CH 12 SOLUTIONS.

1. $\rho_{\text{OCEAN WATER}} = 1.03\,\text{gm/cc}$

$P = P_0 + \rho g h$

P_0 = SEA LEVEL ATMOSPHERIC PRESSURE $= 1.013 \times 10^5\, N/m^2$ [PA]
$= 14.70\ \#/IN^2$

$P = P_0 + 1.03 \times 10^3 \frac{kg}{m^3} \cdot 9.8 \frac{m}{s^2} \cdot 200\,m$

$$\boxed{= 2.1 \times 10^6\, PA = 3.1 \times 10^2\ \#/IN^2}$$

AT AN ALTITUDE OF 10 MILES = 16.1 Km
FROM CLASS

$P = P_0\, e^{-h/8200\,m}$ $P_0 = 1.013 \times 10^5 PA$

$= P_0\, e^{-\frac{16.1 \times 10^3 m}{8200\,m}}$

$$\boxed{= 1.4 \times 10^4\, PA = 2.0\ \#/IN^2}$$

2. (a) FOLLOW WHAT WE DID IN CLASS ON TUESDAY —

BY PASCAL'S LAW (HYDROSTATIC EQUILIBRIUM)

$$\frac{dP}{dy} = -\rho g$$

THE IDEAL GAS LAW IS $\rho = \frac{mP}{k_B T}$

USING

AVERAGE

$m \equiv$ MASS OF INDIVIDUAL AIR MOLECULES

$K_B \equiv$ BOLTZMANN'S CONSTANT

THEN

$$\frac{dP}{dy} = -\rho g = \frac{-mg}{K_B T} P$$

AND

$$\int_{P_0}^{P} \frac{dP}{P} = -\int_{h_0}^{h} \frac{mg}{K_B T} dy$$

BUT INSTEAD OF AN ISOTHERMAL TROPOSPHERE WE USE $T = T_E - \beta y$

BUT STILL TAKE $g \approx$ CONSTANT

$$\ln \frac{P}{P_0} = \frac{-mg}{K_B} \int_{h_0}^{h} \frac{dy}{(T_E - \beta y)}$$

$$= -\frac{mg}{\beta K_B} \ln (T_E - \beta y) \Big|_{h_0}^{h}$$

TAKING $h_0 \equiv 0\,m$ = SEALEVEL

$$\boxed{P = P_0 \left(\frac{T_E}{T_E - \beta h} \right) e^{-\frac{mg}{\beta K_B}}}$$

(b) USING $T_E = 293K$, $h = 35000\,ft = 10668m$

$m = 29\,AMU \cdot 1.67 \times 10^{-27} Kg/AMU$

$K_B = 1.38 \times 10^{-23}\, J/K \qquad \beta = 6K/10^3 m$

$$\frac{mg}{\beta K_B} = 5.73$$

So $$P = P_0 \left[\frac{293K}{(293K - (6 \times 10^{-3} K/m)h} \right]^{-5.73}$$

$$= (1.28)^{-5.73} P_0$$

$$\boxed{= 0.24 \text{ ATMOSPHERES} \doteq 2.5 \times 10^4 \text{ PA}.}$$

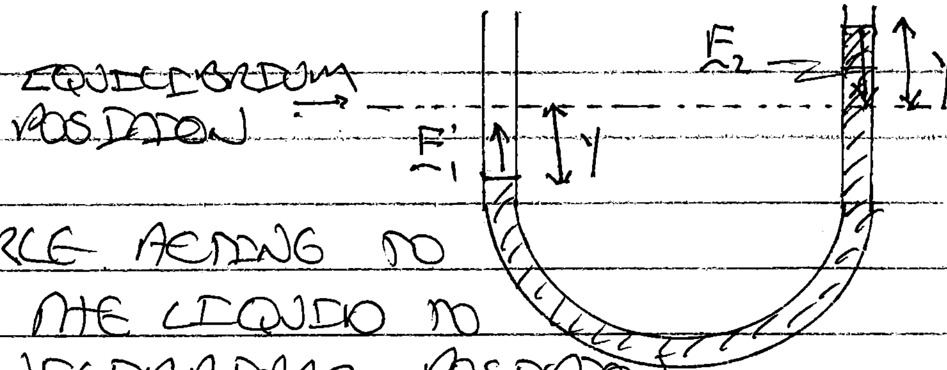
(c) IN CLASS WE ASSUMED AN AVERAGE VALUE

$T = 280K = 7°C$

FOR $P = P_0 e^{-h/8200m}$

$$= P_0 e^{-\frac{10668}{8200}} = 0.27 P_0$$

$$\boxed{\begin{aligned} &= 0.27 \text{ ATMOSPHERES} = \\ &= 2.8 \times 10^4 \text{ PA}. \end{aligned}}$$



(3) THE FORCE ACTING TO RESTORE THE LIQUID TO ITS EQUILIBRIUM POSITION IS.

$$F = F_1 + F_2 = 2PA = 2(\rho g y)A = ma.$$

↳ $\rho g y A$ ON EACH SIDE OF THE TUBE.

$$ma = [\rho(AL)]\frac{d^2y}{dt^2} = 2\rho g A y$$

$$\frac{d^2y}{dt^2} = \frac{2g}{L}\,y$$

SO $\omega^2 = \frac{2g}{L}$ $\quad \boxed{T = \frac{2\pi}{\omega} = \pi\left(\frac{2L}{g}\right)^{1/2}}$

4 ASSUMING THE AREA OF THE CONTAINER >> THE AREA OF THE TUBE THE LEVEL IN THE CONTAINER WILL DROP VERY SLOWLY SO THE VELOCITY OF THE FLUID IN THE CONTAINER IS $\simeq 0$.
BERNOULLI'S EQUATION GIVE.

$$(P_{CONTAINER} - P_{h_1}) + \rho g (0 - h_1) + \frac{1}{2}(V_{CONTAINER}^2 - V_{h_1}^2) = 0$$

WHERE THE SUBSCRIPTS REFER TO THE VALUES IN THE TUBE AT HEIGHT h_1.

$P_{CONTAINER} = P_0$

$V_{CONTAINER} \sim 0$

ALSO FLOW WILL STOP IF $V_{h_1} = 0$

SO

$$P_0 - P_{h_1} - \rho g h_1 \geq 0 \quad *$$

THE MINIMUM VALUE OF $P_{h_1} = 0$

SO $\quad P_0 \geq \rho g h_1$

OR

$$\boxed{h_1 \leq P_0 / \rho g}$$

SO h_1 MAX $\simeq 10.3$ m FOR H_2O AT STP

*WE IGNOR THE IMPORTANT FACT THAT H_2O AT STP TURNS TO VAPOR BEFORE $P_{h_1} \to 0$.