Chapter 2

2.1 40°API oil $\quad$ $\text{sp. gr.} = \dfrac{141.5}{131.5 + °\text{API}} = \dfrac{141.5}{131.5 + 40}$

$$\boxed{\text{sp. gr.} = \frac{141.5}{171.5} = 0.825}$$

2.2 sp. gr. = 0.826; $\boxed{\rho = 1000(0.826) = 826\ \text{kg/m}^3}$

$$\boxed{\rho = 62.4(0.826) = 51.54\ \text{lbm/ft}^3}$$

$$\text{sp. gr.} = \frac{141.5}{131.5 + °\text{API}} \qquad 131.5 + °\text{API} = \frac{141.5}{0.826}$$

°API = 171.3 - 131.5; $\boxed{°\text{API} = 39.8°\text{API} \approx 40°\text{API}}$

2.3 $\text{sp. gr.} = \dfrac{141.5}{131.5 + °\text{API}} = \dfrac{141.5}{131.5 + 50} = 0.7796$ for a 50° oil

$\text{sp. gr.} = \dfrac{141.5}{131.5 + °\text{API}} = \dfrac{141.5}{131.5 + 40} = 0.826$ for a 40° oil

0.825 – 0.7796 = 0.0455 density difference

2.4 40°API oil $\quad$ $\text{sp. gr.} = \dfrac{141.5}{131.5 + °\text{API}} = \dfrac{141.5}{131.5 + 40} = 0.825$

$\mu = 0.743\ \text{N·s/m}^2 \qquad \nu = \dfrac{\mu g_c}{\rho} = \dfrac{0.743}{0.825(1000)} = 9 \times 10^{-4}$

Highly viscous; try

$\nu = 0.2158 \times 10^{-6}(\text{SUS})$ if SUS > 215

$$\text{SUS} = \frac{9 \times 10^{-4}}{0.2158 \times 10^{-6}} = \boxed{4171\ \text{SUS}}$$

2.5 Air at 27°C = 300 K has $\rho = 1.177\ \text{kg/m}^3$
CO_2 at 27°C = 300 K has $\rho = 1.797\ \text{kg/m}^3$
For a volume of 1.2 m^3, the weight of air is
$(1.177\ \text{kg/m}^3)(1.2\ \text{m}^3)(9.81\ \text{m/s}^2) = 13.86\ \text{N}$
For CO_2
$(1.797\ \text{kg/m}^3)(1.2\ \text{m}^3)(9.81\ \text{m/s}^2) = 21.15\ \text{N}$
Weight difference is 21.15 – 13.86 = $\boxed{7.29\ \text{N}}$

2.6 Castor Oil $\rho = 0.96(1000)\ \text{kg/m}^3$

$$\frac{\text{buoyant force}}{\text{volume}} = \frac{mg_{\text{in air}} - mg_{\text{submerged}}}{\not{V} g_c} = \frac{\rho g}{g_c}$$

$$\rho = \frac{10-7}{(0.03)^3}\frac{1}{9.81} = \boxed{11\,330\ \text{kg/m}^3}$$

2.7 Buoyant force = $mg_{\text{in air}} - mg_{\text{submerged}} = mg - 0.8$ $\quad g_c = 1$ in this system

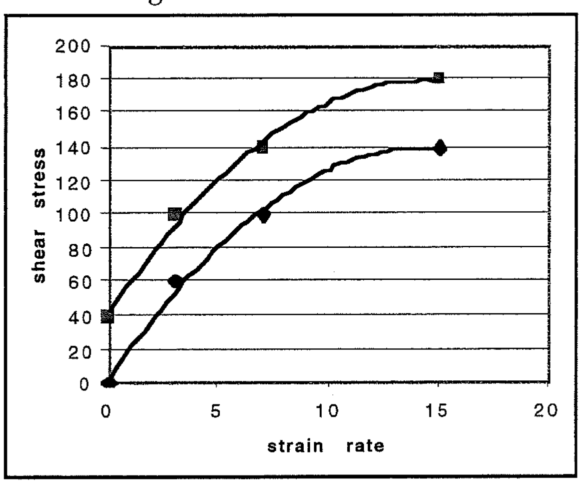
$$\frac{\text{buoyant force}}{\text{volume}} = \frac{mg - 0.8}{\not{V}} = \rho g \qquad \not{V} = \frac{\pi D^2}{4}h = \frac{\pi}{4}(1/12)^2(4/12) = 1.818 \times 10^{-3}\ \text{ft}^3$$

$$mg = \rho_b \not{V} g = 8.5(1.94)(1.818 \times 10^{-3})(32.2) = 0.965\ \text{lbf}$$

$$\rho = \frac{mg - 0.8}{g\not{V}} = \frac{0.965 - 0.8}{32.2(1.818 \times 10^{-3})}$$

$$\boxed{\rho = 2.82\ \text{slug/ft}^3}$$

2.8 The topmost line is the given data, but to curve fit, we subtract 40 from all shear stress readings.



$$\tau = \tau_o + K\left(\frac{dV}{dy}\right)^n \qquad \text{which becomes } \tau' = \tau - \tau_o = K\left(\frac{dV}{dy}\right)^n$$

Can be done instantly with spreadsheet; hand calculations:

dV/dy	ln(dV/dy)	τ	τ'	ln τ'	ln(τ')·ln(dV/dy)
0	—	40	0	—	—
3	1.099	100	60	4.094	4.499
7	1.946	140	100	4.605	8.961
15	2.708	180	140	4.942	13.38
Sum	5.753			13.64	26.84

m = 3 Summation $(\ln(dV/dy))^2 = 12.33$

$$b_1 = \frac{3(26.84) - 5.753(13.64)}{3(12.33) - 5.753^2} = 0.526$$

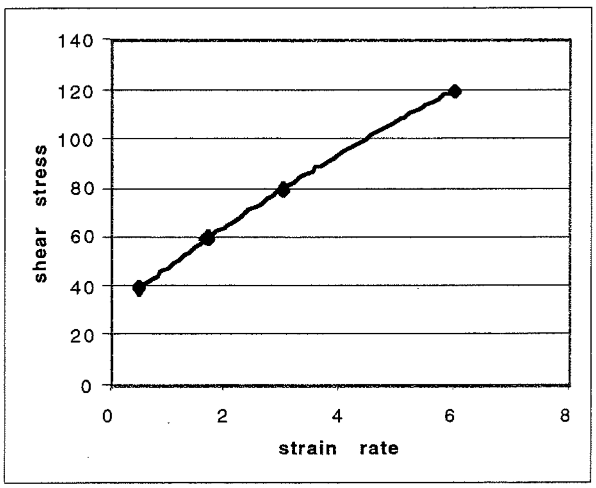
$$b_0 = \frac{13.64}{3} - 0.526\frac{5.753}{3} = 3.537$$

$K = \exp(b_0) = 34.37$; $n = b_1 = 0.526$

$$\tau = \tau_o + K\left(\frac{dV}{dy}\right)^n = 40 + 34.37\left(\frac{dV}{dy}\right)^{0.526}$$

where dV/dy is in rev/s and τ in g/cm^2; these are not standard units.

2.9 Cod liver oil; graph excludes the first data point.



$$\tau = K\left(\frac{dV}{dy}\right)^n$$

Can be done instantly with spreadsheet; hand calculations:

dV/dy	ln(dV/dy)	τ	ln τ	$\ln(\tau)\cdot\ln(dV/dy)$
0.5	-0.6931	40	3.689	-2.557
1.7	0.5306	60	4.094	2.172
3	1.099	80	4.382	4.816
6	1.792	120	4.787	8.578
Sum	2.729		16.95	13.01

m = 4 Summation $(\ln(dV/dy))^2 = 5.181$

$$b_1 = \frac{4(13.01) - 2.729(16.95)}{4(5.181) - 2.729^2} = 0.4356$$

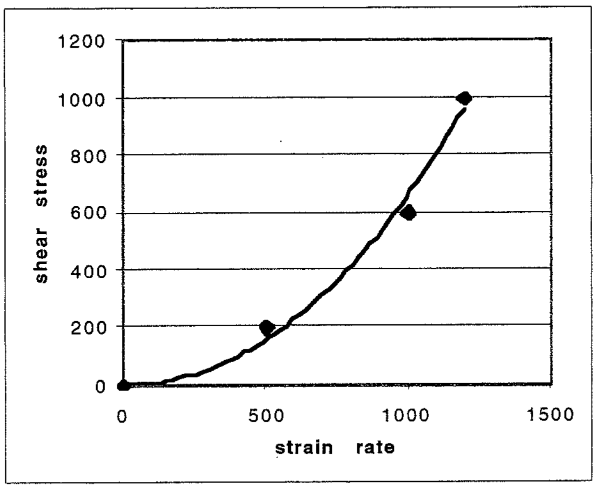
$$b_0 = \frac{16.95}{4} - 0.4356\frac{2.729}{4} = 3.537$$

$K = \exp(b_0) = 51.43;$ $n = b_1 = 0.4356$

$$\tau = \tau_o + K\left(\frac{dV}{dy}\right)^n = 51.43\left(\frac{dV}{dy}\right)^{0.4356}$$

where dV/dy is in rev/s and τ in lbf/ft^2; these are not standard units.

2.10 Vaseline



$$\tau = K\left(\frac{dV}{dy}\right)^n$$

Can be done instantly with spreadsheet; hand calculations:

dV/dy	ln(dV/dy)	τ	ln τ	ln(τ)·ln(dV/dy)
0	—	0	—	·
500	6.215	200	5.298	32.93
1000	6.908	600	6.397	44.19
1200	7.090	1000	6.908	48.98
Sum	20.21		18.60	126.1