CHAPTER 1

1.1 a) 3 teaspoons in 1 tablespoon
b) 236.5 ml in 1 cup

1.2 m = 6 slugs, g = 32.0 ft/s², W = mg = 6(32) = **192 lbf**

$m = 6$ slugs, $g = 32.0\ ft/s^2$, $W = mg = 6(32) = \boxed{192\ lbf}$

1.3 $m = 46$ kg, $W = 450$ N, $g = \frac{W}{m} = \frac{450}{46} = \boxed{9.78\ m/s^2}$

1.4
$128\ fl\ oz \cdot 2.957 \times 10^{-5} = 3.78 \times 10^{-3}\ m^3$
$3.78\ l \cdot 1 \times 10^{-3} = 3.78 \times 10^{-3}\ m^3$
$1\ gallon \cdot 3.785 \times 10^{-3} = 3.78 \times 10^{-3}\ m^3$ all equivalent

$\frac{m}{V\!\!\!-} = \rho;\ m = \rho V\!\!\!- = 1\,030(3.78 \times 10^{-3}\ m^3)$

$\boxed{m = 3.9\ kg}$

1.5
$1/2\ gallon \cdot 3.785 \times 10^{-3} = 1.89 \times 10^{-3}\ m^3$
$2\ liter \cdot 1 \times 10^{-3} = 2 \times 10^{-3}\ m^3$ $(2 - 1.89)/2 = 0.055 = 5.5\%$

$\boxed{\text{close enough to allow use of same container}}$

1.6 $V\!\!\!- = 1\ ft^3$; $W = 62.4$ lbf; $W = mg$; $m = \frac{W}{g} = \frac{62.4}{32.2}$

a) $\boxed{m = 1.94\ slug}$ $W_{moon} = mg = 1.94(32.2/6)$ or

b) $\boxed{W = 10.4\ lbf}$

1.7 $\frac{BTU}{hr} \cdot \frac{1\ hr}{3600\ s} \cdot \frac{1054}{745.7} = \boxed{3.926 \times 10^{-4} \frac{HP}{(BTU/hr)}}$

1.8
$1\ gallon \cdot 3.785 \times 10^{-3} = 3.785 \times 10^{-3}\ m^3$
$m = 1\,000\ kg/m^3(3.785 \times 10^{-3}\ m^{3)} = 3.785\ kg$

$\boxed{W = mg = 3.785(9.81) = 37.13\ N = 8.35\ lbf}$

1.9 Plot of data

1.10 $\rho = 1\,000\ kg/m^3$ (SI); $\rho = \frac{1\,000}{16.01} = \boxed{62.5\ lbm/ft^3}$

$\rho = \frac{1\,000}{16.01(32.2)} = \boxed{1.94\ slug/ft^3}$ $\rho = \frac{1\,000}{1\,000} = \boxed{1\ g/cm^3}$

1.11 Sphere $D = 8000 \text{ miles} \cdot 5280 \text{ ft/mile} = 4.224 \times 10^7 \text{ ft}$

$$\forall = \frac{\pi D^3}{6} = \frac{\pi (4.224 \times 10^7)^3}{6} = 5.92 \times 10^{22} \text{ ft}^3 \qquad \rho = 6\,560 \text{ kg/m}^3 = 410 \text{ lbm/ft}^3$$

$$m = \rho \forall = 410(5.92 \times 10^{22}) = \boxed{2.43 \times 10^{25} \text{ lbm}}$$

$$m = 2.43 \times 10^{25} \cdot 4.535 \times 10^{-1} = \boxed{1.1 \times 10^{25} \text{ kg} = m}$$

1.12 Liquid weighs 1 - 1/2 = 1/2 lbf; $\rho g = \frac{0.5 \text{ lbf}}{8 \text{ ounces}}$; using conversions,

$$\rho g = \frac{0.5 \text{ lbf}}{8 \text{ oz}} \cdot \frac{4.448}{2.957 \times 10^{-5}} = \boxed{9.4 \times 10^3 \text{ N/m}^3 = SW}$$

$$\rho = \frac{9\,400}{9.81} = \boxed{958 \text{ kg/m}^3 = \rho} \qquad \rho = \frac{958}{515.379} = \boxed{1.86 \text{ slug/ft}^3 = \rho}$$

$$\rho g = 1.86(32.2) = \boxed{59.9 \text{ lbf/ft}^3 = SW}$$

1.13 $\forall = 1 \text{ ft}^3$; Carbon tetrachloride Appendix Table A-5, $\rho = 1.59(1.94) \text{ slug/ft}^3$;

$W = mg = \rho \forall g = 1.59(1.94)(1)(32.2) = 99.3 \text{ lbf}$; $W = 99.3(4.448)$ or

$$\boxed{W = 442 \text{ N}}$$

1.14 $\forall = 5 \text{ ft}^3$, Kerosene Appendix Table A-5, $\rho = 0.823(1.94 \text{ slug/ft}^3)$;

$m = \rho \forall = 0.823(1.94)(5) = 7.99 \text{ slug}$; $m = 7.99(14.59)$ or

$$\boxed{m = 116.5 \text{ kg}}$$

1.15 minimum shear required is τ_o; movement impending when $\tau = \tau_o$

$$\tau_o = 4 \text{ N/m}^2 = \frac{\text{force}}{\text{area}} = \frac{mg}{A};$$

$$\text{so } m = \frac{A\tau_o}{g} = \frac{0.5 \text{ m}^2 (4 \text{ N/m}^2)}{9.81 \text{ m/s}^2} = 0.204 \text{ N}\cdot\text{s}^2/\text{m} = 0.204 \text{ kg}$$

$$\boxed{\text{so for movement to begin, } m > 0.204 \text{ kg}}$$

1.16 $m = 0.25 \text{ kg}$; $W = mg = 0.25(9.81) = 2.45 \text{ N}$; $\tau = \frac{F}{A} = \frac{2.45}{0.5} = 4.9 \text{ N/m}^2$

By definition, $\tau = \tau_o + \mu_o \frac{\Delta V}{\Delta y}$; $\qquad 4.9 = 4 + 4 \times 10^{-3} \frac{\Delta V}{0.005}$

$$\boxed{\Delta V = 1.13 \text{ m/s}}$$

1.17 $\tau = \mu \frac{\Delta V}{\Delta y}$; $\tau = \frac{W}{A} = \frac{W}{0.5 \text{ m}^2}$

Table A-5 for turpentine, $\mu = 1.375 \times 10^{-3} \text{ N}\cdot\text{s/m}^2$

$\Delta V = 0.05\ m/s$; By substitution, $\frac{W}{0.5} = 1.375 \times 10^{-3} \frac{0.05}{0.005}$

$\boxed{W = 0.007\ N}$

1.18 $\frac{F}{A} = \mu \frac{\Delta V}{\Delta y}$; $F = 0.89\ N$; $A = 0.16\ m^2$; $\Delta V = 0.12\ m/s$;

Table A-5, $\mu = 1.53 \times 10^{-5}\ N{\cdot}s/m^2$

$\Delta y = \frac{\mu \Delta V A}{F} = \frac{1.53 \times 10^{-5}(0.12)(0.16)}{8.9}$ or

$\boxed{\Delta y = 3.3 \times 10^{-5}\ m}$

1.19 $\frac{F}{A} = \mu \frac{\Delta V}{\Delta y}$; $F = 0.025\ kg(9.81\ m/s^2) = 0.245\ N$

$\Delta y = 0.01\ m$; $\mu = 650 \times 10^{-3}\ N{\cdot}s/m^2$; $A = 0.75\ m^2$

$\Delta V = \frac{0.245(0.01)}{0.75(650 \times 10^{-3})} = 5.03 \times 10^{-3}\ m/s$

so $\boxed{V = 5.03\ mm/s}$

1.20 Plot of data

1.21 $\frac{F}{A} = \mu \frac{\Delta V}{\Delta y}$; $A = 2\ \text{sides} \cdot \frac{2.5\ m^2}{\text{side}} = 5\ m^2$; $\Delta V = 0.002\,5\ m/s$; $\Delta y = 0.012\ m$

Table A-5 $\mu = 1.64 \times 10^{-3}\ N{\cdot}s/m^2$

so $F = \frac{5(1.64 \times 10^{-3})(0.002\,5)}{0.012}$ or

$\boxed{F = 1.708 \times 10^{-3}\ N}$

1.22 $\frac{F}{A} = \mu \frac{\Delta V}{\Delta y}$; $F = 2\ lbf$; $\mu = 1.11 \times 10^{-5}\ lbf{\cdot}s/ft^2$; $\Delta V = 12\ in./s = 1\ ft/s$

$\Delta y = (0.05/12)\ ft$; $2A = \frac{F\Delta y}{\mu \Delta V} = \frac{2(0.05/12)}{1.11 \times 10^{-5}(1)} = 750\ ft^2$

$\boxed{A = 375\ ft^2}$

1.23 τ is the same on both sides. Given $\Delta y_1 + \Delta y_2 = 1 - 0.1$ or

$\Delta y_1 + \Delta y_2 = 0.9\ cm = 0.009\ m$

$\tau = \mu_1 \frac{\Delta V}{\Delta y_1} = \mu_2 \frac{\Delta V}{\Delta y_2}$ so $\frac{\mu_1}{\Delta y_1} = \frac{\mu_2}{\Delta y_2}$ From Table A-5, we get

$$\frac{\mu_1}{\mu_2} = \frac{16.2}{42} = \frac{\Delta y_1}{\Delta y_2} \qquad \text{or} \qquad \frac{0.009 \text{ m} - \Delta y_2}{\Delta y_2} = 0.386 \qquad 1.386\Delta y_2 = 0.009$$

Solving,

$\boxed{\Delta y_2 = 0.006\,5 \text{ m} = 0.65 \text{ cm}}$ $\qquad \Delta y_1 = 0.9 - 0.65$ or

$\boxed{\Delta y_1 = 0.35 \text{ cm}}$

1.24 The shear applied to both fluids is the same. Thus on the left,

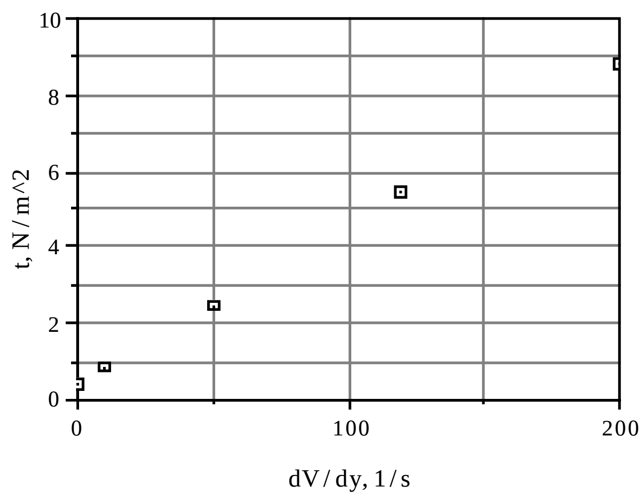
$$\tau = \mu_1 \frac{\Delta V}{\Delta y_1} \text{ and on the right, } \tau = \mu_2 \frac{\Delta V}{\Delta y_2}\text{ ;} \qquad \text{so} \qquad \frac{\mu_1}{\Delta y_1} = \frac{\mu_2}{\Delta y_2}$$

From Table A-5, $\mu_1 = 1.095 \times 10^{-3}$ N·s / m^2

Also, $\Delta y_1 = 2\Delta y_2$; With $\mu_2 = \mu_1 \frac{\Delta y_2}{\Delta y_1} = 1.095 \times 10^{-3} \cdot (1/2)$ or

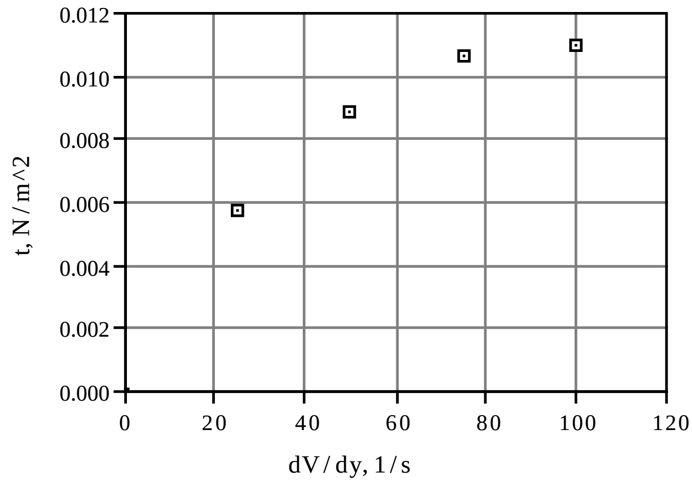
$\boxed{\mu_2 = 0.548 \times 10^{-3} \text{ N·s / m}^2}$

1.25



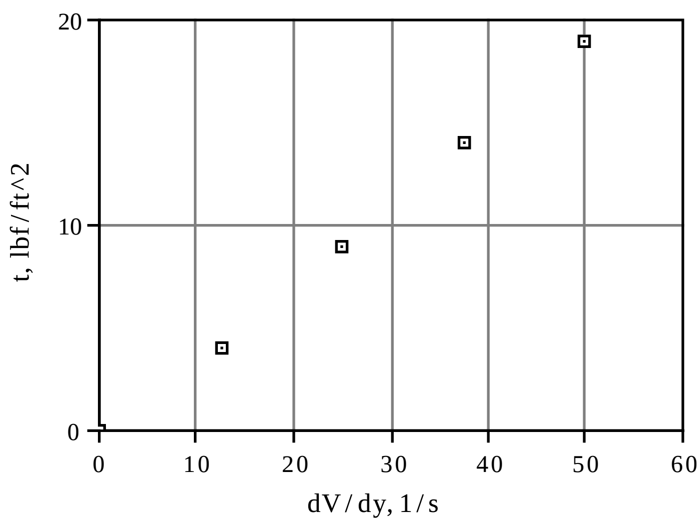
Bingham Plastic

1.26



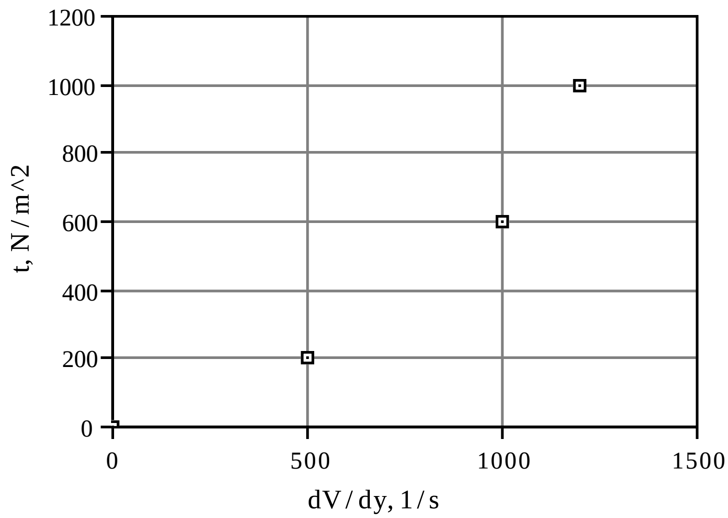
Pseudoplastic

1.27



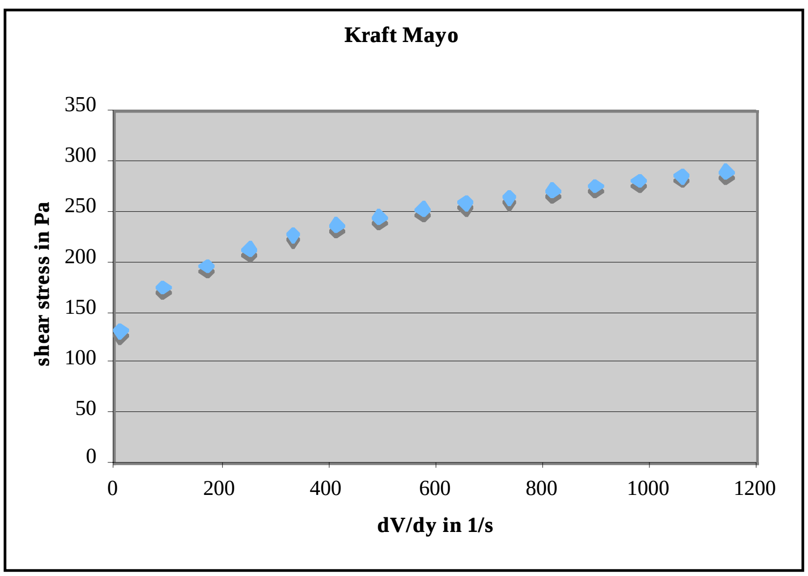
Newtonian (close enough)

1.28



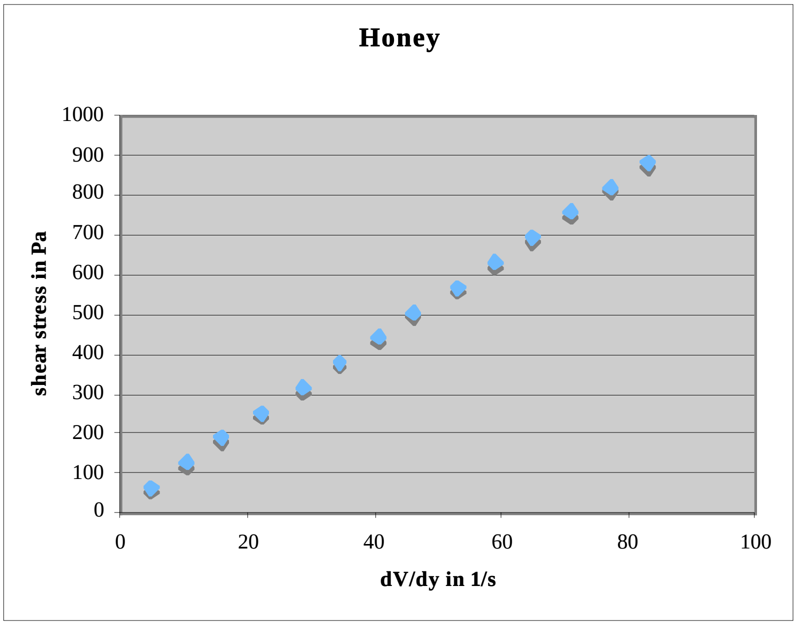
Dilatant

1.29



pseudoplastic with an initial yield stress

1.30



Newtonian

1.31 $A = 0.09 \cdot 0.016 = 0.0014\ \text{m}^2$; $V = 5\ \text{cm/s} = 0.05\ \text{m/s}$

$\Delta y = 2\ \text{mm} = 0.002\ \text{m}$

a) $\tau = \dfrac{F}{A} = \dfrac{0.07}{0.0014} = \boxed{48.6\ \text{N/m}^2}$

b) $\dfrac{dV}{dy} = \dfrac{\Delta V}{\Delta y} = \dfrac{0.05}{0.002} = \boxed{25/\text{s}}$

c) $\mu = \dfrac{\tau}{dV/dy} = \dfrac{48.6}{25} = \boxed{1.94\ \text{N}\cdot\text{s/m}^2}$

1.32 Assume oil is Newtonian so $\tau = \mu \dfrac{dV}{dy}$; sleeve is stationary, shaft velocity is $V = 5\ \text{in./s} = 0.417\ \text{ft/s}$; $\tau = \dfrac{F}{A}$; A = area of contact. Surface area of shaft does not equal surface of sleeve, so take an average. For shaft, $A = \pi DL = \pi(4/12)(12/12) = 1.047\ \text{ft}^2$; for the sleeve, $A = \pi(4.01/12)(12/12) = 1.05\ \text{ft}^2$; use $A = \dfrac{1.05 + 1.047}{2} = 1.048\ \text{ft}^2$

$\tau = \dfrac{25}{1.048} = 23.8\ \text{lbf/ft}^2$; $\dfrac{dV}{dy} = \dfrac{\Delta V}{\Delta y} = \dfrac{5/12 - 0}{0.005/12} = 1000$

$\mu = \dfrac{\tau}{dV/dy} = \dfrac{23.8}{1000}$ or $\boxed{\mu = 23.8 \times 10^{-3}\ \text{lbf}\cdot\text{s/ft}^2}$

1.33 Pseudoplastic $\tau = K\left(\frac{dV}{dy}\right)^n$; substituting,

$4.63 \times 10^{-2} = K(25)^n$ and $6.52 \times 10^{-2} = K(50)^n$; dividing gives

$\frac{4.63}{6.52} = \left(\frac{25}{50}\right)^n$; which becomes $0.71 = (0.5)^n$; $\ln(0.71) = n \ln(0.5)$;

$\boxed{n = 0.494}$

$4.63 \times 10^{-2} = K(25)^{0.494}$; $K = \frac{4.63 \times 10^{-2}}{4.91}$

$\boxed{K = 9.44 \times 10^{-3}}$

Check with second equation: $9.44 \times 10^{-3} (50)^{0.494} = 6.52 \times 10^{-2}$ which is OK.

$\tau = 9.44 \times 10^{-3} (dV/dy)^{0.494}$; when $\tau = 7 \times 10^{-2}$,

$7 \times 10^{-2} = 9.44 \times 10^{-3} \left(\frac{dV}{dy}\right)^{0.494}$; $\frac{dV}{dy} = (7.42)^{1/0.494}$ or

$\boxed{\frac{dV}{dy} = 57.7 \text{ rad/s}}$

1.34 $\tau = K\left(\frac{dV}{dy}\right)^n$; $8.72 \times 10^{-3} = K(20)^n$ and $2.10 \times 10^{-2} = K(40)^n$; dividing,

$\frac{8.72 \times 10^{-3}}{2.10 \times 10^{-2}} = \left(\frac{20}{40}\right)^n$; $0.415 = (0.5)^n$; $\ln(0.415) = n \ln(0.5)$

$\boxed{n = 1.27}$

$8.27 \times 10^{-3} = K(20)^{1.27}$; $\boxed{K = 1.95 \times 10^{-4}}$

Check $1.95 \times 10^{-4} (40)^{1.27} = 2.1 \times 10^{-2}$ OK

$\tau = 1.95 \times 10^{-4} \left(\frac{dV}{dy}\right)^{1.27}$; $\tau = 3 \times 10^{-2}$

$\frac{dV}{dy} = \left(\frac{3 \times 10^{-2}}{1.95 \times 10^{-4}}\right)^{1/1.27}$

$\boxed{\frac{dV}{dy} = 53.1 \text{ rad/s}}$

1.35 $\mu_o = 0.029 \text{ lbf·s/ft}^2$; $\tau = 2.7 \text{ lbf/ft}^2$; $\frac{dV}{dy} = 74.5 \text{ rad/s}$

$\tau = \tau_o + \mu_o \frac{dV}{dy}$; $2.7 = \tau_o + 0.029(74.5)$; $\tau_o = 2.7 - 0.029(74.5)$

$\boxed{\tau_o = 0.54 \text{ lbf/ft}^2}$

1.36 Table A-5 for acetone $\rho = 0.787(1\,000) = 787\ \text{kg/m}^3$

$\mu = 0.316 \times 10^{-3}\ \text{N·s/m}^2$ $\nu = \mu/\rho = 4.015 \times 10^{-7}\ \text{m}^2/\text{s}$

Using conversions from Table A-1,

$$\nu = \frac{4.015 \times 10^{-7}}{9.290304 \times 10^{-2}};$$

$\boxed{\nu = 4.32 \times 10^{-6}\ \text{ft}^2/\text{s}}$ (Engineering system, Brit Grav & Brit abs)

$$\nu = \frac{4.015 \times 10^{-7}}{(1\ \text{m}/100\ \text{cm})^2}$$

$\boxed{\nu = 4.015 \times 10^{-3}\ \text{cm}^{-3}/\text{s}}$ (CGS)

1.37 At 0°C, Table A-4 $\mu = 1.787 \times 10^{-3}\ \text{N·s/m}^2$

At 100°C, $\mu = 0.2818 \times 10^{-3}\ \text{N·s/m}^2$

$$\%\ \text{change} = \frac{\mu_{100} - \mu_0}{\mu_0} = \frac{0.2818 - 1.787}{1.787}; \quad \boxed{\%\ \text{change} = -\,84\%}$$

At 0°C, $\nu = 1.787 \times 10^{-6}\ \text{m}^2/\text{s}$

At 100°C $\nu = 0.2940 \times 10^{-6}$

$$\%\ \text{change} = \frac{\mu_{100} - \mu_0}{\mu_0} = \frac{0.2940 - 1.787}{1.787}; \quad \boxed{\%\ \text{change} = -\,83.5\%}$$

1.38 $\mu = 8\ \text{cp} \cdot 1 \times 10^{-3} = 8 \times 10^{-3}\ \text{N·s/m}^2;\ \rho = 59\ \text{lbm/ft}^3 \cdot 16.01 = 945\ \text{kg/m}^3$

$$\nu = \frac{\mu}{\rho} = \frac{8 \times 10^{-3}}{945} = 8.47 \times 10^{-6}\ \text{m}^2/\text{s} \cdot (100^2\ \text{cm}^2/\text{m}^2)$$

$\boxed{\nu = 8.47 \times 10^{-2}\ \text{cm}^2/\text{s}}$

1.39 $p_i - p_o = \frac{2\sigma}{R};\ \ p_o = 101\,300\ \text{N/m}^2;\ R = 0.001\ \text{m};\ \sigma = 23.1 \times 10^{-3}\ \text{N/m}$, so

$$p_i = 101\,300 + \frac{2(23.1 \times 10^{-3})}{0.001} = \boxed{101\,346\ \text{N/m}^2}$$

1.40 $p_i - p_o = \frac{2\sigma}{R};\ \ p_o = 70\,000\ \text{N/m}^2;\ R = 250 \times 10^{-6}\ \text{m};\ \sigma = 72 \times 10^{-3}\ \text{N/m}$, so

$$p_i = 70\,000 + \frac{2(72 \times 10^{-3})}{250 \times 10^{-6}} = \boxed{70\,576\ \text{N/m}^2}$$

1.41 $p_i - p_o = \frac{2\sigma}{R};\ D = 1/16\ \text{in.} = 0.0052\ \text{ft};\ R = 0.0026\ \text{ft}$

$p_o = 14.7(144) = 2117\ \text{lbf/ft}^2;\ \sigma = 27.14 \times 10^{-3}\ \text{N/m}$ (Table A-5); converting,

$$\sigma = \frac{27.14 \times 10^{-3}}{4.448}(0.3048) = 1.86 \times 10^{-3} \text{ lbf/ft so}$$

$$p_i = 2117 + \frac{2(1.86 \times 10^{-3})}{0.0026} \quad \text{or} \quad \boxed{p_i = 2118 \text{ lbf/ft}^2}$$

1.42 Benzene $\sigma = 28.2 \times 10^{-3}$ N / m (Table A-9); D = 1 mm;

$R = 0.5$ mm = 0.000 5 m; $p_o = 100\,000$ N / m^2 ; $p_i - p_o = \frac{2\sigma}{R}$;

$$p_i = 100\,000 + \frac{2(28.2 \times 10^{-3})}{0.000\,5} \text{ ; solving,}$$

a) $\boxed{p_i = 1.001 \times 10^5 \text{ N/m}^2}$ (benzene)

b) $p_i - p_o = 113 \text{ N/m}^2 = \frac{2\sigma}{R}$ for Hg; $R = \frac{2\sigma}{113}$; $\sigma = 484 \times 10^{-3}$ N / m (from Appendix Table A-5 or A-9); $R = \frac{2(0.484)}{113}$ or

b) $\boxed{R = 0.008\,6 \text{ m} = 8.6 \text{ mm}}$

1.43 $h = \frac{2\sigma}{\rho R g}\cos\theta$; $\rho = 1\,000$ kg / m^3, R = 0.002 m, $\theta = 0°$

H_2O at room temperature, Table A-5; $\sigma = 71.97 \times 10^{-3}$ N / m

$$h = \frac{2(71.97 \times 10^{-3})}{1\,000(0.002)(9.81)} \text{ ; solving,}$$

a) $\boxed{h = 0.007\,337 \text{ m} = 7.34 \text{ mm}}$

Table A-5 for Hg, $\sigma = 484 \times 10^{-3}$ N / m; $\rho = 13.6(1\,000)$

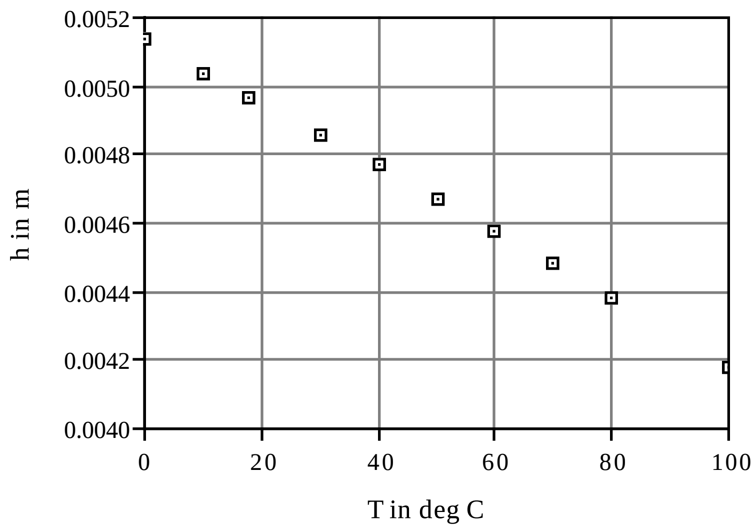
$$h = \frac{2(484 \times 10^{-3})\cos 140°}{13.6(1\,000)(9.81)(0.002)} \text{ ; and}$$

b) $\boxed{h = -2.8 \times 10^{-3} \text{ m} = -2.8 \text{ mm}}$

1.44 $h = \frac{2\sigma}{\rho R g}$; R = 0.003 m; $h = \frac{2\sigma}{\rho R g} = \frac{2\sigma}{\rho(0.003)(9.81)} = 67.96\,\frac{\sigma}{\rho}$

Table A-4

T, °C	σ, N / m	ρ, kg / m³	h, m
0	75.6×10^{-3}	0.9999(1 000)	0.00514
10	74.2	0.9997	0.00504
18	73.1	0.9986	0.00497
30	71.2	0.9957	0.00486
40	69.6	0.9922	0.00477
50	67.9	0.9881	0.00467
60	66.2	0.9832	0.00458
70	64.4	0.9778	0.00448
80	62.6	0.9718	0.00438
100	58.9	0.9584	0.00418

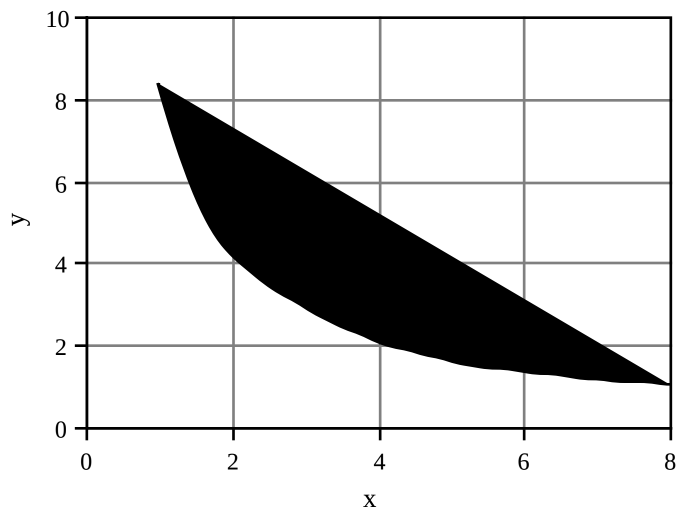


1.45 $\sigma = \frac{xy\theta}{2}\rho g$; $\sigma = 71.97 \times 10^{-3}$ N / m; $\rho = 1\,000$ kg / m^3 ; $\theta = 1° \cdot 2\pi / 360$

$\theta = 0.017\,45$ rad; substituting,

$71.97 \times 10^{-3} = xy\left(\frac{0.017\,45}{2}\right)(1\,000)(9.81)$; $xy = 8.048 \times 10^{-4}$ m^2

x	y
1	8.408
2	4.2
4	2.1
8	1.05



1.46 $h = \frac{2\sigma}{\rho R g}\cos\theta$; $\theta = 140°$ for Hg; Table A-5 for Hg, $\rho = 13.6(1.94$ slug / ft$^3)$

D = 0.2 in. = 0.0166 ft; R = 0.00833 ft; h = - 0.052 in. = - 0.0043 ft

$$\sigma = \frac{\rho R h g}{2\cos\theta} = \frac{13.6(1.94)(0.00833)(-0.0043)(32.2)}{2\cos 140°}$$

$\sigma = 0.0198$ lbf / ft

1.47 $\theta = 0°$; R = 0.002 5 m, ethyl alcohol, Table A-5; $\sigma = 22.33 \times 10^{-3}$ N / m;

$\rho = 787$ kg / m^3 ; $h = \frac{2\sigma}{\rho R g} = \frac{2(22.33 \times 10^{-3})}{787(0.002\,5)(9.81)}$

h = 2.31 mm

1.48 $\theta = 0°$; R = 0.002 m, benzene, Table A-5; $\sigma = 28.18 \times 10^{-3}$ N / m;

$$\rho = 876 \text{ kg/m}^3 \text{ ; } h = \frac{2\sigma}{\rho R g} = \frac{2(28.18 \times 10^{-3})}{876(0.002)(9.81)}$$

$$\boxed{h = 3.28 \text{ mm}}$$

1.49 $\theta = 0°$; R = 0.001 5 m, carbon tet, Table A-5; $\sigma = 26.3 \times 10^{-3}$ N / m;

$$\rho = 1\,590 \text{ kg/m}^3 \text{ ; } h = \frac{2\sigma}{\rho R g} = \frac{2(26.3 \times 10^{-3})}{1\,590(0.001\,5)(9.81)}$$

$$\boxed{h = 2.25 \text{ mm}}$$

1.50 $\theta = 0°$; R = 0.001 25 m, glycerin, Table A-5; $\sigma = 63.0 \times 10^{-3}$ N / m;

$$\rho = 1\,263 \text{ kg/m}^3 \text{ ; } h = \frac{2\sigma}{\rho R g} = \frac{2(63.0 \times 10^{-3})}{1\,263(0.001\,25)(9.81)}$$

$$\boxed{h = 8.14 \text{ mm}}$$

1.51 $\theta = 0°$; R = 0.001 m, octane, Table A-5; $\sigma = 21.14 \times 10^{-3}$ N / m;

$$\rho = 701 \text{ kg/m}^3 \text{ ; } h = \frac{2\sigma}{\rho R g} = \frac{2(21.14 \times 10^{-3})}{701(0.001)(9.81)}$$

$$\boxed{h = 6.15 \text{ mm}}$$

1.52 $\theta = 140°$; R = 0.005 m, Hg, Table A-5; $\sigma = 484 \times 10^{-3}$ N / m;

$$\rho = 13\,600 \text{ kg/m}^3 \text{ ; } h = \frac{2\sigma}{\rho R g} \cos\theta = \frac{2(484 \times 10^{-3})}{13\,600(0.005)(9.81)} \cos 140°$$

$$\boxed{h = -1.11 \text{ mm}}$$

1.53 m = 0.1 slug; $\Delta T = 25°F$; Table A-6 for air, $c_p = 7.72$ BTU / slug·°R

$$\tilde{Q} = mc_p\Delta T = 0.1(7.72)(25)$$

$$\boxed{\tilde{Q} = 19.3 \text{ BTU}}$$

1.54 CO_2 Appendix Table A-6 $c_p = 876$ J / (kg·K); m = 1.5 kg; $\Delta T = 25°C$

$$\tilde{Q} = mc_p\Delta T = 1.5(876)(25) = 3.28 \times 10^4 \text{ J;}$$

$$\tilde{Q}/m = 3.28 \times 10^4 / 1.5 = \boxed{2.2 \times 10^4 \text{ J/kg}}$$

1.55 $\tilde{Q} = mc_v\Delta T$; Table A-6, $c_p = 523$ J/(kg·K); $c_p/c_v = 1.67$; so we calculate

$c_v = 313$ J/(kg·K); $\tilde{Q} = 8$ kg(313 J/(kg·K))(ΔT) = 50 000 J; solving,

$\Delta T = 20.0$ K increase in temperature

1.56 CO_2 Appendix Table A-6 $c_p = 876$ J/(kg·K); $\gamma = 1.30$;

$c_v = \frac{876}{1.3} = 674$ J/(kg·K); $\Delta u = c_v\Delta T = 674(50 - 25)$

$\Delta u = 1.68 \times 10^4$ J/kg

1.57 m = 1 kg; $\Delta T = 25°C$

from Table A-6

He $c_p = 5\,188$ J/(kg·K)

H_2 $c_p = 14\,310$ J/(kg·K)

$\tilde{Q} = mc_p\Delta T = 1(5\,188)(25)$

$\tilde{Q} = 1.3 \times 10^5$ J for He

$\tilde{Q} = mc_p\Delta T = 1(14\,310)(25)$

$\tilde{Q} = 3.6 \times 10^5$ J for H_2

$\Delta h = \frac{\tilde{Q}}{m} = \frac{1.3 \times 10^5}{1}$; **$\Delta h = 1.3 \times 10^5$ J/kg for He**

$\Delta h = \frac{\tilde{Q}}{m} = \frac{3.6 \times 10^5}{1}$; **$\Delta h = 3.6 \times 10^5$ J/kg for H_2**

Hydrogen requires more energy

1.58 Air loses $\tilde{Q} = mc_v(120 - T_f)$

H_2 gains $\tilde{Q} = mc_v(T_f - 60)$

$m_{air} = 2m_{H2}$; Table A-6 gives

air $c_p = 7.72$ BTU/slug·°R; $c_p/c_v = 1.4$

H_2 $c_p = 110$ BTU/slug·°R; $c_p/c_v = 1.405$

$c_{vair} = \frac{7.72}{1.4} = 5.51$; $c_{vH2} = \frac{110}{1.405} = 78.3$

$\tilde{Q}$ are equal so; $mc_v(120 - T_f)|_{air} = mc_v(T_f - 60)|_{H2}$

substituting, $2m_{H2}(5.51)(120 - T_f) = m_{H2}(78.3)(T_f - 60)$;

$1322 - 11.02T_f = 78.3T_f - 4698$; $6020 = 89.32T_f$

T = 67.4°F
