1. What is the specific weight and density of air at an absolute pressure of 700 kPa and a temperature of 200 °C?

$$\rho_{air} = \frac{P}{RT}$$
$$= \frac{700{,}000}{287(200+273)}$$
$$= 5.17\ \frac{kg}{m^3}$$

$$\gamma_{air} = \rho_{air} \times g$$
$$= 5.17 \times 9.81$$
$$= 50.58$$

2. If a gas has $\gamma = 20\frac{N}{m^3}$, what is its density? What is its specific gravity?

$$\gamma = \frac{\rho}{g} \qquad \rho = \frac{\gamma}{g}$$
$$\gamma = 20\frac{N}{m^3}$$
$$\rho = \left(\frac{20N}{m^3}\right)\left(\frac{1s^2}{9.81m}\right) = 2.04\frac{kg}{m^3}$$

3. The velocity distribution for water (20 °C) near a wall is given by $u = a\left(\frac{y}{b}\right)^{\frac{1}{6}}$, where $a = 15\,m/s$, $b = 4\,mm$, and y is the distance from the wall in mm. Determine the shear stress in the water at $y = 1\,mm$.

$$\frac{du}{dy} = \frac{d}{dy}\left[a\left(\frac{y}{b}\right)^{\frac{1}{6}}\right] = \frac{a}{6b}\left(\frac{b}{y}\right)^{\frac{5}{6}}$$

At $y = 1\,mm$:

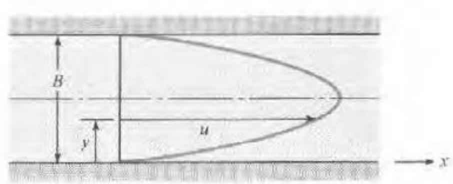
$$\frac{du}{dy} = \frac{a}{6b}\left(\frac{b}{y}\right)^{\frac{5}{6}} = \frac{15\,{}^{m}/_{s}}{6 \times 0.004m}\left(\frac{4mm}{1mm}\right)^{\frac{5}{6}} = 1984s^{-1}$$

4. What is the ratio of the *dynamic viscosity* of air to that of water at *standard atmospheric pressure* and a temperature of $20\ °C$? What is the ratio of the *kinematic viscosity* of air to that of water for the same conditions?

$$\frac{\mu_{air}}{\mu_{water}} = \frac{1.81 \times 10^{-5} N.{}^{s}/_{m^2}}{1.00 \times 10^{-3} N.{}^{s}/_{m^2}} = 1.81 \times 10^{-2}$$
$$\frac{\nu_{air}}{\nu_{water}} = \frac{151 \times 10^{-5} N.{}^{s}/_{m^2}}{1.00 \times 10^{-6} N.{}^{s}/_{m^2}} = 15.1$$

5. A liquid flows between parallel boundaries as shown below. The velocity distribution near the lower wall is given in the following table. If the viscosity of the liquid is $10^{-3} Ns/m^2$, what is the maximum shear stress in the liquid? Conceptually, where will the minimum shear stress occur?

$\boldsymbol{y}\ (\boldsymbol{mm})$	$\boldsymbol{u}\ (\boldsymbol{m/s})$
0.0	0.00
1.0	1.00
2.0	1.99
3.0	2.98



$$\tau = \mu \frac{dv}{dy}$$

$$\tau_{max} \cong \mu \left(\frac{\Delta v}{\Delta y}\right) \; next\ to\ wall$$

$$\tau_{max} = (10^{-3} N.s/m^2)((1\frac{m}{s})/0.001m)$$

$$\tau_{max} = 1.0 \frac{N}{m^2}$$

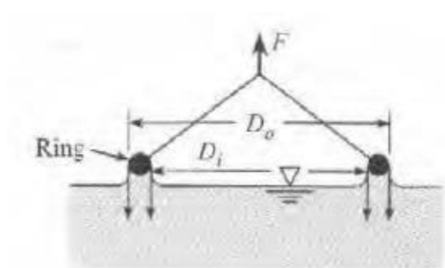
6. How deep can a diver descend in the ocean without damaging his watch, which will withstand an absolute pressure of 5.5 bar? Take the density of ocean water, $\rho = 1025 \frac{kg}{m^3}$.

Use the static equation: $p = \rho g h$

Hence the depth can be calculated as:

$$h = \frac{P}{\rho . g} = \frac{(5.5-1)x10^5}{1025x9.81} = 44.75m\ Water$$

7. The surface tension of a liquid is being measured with a ring as shown. The ring has an outside diameter of $10\ cm$ and an inside diameter of $9.5\ cm$. The mass of the ring is $10\ g$. The force required to pull the ring from the liquid is the weight corresponding to a mass of $16\ g$. What is the surface tension (σ) of the liquid (in N/m)?



1. Force equilibrium

$$\begin{aligned}\text{(Upward force)} &= \text{(Weight of fluid)} + \text{(Force due to surface tension)}\\ F &= W + \sigma(\pi D_i + \pi D_o)\end{aligned}$$

2. Solve for surface tension

$$\begin{aligned}\sigma &= \frac{F - W}{\pi(D_i + D_o)}\\ \sigma &= \frac{(0.016 - 0.010)\,\text{kg} \times 9.81\,\text{m/s}^2}{\pi(0.1 + 0.095)\,\text{m}}\\ \sigma &= 9.61 \times 10^{-2}\frac{\text{kg}}{\text{s}^2}\end{aligned}$$

$$\boxed{\sigma = 0.0961\ \text{N/m}}$$