2.2 GIVEN: CARBON DIOXIDE AT

$p = 300 \frac{kN}{m^2}$ ABSOLUTE AND $T = 60°C$

FIND: DENSITY AND SPECIFIC WEIGHT

SOLUTION: OBTAIN CO_2 DENSITY BY APPLYING THE IDEAL GAS LAW.

$$\rho = \frac{p}{RT}$$

OBTAIN GAS CONSTANT, R, FROM TABLE A.2

$R = 189 \frac{J}{kg \cdot K}$ $\qquad 1 J = 1 N \cdot m$

$$\rho = \frac{300{,}000 \frac{N}{m^2}}{\left(189 \frac{N \cdot m}{kg \cdot K}\right)(333 K)} = 4.77 \frac{kg}{m^3}$$

$$\boxed{\rho = 4.77 \frac{kg}{m^3}}$$

SPECIFIC WEIGHT

$\gamma = \rho g$

$$\boxed{\gamma = 46.7 \frac{N}{m^3}}$$

2.5 GIVEN: AIR AND WATER AT $T = 100°C$
AND $p = 5$ ATMOSPHERES

FIND: DENSITY RATIO, ρ_w / ρ_a

SOLUTION:

WATER — ASSUME THAT THE WATER IS INCOMPRESSIBLE AND USE TABLE A.5 TO OBTAIN ρ_w

$$\rho_w = 958 \ \frac{kg}{m^3}$$

AIR - USE IDEAL GAS LAW TO CALCULATE ρ_a.

$$\rho_a = \frac{p_a}{R T_a} \qquad p_a = 5 \left(101{,}000 \ \frac{N}{m^2}\right)$$

$$T_a = 100 + 273 = 373 \ K$$

$$\rho_a = \frac{505\,000}{(287)(373)} = 4.72 \ \frac{kg}{m^3}$$

$$\boxed{\frac{\rho_w}{\rho_a} = 203 \quad \text{DIMENSIONLESS}}$$

2.13

GIVEN: WATER AND AIR AT STANDARD ATMOSPHERIC PRESSURE, $p = 101\ kN/m^2$.

FIND: CHANGE IN ρ AND μ BETWEEN $T_1 = 10°C$ AND $T_2 = 70°C$.

SOLUTION:

WATER: TABLE A.5

$$\rho_1 = 1000\ kg/m^3, \quad \rho_2 = 978\ kg/m^3$$

$$\mu_1 = 1.31 \times 10^{-3}\ \frac{N \cdot S}{M^2}, \quad \mu_2 = 4.04 \times 10^{-4}\ \frac{N \cdot S}{M^2}$$

AIR: TABLE A.3

$$\rho_1 = 1.25\ kg/m^3, \quad \rho_2 = 1.03\ kg/m^3$$

$$\mu_1 = 1.76 \times 10^{-5}\ \frac{N \cdot S}{m^2}, \quad \mu_2 = 2.04 \times 10^{-5}\ \frac{N \cdot S}{M^2}$$

2.33 GIVEN: GLYCERIN AT 20°C IS FLOWING IN A CHANNEL.

$$u = \frac{-1}{2\mu}\frac{dp}{dx}\left(By - y^2\right)$$

CHANNEL WIDTH: $B = 5.0\,cm$

PRESSURE GRADIENT: $\frac{dp}{dx} = -1.6\ \frac{kN}{m^3}$

FIND: VELOCITY AND SHEAR STRESS AT THE WALL AND 12 mm FROM THE WALL.

PLOT THE VELOCITY PROFILE.

SOLUTION: AT THE WALL $(y=0)$ THE VELOCITY IS ZERO $\boxed{(u=0)}$

LOOK UP VISCOSITY OF GLYCERIN IN TABLE A.4 $\mu = 1.41\ \frac{N \cdot S}{m^2}$

AT $y = 0.012\,m$

$$u = \frac{-1}{2(1.41)}(-1600)\left[(0.05)(0.012) - (0.012)^2\right]$$

$$\boxed{u = 0.26\ \frac{m}{s}}$$

SHEAR STRESS $\tau = \mu \frac{du}{dy}$

$$\frac{du}{dy} = -\frac{1}{2\mu}\frac{dp}{dx}\left(B - 2y\right)$$

$$\tau = -\frac{1}{2}\frac{dp}{dx}\left(B - 2y\right)$$

AT $y = 0$ $\quad \tau = -\frac{1}{2}\frac{dp}{dx}B = -\frac{1}{2}(-1600)(0.05)$

$$\boxed{\tau = 40\ \frac{N}{m^2}}$$

AT $y = 0.012$ $\quad \tau = -\frac{1}{2}\frac{dp}{dx}(B - 2y)$

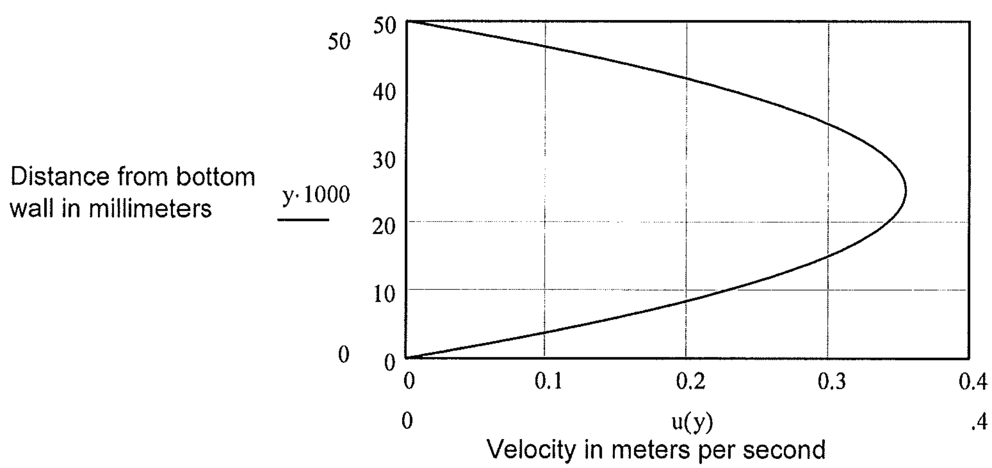
$$\tau = -\frac{1}{2}(-1600)(0.05 - .024)$$

$$\boxed{\tau = 20.8\ \frac{N}{m^2}}$$

Graph of Velocity Profile for Problem 2.33 (using Mathcad 2000)

$B := 0.05$	channel width in meters
$\mu := 1.41$	absolute viscosity of glycerin in Newton-seconds per meter squared
$dpdx := -1600$	pressure gradient in Newtons per meter cubed
$y := 0, .0005 .. .05$	distance from bottom of channel in meters

$$u(y) := -\frac{1}{2\cdot\mu}\cdot dpdx\cdot\left(B\cdot y - y^2\right)$$



2.45

GIVEN: WATER AT STANDARD CONDITIONS FILLS A 1000 CM^3 CONTAINER. A PRESSURE OF 2×10^6 N/m² IS APPLIED.

FIND: "ESTIMATE OF WATER VOLUME AFTER PRESSURE HAS BEEN APPLIED.

SOLUTION:

DEFINITION OF BULK MODULUS.

$$E_v = -\frac{dp}{d\forall/\forall}$$

$E_v = 2.2\ GN/m^2$ FOR WATER (PAGE 21, TEXT)

$$d\forall = -\frac{dp}{E_v}\forall = -\frac{2 \times 10^6 \frac{N}{m^2}}{2.2 \times 10^9 \frac{N}{m^2}}(1000\ cm^3)$$

$$d\forall = -0.909\ cm^3$$

$$\forall_f = \forall_i + d\forall = 1000\ cm^3 - 0.909\ cm^3$$

$$\boxed{\forall_f = 999.1\ cm^3}$$