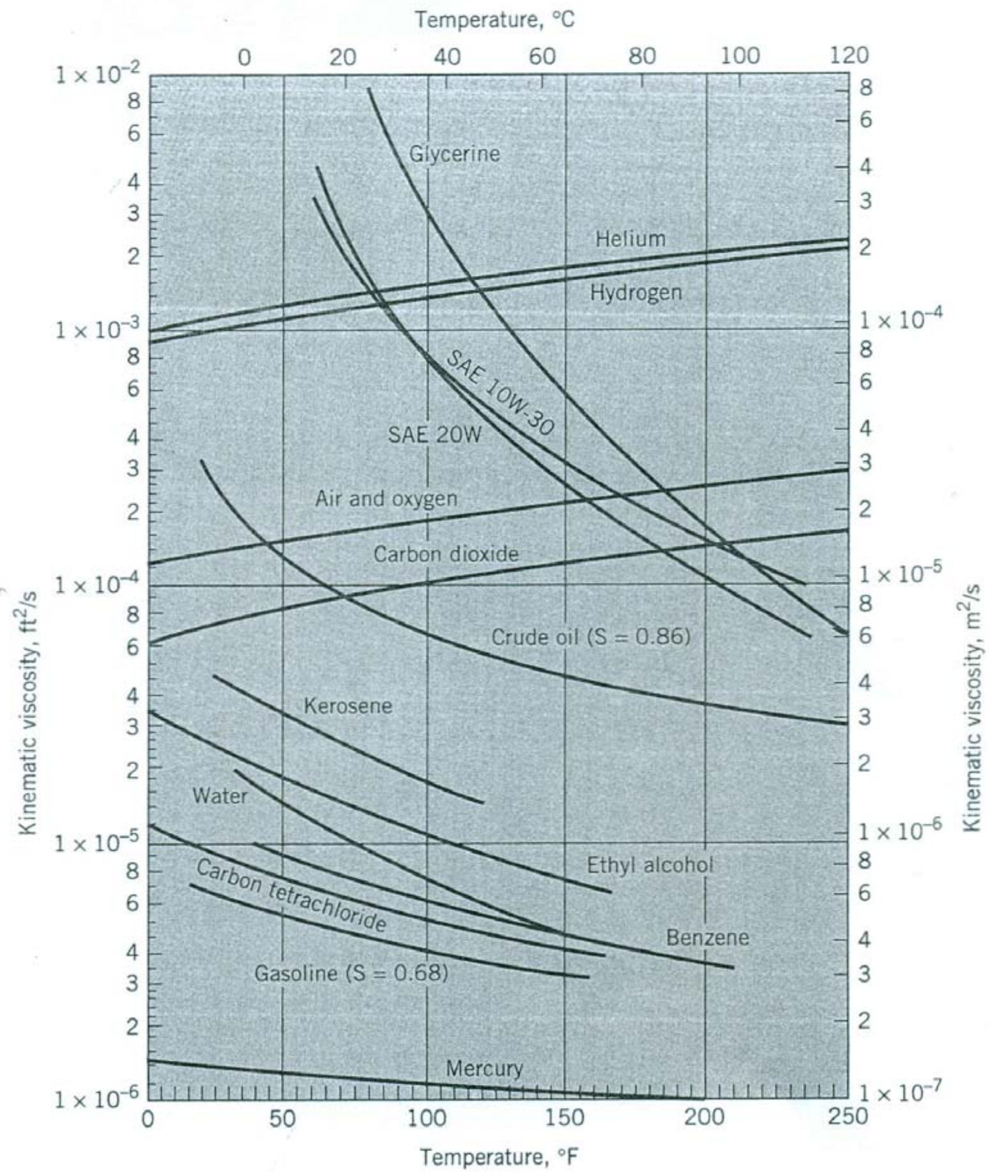
FLUID PROPERTIES

The variation of *Kinematic Viscosity* for fluids with temperature is given in (Fig. A.3) in the Appendix of the text book.

Figure (A-3) on Page (A-10)

FIGURE A.3

Kinematic viscosities of certain gases and liquids. The gases are at standard pressure. [Adapted from Fluid Mechanics, *5th ed., by V. L. Streeter. Copyright © 1971, McGraw-Hill Book Company, New York. Used with permission of the McGraw-Hill Book Company.]*



Example (2-3)

The dynamic viscosity of water at 20°C is 1.00×10^{-3} N · s/m^2, and the viscosity at 40°C is 6.53×10^{-4} N · s/m^2. Using Eq. (2.8), estimate the viscosity at 30°C.

Solution Taking the logarithm of Eq. (2.8) gives

$$\mu = Ce^{b/T}$$

$$\ln \mu = \ln C + b/T$$

Substituting in the data for μ and T at the two data points, we get

$$-6.908 = \ln C + 0.00341 b$$

$$-7.334 = \ln C + 0.00319 b$$

Solving for $\ln C$ and b gives

$$\ln C = -13.51 \qquad b = 1936 \text{ (K)}$$

Substituting back into Eq. (2.8) results in

$$\mu = 1.357 \times 10^{-6} e^{1936/T}$$

Evaluating for the viscosity at 30°C gives

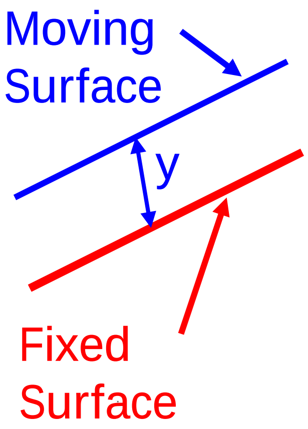
$$\mu = 8.08 \times 10^{-4} \text{ N} \cdot \text{s/m}^2 \qquad \triangleleft$$

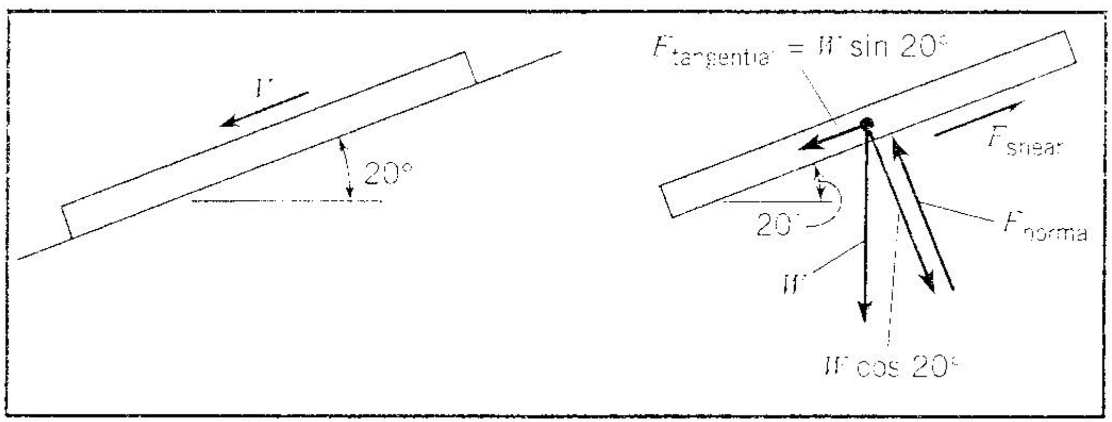
This value differs by 1% from the reported value but provides a much better estimate than would be obtained using a linear interpolation.

Example (2-4)

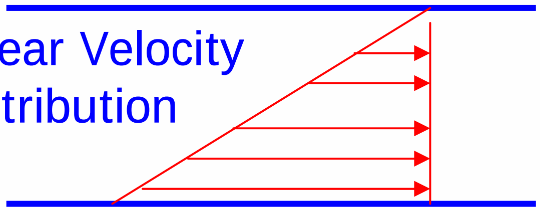
A board 1 m by 1 m that weighs 25 N slides down an inclined ramp (slope = 20°) with a velocity of 2.0 cm/s. The board is separated from the ramp by a thin film of oil with a viscosity of 0.05 $N \cdot s/m^2$. Neglecting edge effects, calculate the spacing between the board and the ramp.

Solution The board and ramp (left) and a free body of the board (right) are shown below. For a constant sliding velocity, the resisting shear force is equal to the component of weight parallel to the inclined ramp. Therefore,





Example (2-4)



$$F_{\text{tangential}} = F_{\text{shear}}$$

$$W\sin 20° = \tau A$$

$$W\sin 20° = \mu \frac{dV}{dy} A$$

In this case we can assume a linear velocity distribution in the oil, so dV/dy can be expressed as $\Delta V/\Delta y$, where ΔV is the velocity of the board and Δy is the spacing between the board and the ramp. We then have

$$W\sin 20° = \mu \frac{\Delta V}{\Delta y} A$$

or

$$\Delta y = \frac{\mu \Delta V A}{W\sin 20°}$$

$$= \frac{0.05\ \text{N} \cdot \text{s/m}^2 \times 0.020\ \text{m/s} \times 1\ \text{m}^2}{25\ \text{N} \times \sin 20°}$$

$$= 0.000117\ \text{m}$$

$$= 0.117\ \text{mm}$$ ◁

FLUID PROPERTIES

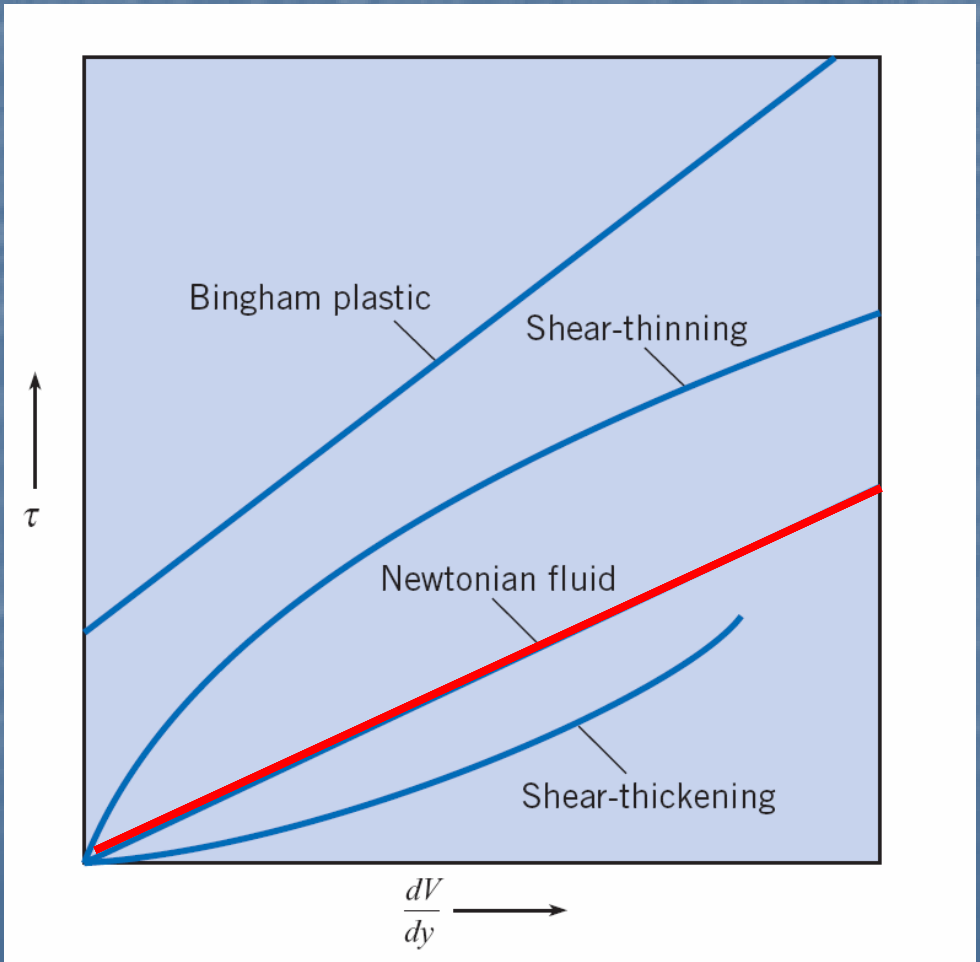
Newtonian and Non-Newtonian Fluids

Newtonian fluids are identified

when only $\tau \ \alpha \left(\frac{dV}{dy} \right)$

- Shear Thinning: (paints, printer ink)

- Shear thickening: (gypsum-water mixture)



END of

Lecture (4)