2.1 $\rho = p/RT = (1.2)(1.01 \times 10^5)/(287)(300)$

$\rho = 1.41 \text{ kg/m}^2$

$v = 1/\rho = 1/1.41 = \boxed{0.71 \text{ m}^3\text{/kg}}$

2.2 Mean kinetic energy of each atom =

$$\frac{3}{2}\ k\ T = \frac{3}{2}\ (1.38 \times 10^{-23})(500) = 1.035 \times 10^{-20}\ \text{J}$$

One kg-mole, which has a mass of 4 kg, has 6.02×10^{26} atoms Hence 1 kg has $\frac{1}{4}$ $(6.02 \times 10^{26}) = 1.505 \times 10^{26}$ atoms

Total internal energy = (energy per atom)(number of atoms)

$= (1.035 \times 10^{-20})(1.505 \times 10^{26}) = \boxed{1.558 \times 10^6\ \text{J}}$

2.3 $$\rho = \frac{p}{RT} = \frac{2116}{(1716)(460+59)} = 0.00237 \frac{\text{slug}}{\text{ft}^3}$$

Volume of the room $= (20)(15)(8) = 2400 \text{ ft}^3$

Total mass in the room $= (2400)(0.00237) = 5.688$ slug

Weight $= (5.688)(32.2) = \boxed{183 \text{ lb}}$

2.4 $$\rho = \frac{p}{RT} = \frac{2116}{(1716)(460-10)} = 0.00274 \frac{\text{slug}}{\text{ft}^3}$$

Since the volume of the room is the same, we can simply compare densities between the two problems.

$$\Delta\rho = 0.00274 - 0.00237 = 0.00037 \frac{\text{slug}}{\text{ft}^3}$$

$$\% \text{ change} = \frac{\Delta\rho}{\rho} = \frac{0.00037}{0.00237} \text{ x } (100) = \boxed{15.6\% \text{ increase}}$$

2.5 First, calculate the density from the known mass and volume,

$$\rho = 1500/900 = 1.67 \text{ lb}_m/\text{ft}^3$$

In consistent units, $\rho = 1.67/32.2 = 0.052 \text{ slug/ft}^3$. Also, T = 70F = 70 + 460 = 530R.

Hence,

$$p = \rho RT = (0.52)(1716)(530)$$

$$p = 47290 \text{ lb/ft}^2$$

or $$p = 47290/2116 = \boxed{22.3 \text{ atm}}$$

2.6 $p = \rho RT$

$$\ell n p = \ell n \rho + \ell n R + \ell n T$$

Differentiating with respect to time,

$$\frac{1}{p}\frac{dp}{dt} = \frac{1}{\rho}\frac{d\rho}{dt} + \frac{1}{T}\frac{dT}{dt}$$

or, $$\frac{dp}{dt} = \frac{p}{\rho}\frac{d\rho}{dt} + \frac{p}{T}\frac{dT}{dt}$$

or, $$\frac{dp}{dt} = RT\frac{d\rho}{dt} + \rho R\frac{dT}{dt} \qquad (1)$$

At the instant there is 1000 lb_m of air in the tank, the density is

$$\rho = 1000/900 = 1.11 \text{ lb}_m/\text{ft}^3$$

$$\rho = 1\ 11/32.2 = 0\ 0345 \text{ slug/ft}^3$$

Also, in consistent units, is is given that

$$T = 50 + 460 = 510R$$

and that

$$\frac{dT}{dt} = 1F/\min = 1R/\min = 0.0167R/\sec$$

From the given pumping rate, and the fact that the volume of the tank is 900 ft^3, we also have

$$\frac{d\rho}{dt} = \frac{0 5\ lb_m/\sec}{900\ ft^3} = 0.000556\ lb_m/(ft^3)(\sec)$$

$$\frac{d\rho}{dt} = \frac{0.000556}{32\ 2} = 1.73 \times 10^{-5} \text{ slug/(ft}^3)(\sec)$$

Thus, from equation (1) above,

$$\frac{dp}{dt} = (1716)(510)(1.73 \times 10^{-5}) + (0\ 0345)(1716)(0.0167)$$

$$= 15\ 1 + 0\ 99 = 16.1\ lb/(ft^2)(\sec) = \frac{16.1}{2116}$$

$$= \boxed{0.0076 \text{ atm/sec}}$$

2.7 In consistent units,

$$T = -10 + 273 = 263K$$

Thus,

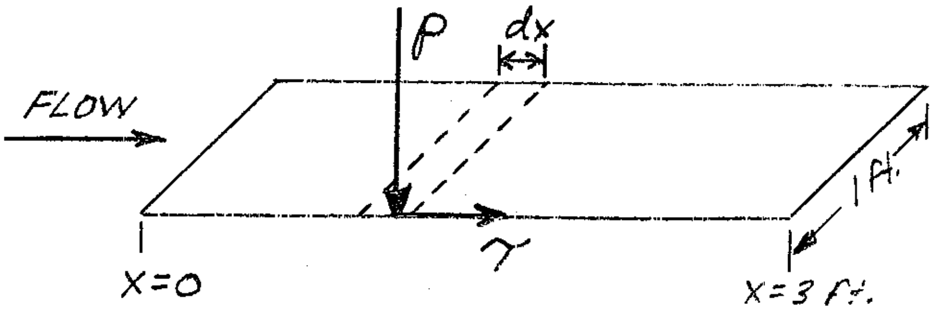
$$\rho = p/RT = (1\ 7 \times 10^4)/(287)(263$$

$$\rho = \boxed{0.225 \text{ kg/m}^3}$$

2.8 $\rho = p/RT = 0.5 \times 10^5/(287)(240) = 0.726 \text{ kg/m}^3$

$v = 1/\rho = 1/0.726 = \boxed{1.38 \text{ m}^3/\text{kg}}$

2.9

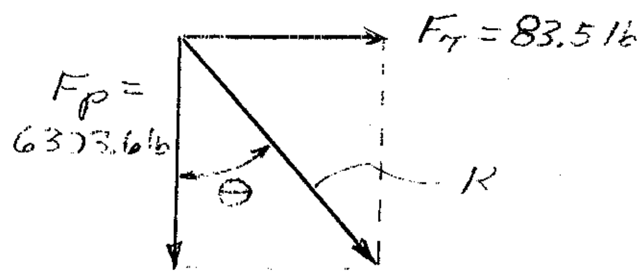


F_p = Force due to pressure = $\int_0^3 p\, dx = \int_0^3 (2116 - 10x)\, dx$

$= [2116x - 5x^2]_0^3 = 6303$ lb perpendicular to wall

F_τ = Force due to shear stress = $\int_0^3 \tau\, dx = \int_0^3 \frac{90}{(x+9)^{\frac{1}{2}}} dx$

$= [180\,(x+9)^{\frac{1}{2}}]_0^3 = 623.5 - 540 = 83.5$ lb tangential to wall



Magnitude of the resultant aerodynamic force =

$R = \sqrt{(6303)^2 + (83.5)^2} = \boxed{6303.6 \text{ lb}}$

$$\theta = \text{Arc Tan}\left(\frac{83.5}{6303}\right) = \boxed{0.76^\circ}$$

2.10 $V = \frac{3}{2} V_\infty \sin\theta$

Minimum velocity occurs when $\sin\theta = 0$, i.e. when $\theta = 0^\circ$ and 180°.

$\boxed{V_{min} = 0}$ at $\theta = 0^\circ$ and 180°, i.e., at its most forward and rearward points

Maximum velocity occurs when $\sin\theta = 1$, i.e. when $\theta = 90^\circ$ Hence

$$V_{max} = \frac{3}{2}(85)(1) = \boxed{127.5 \text{ mph}} \text{ at } \theta = 90^\circ,$$

i.e., the entire rim of the sphere in a plane perpendicular to the freestream direction.

2.11 The mass of air displaced is

$$M = (2.2)(0.002377) = 5.23 \times 10^{-3} \text{ slug}$$

The weight of this air is

$$W_{air} = (5.23 \times 10^{-3})(32.2) = 0.168 \text{ lb}$$

This is the lifting force on the balloon due to the outside air. However, the helium inside the balloon has weight, acting in the downward direction. The weight of the helium is less than that of air by the ratio of the molecular weights

$$W_{H_e} = (0.168)\frac{4}{28.8} = 0.0233 \text{ lb}.$$

Hence, the maximum weight that can be lifted by the balloon is

$$0.168 - 0.0233 = \boxed{0.145 \text{ lb}}$$
