13-5

SPECIFIC GRAVITY $= \frac{\rho}{\rho_{water}} = \frac{\rho \cdot V}{\rho_{water} \cdot V} = \frac{m}{m_{water}}$

$m = 89.22g - 35g = 54.22g$

$m_{water} = 98.44 - 35g = 64.44g$

SO $S.G. = \frac{54.22g}{64.44g} = \boxed{0.84}$

13-15

(A) $P = P_0 + \rho g h = 1.013 \times 10^5 N/m^2 + (1000 kg/m^3)(10 m/s^2)(1.8 m)$

$P = 1.19 \times 10^5 N/m^2$

$F = P \cdot A = (1.19 \times 10^5 N/m^2)(28 m \cdot 8.5 m) = \boxed{2.8 \times 10^7 N = F}$

(B) AT THE BOTTOM THE PRESSURE ON THE SIDE IS THE SAME AS ON THE BOTTOM.

13-18

(a) MASS $= \pi r^2 h \rho = \pi (0.003 m)^2 (12 m)(1000 kg/m^3)$

$\boxed{m = 0.34 \text{ kg}}$

(b) $P = \rho g h = (1000 kg/m^3)(10 m/s^2)(12 m) = 120{,}000 Pa$

$F = P \cdot A = (120{,}000 N/m^2)(\pi \cdot (0.21 m)^2) = 1.7 \times 10^4 N$

$\boxed{F = 1.7 \times 10^4 N}$

13-27

THE CHANGE IN WEIGHT IS DUE TO THE BOUYANCY FORCE, WHICH IS EQUAL TO THE MASS OF THE DISPLACED WATER TIMES g

$$\rightarrow \quad (M_{actual})g - (M_{apparent})g = M_{\substack{\text{WATER} \\ \text{DISPLACED}}}\, g$$

SO

$$M_{ACT.} - M_{APP} = \underset{\substack{\uparrow \\ \rho_{WATER} \cdot V_{ROCK}}}{M_{WD}} = \rho_{WATER} V_{ROCK}$$

BUT $\quad V_{ROCK} = \dfrac{M_{ACT}}{\rho_{ROCK}}$

SO

$$\rho_{ROCK} = \rho_{WATER}\left(\frac{M_{ACT}}{M_{ACT} - M_{APP}}\right)$$

$$= \left(1\times10^{3}\ \text{kg/m}^3\right)\left(\frac{9.28\ \text{kg}}{9.28\ \text{kg} - 6.18\ \text{kg}}\right) = \boxed{2990\ \text{kg/m}^3}$$

13-33

FOR THE DRUM TO FLOAT ITS TOTAL WEIGHT MUST BE LESS THAN THE BOYANCY FORCE

$$F_B = \rho_w V_{DRUM}\, g = W_{STEEL} + W_{gas}$$

$$\downarrow$$

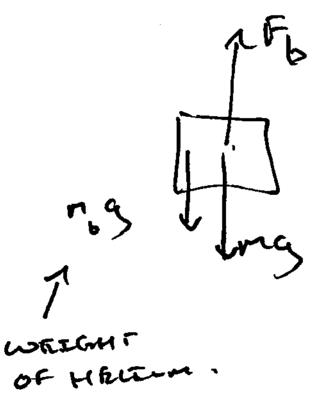
$$\rho_w (V_{STEEL} + V_{gas}) g = V_{STEEL}\,\rho_{STEEL}\, g + V_{gas}\,\rho_{gas}\, g$$

$$V_{STEEL} = V_{gas}\left(\frac{\rho_w - \rho_{gas}}{\rho_{steel} - \rho_w}\right) = (230L)\left(\frac{1000\,kg/m^3 - 680\,kg/m^3}{7800\,kg/m^3 - 1000\,kg/m^3}\right)$$

$$\boxed{V_{STEEL} = 1.1 \times 10^{-2}\, m^3}$$

10-39

NEGLECT THE MASS OF THE BALLOONS (ONLY CONSIDER THE MASS OF THE HELIUM)



$$\Sigma F_y = F_b - mg - m_b g = 0$$

$$F_b - mg = m_b g$$

BUT $F_b = n\rho_{AIR} V g$ AND $m_b = n\rho_{He} V$

\# OF BALLOONS

V = VOLUME OF 1 BALLOON

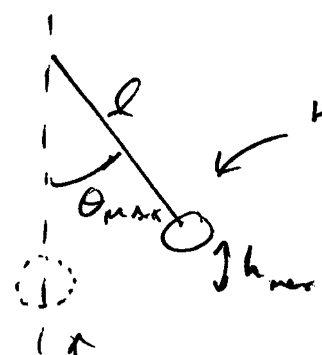
SO

$$n\rho_{AIR} V g - mg = n\rho_{He} V g$$

$$n(\rho_{AIR} - \rho_{He})V = m \Rightarrow n = \frac{m}{(\rho_{AIR} - \rho_{He})V}$$

$$\boxed{n = 3588 \text{ BALLOONS}}$$

13-47 | CAREFUL HERE, YOU NEEDN'T THINK ABOUT THE PENDULUM AS AN OSCILLATOR TO DO THIS PROBLEM. ALL YOU NEED TO DO IS CONSERVE ENERGY



HERE $E = mgh_{max}$

$h_{max} = l - l\cos\theta$

HERE $E = \frac{1}{2}mv_{max}^2$

SO

$$\frac{1}{2}mv_{max}^2 = mgh_{max} = mg\,l(1-\cos\theta)$$

$$\boxed{v_{max} = \sqrt{2gl(1-\cos\theta)}}$$

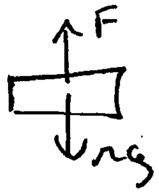
13-49 | USE BERNOULLI EQ

$$P_{ABOVE} + \frac{1}{2}\rho v^2 = P_{INSIDE}$$

$$\cancel{P_{ABOVE} - P_{INSIDE}} \quad P_{INSIDE} - P_{ABOVE} = \frac{1}{2}\rho v^2$$

THEN, FORCE ON ROOF IS

$$F = (P_{INSIDE} - P_{OUTSIDE})A = \frac{1}{2}\rho v^2 A$$

Roof →


$$\Sigma F_y = F - mg = 0$$ (MINIMUM F TO LIFT THE ROOF)

$$\rightarrow F = mg$$

$$\frac{1}{2}\rho v^2 A = mg = \text{WEIGHT}$$

$$\text{WEIGHT} = \frac{1}{2}(1.29\ \text{kg/m}^3)\left(180\ \frac{\text{km}}{\text{hr}}\right)\left(\frac{1\,\text{hr}}{3600\,\text{s}}\right)^2(6.2\,\text{m})(12.4\,\text{m})$$

$$\boxed{= 1.2 \times 10^5\ \text{N}}$$

13-54 | WATER IS INCOMPRESSIBLE SO WE CAN USE THE CONTINUITY EQ.

$$A_1 V_1 = A_2 V_2 \rightarrow \pi r_1^2 V_1 = \pi r_2^2 V_2 \rightarrow V_2 = \frac{R_1^2}{R_2^2} V_1$$

$$\boxed{V_2 = 2.2\ \text{m/s}}$$

FOR PRESSURE, USE BERNOULLI EQUATION.

$$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$$

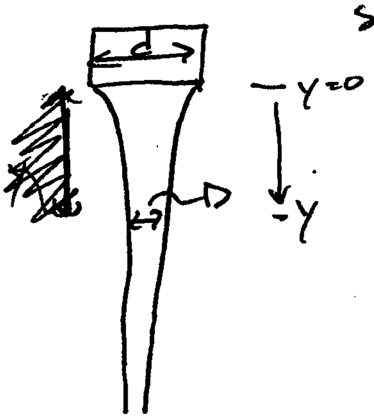
$$P_2 = P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 - \frac{1}{2}\rho v_2^2 - \rho g y_2$$

$$P_2 = (3.8)(1.013 \times 10^3\ \text{N/m}^2) + \frac{1}{2}(1000\ \text{kg/m}^3)(0.68\ \text{m/s})^2 + 0$$
$$- \frac{1}{2}(1000\ \text{kg/m}^3)(2.2\ \text{m/s})^2 - (1000\ \text{kg/m}^3)(10\ \text{m/s}^2)(18\,\text{m})$$

$$\boxed{P = 2.0 \times 10^5\ \text{N/m}^2}$$ (~ 2 ATM)

13-95

WATER IS INCOMPRESSIBLE



SO $A_y v_y = A_0 v_0$

THEN $\left(\pi \left(\frac{d}{2}\right)^2\right) v_0 = \pi \left(\frac{D}{2}\right)^2 v_y$

SO $D^2 = d^2 \frac{v_0}{v_y}$

BUT WE DON'T KNOW v_y.

WE CAN FIND IT VIA BERNOULLI EQ.

$$P_0 + \frac{1}{2}\rho v_0^2 + \rho g y_0 = P_0 + \frac{1}{2}\rho v_y^2 + \rho g y$$

$$v_y^2 = v_0^2 + 2gy_0 - 2gy$$

$$v_y = \sqrt{v_0^2 + 2g(y_0 - y)}$$

SO

$$D^2 = d^2 \frac{v_0}{\sqrt{v_0^2 + 2g(y_0 - y)}}$$

~~BUT $y_0 = 0$ SO~~ $(y_0 - y) = y$

$$\boxed{D = d\sqrt{\frac{v_0}{(v_0^2 + 2gy)^{1/2}}}}$$

14-13/

(a) For A: $A = 2.5\,m$

For B: $A = 3.5\,m$

(c) A: $T = 4s$ (b) $f = \frac{1}{4s} = 0.25\,Hz$

B: $T = 2s$ $f = \frac{1}{2s} = 0.5\,Hz$

(d) For A: $x(0) = 0$, $x(1s) = 2.5\,m$

so $x(t) = (2.5\,m)\cos\left((0.25\,Hz)2\pi t - \frac{\pi}{2}\right)$

For B: $x(0) = 3.5\,m$ AND $x(0.5s) = 0$

so $x(t) = (3.5\,m)\cos\left((0.5\,Hz)2\pi t\right)$

14-18/ $f = 441\,Hz$, $A = 1.5\,mm$

$\omega = 2\pi(441) =$

(a) so, $x(t) = (1.5\,mm)\cos\left(2\pi(441)t + \phi\right)$

$V(t) = \frac{dx}{dt} = -(2\pi)(441)(1.5\,mm)\sin\left(2\pi(441)t + \phi\right)$

THAN $V_{max} = (2\pi)(441\,1/s)(1.5\,mm) = 4200\,mm/s$

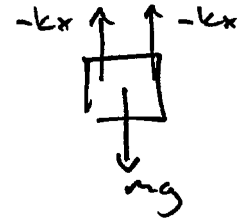
$\boxed{V_{max} = 4.2\,m/s}$

(b) $a(t) = \frac{d^2x}{dt^2} = -(2\pi)^2(441)^2(1.5)\cos\left(2\pi(441)t + \phi\right)$

AND $a_{max} = (2\pi)^2(441)^2(1.5) = 1.2\times10^{7}\,mm/s^2$

$\boxed{a_{max} = 1.2\times10^{4}\,m/s^2}$

14-24/ FBD



$\downarrow x$ (TRUST ME!)

$$\sum F_x = -2kx + mg = ma = m\frac{d^2x}{dt^2}$$

SO, ISOLATING TERMS CONTAINING x WE GET

$$mg = m\frac{d^2x}{dt^2} + 2kx$$

$$\rightarrow \frac{d^2x}{dt^2} + \frac{2k}{m}x = g$$

BECAUSE THE RIGHT SIDE IS NOT ZERO, THIS IS AN "INHOMOGENEOUS" DIFFERENTIAL EQUATION. BUT THIS DOESN'T CHANGE ω, ONLY THE EQUILIBRIUM POSITION.

SO $\omega^2 = \frac{2k}{m} \rightarrow \boxed{\omega = \sqrt{\frac{2k}{m}}}$

SAME AS IT WOULD BE IF WE HAD ONE SPRING WITH CONSTANT $2k$

14-41

PERIOD IS GIVEN BY

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{\ell}{g}}$$

SO ON EARTH

$$T_{\oplus} = 2\pi\sqrt{\frac{\ell}{g_{\oplus}}}$$

AND ON MARS

$$T_{MARS} = 2\pi\sqrt{\frac{\ell}{g_{MARS}}}$$

THEN,

$$\frac{T_{mars}}{T_{\oplus}} = \frac{2\pi\sqrt{\frac{\ell}{g_{mars}}}}{2\pi\sqrt{\frac{\ell}{g_{\oplus}}}} = \sqrt{\frac{g_{\oplus}}{g_{mars}}}$$

AND $T_{mars} = T_{\oplus}\sqrt{\frac{g_{\oplus}}{g_{mars}}} = (1.35\,s)\sqrt{\frac{g}{0.37g}}$

$$\boxed{T_{mars} = 2.2\ s}$$

14-43 WE CAN TAKE THE RELEASE TIME AS $t=0$ THEN, ASSUMING SIMPLE HARMONIC MOTION WE HAVE AN EQUATION FOR θ $\theta(t) = \theta_0 \cos(\omega t)$

$13°$ $\qquad \sqrt{\frac{g}{\ell}}$

(A) $\theta(t=0.35s) = (13°)\cos\left(\sqrt{\frac{g}{0.3m}}\cdot 0.35\,s\right) = -5.4°$

(B) $\theta(t=3.45s) = (13°)\cos\left(\sqrt{\frac{g}{0.3m}}\cdot 3.45\,s\right) = 8.4°$

(C) $\theta(t=6\,s) = (13°)\cos\left(\sqrt{\frac{g}{0.3m}}\cdot 6\,s\right) = -13°$

15-41 $v = \lambda f \rightarrow \lambda = \frac{v}{f}$

SO

AM $\frac{3\times10^8 \text{ m/s}}{550{,}000 \text{ Hz}}$ to $\frac{3\times10^8 \text{ m/s}}{1{,}600{,}000 \text{ Hz}}$

$$\boxed{\lambda_{AM} = 545 \text{ m} \text{ to } 188 \text{ m}}$$

FM $\frac{3\times10^8 \text{ m/s}}{88\times10^6 \text{ Hz}}$ to $\frac{3\times10^8 \text{ m/s}}{108\times10^6 \text{ Hz}}$

$$\lambda_{FM} = 3.4 \text{ m} \text{ TO } 2.8 \text{ m}$$

15-24 $D = (0.22)\sin(5.6x + 34t) = A\sin(kx + \omega t)$

(a) $\lambda = \frac{2\pi}{k} \rightarrow k = 5.6$, so $\boxed{\lambda = 1.1 \text{ m}}$

(b) $f = \frac{\omega}{2\pi} \rightarrow \omega = 34$, so $\boxed{f = 5.4 \text{ Hz}}$

(c) $v = \lambda f = \frac{\omega}{k} = \frac{34}{5.6} = \boxed{6 \text{ m/s} = v}$

~~BUT~~ WAVE IS TRAVELING IN $-x$ DIRECTION.

(d) $\boxed{A = 0.22 \text{ m}}$

(e) MINIMUM SPEED IS ZERO.

$v = \frac{\partial D}{\partial t} = (0.22\text{m})(34 \frac{\text{rad}}{\text{s}})\cos(5.6x + 34t)$

so $v_{max} = 7.5 \text{ m/s}$

15-22

(A) $D(x,t) = (0.015\,m)\sin(\cancel{2}5x - 1200t)$

IS A RIGHT (TOWARD $+x$) TRAVELING WAVE.

THEN

$$D'(x,t) = (0.015\,m)\sin(25x + 1200t)$$

IS THE SAME BUT TRAVELING TO THE LEFT (TOWARD $-x$)

(B) THE SPEED OF A WAVE IS GIVEN BY

$$V = \frac{\omega}{k} = \frac{1200\,rad/s}{25\,\frac{rad}{m}} = \boxed{48\,m/s}$$

15-43

THE FUNDAMENTAL FREQUENCY OF 441 Hz ~~CAN BE~~ CORRESPONDS TO A WAVE OF $\lambda = 2\ell$

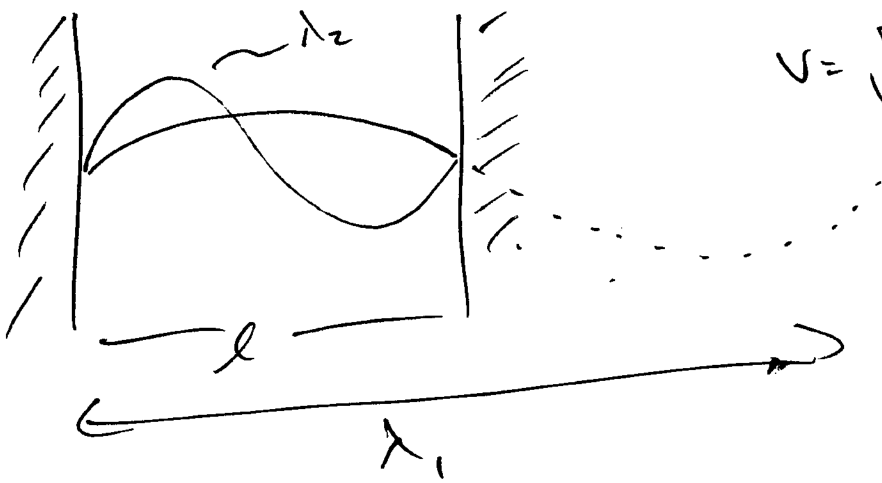
SO $f_{\text{unfingered}} = \dfrac{v}{2\ell}$

BY APPLYING A FINGER THE FUNDAMENTAL MODE IS

$$f_{\text{fingered}} = \frac{v}{2(\frac{2}{3}\ell)} = \left(\frac{3}{2}\right)\frac{v}{2\ell} = \frac{3}{2}(441\ \text{Hz})$$

$$\boxed{f_{\text{fingered}} = 662\ \text{Hz}}$$

15-51



$$v = \sqrt{\frac{F_T}{\mu}} = \lambda f$$

$$f = \frac{v}{\lambda}$$

THE FUNDAMENTAL WAVELENGTH IS $\lambda_1 = 2\ell$

THE FIRST HARMONIC WAVELENGTH IS $\lambda_2 = \ell$

$\lambda_3 = \frac{2}{3}\ell$

SO $\lambda_n = \dfrac{2\ell}{n}$ $\quad n = 1, 2, 3 \ldots$

SO

$$f_n = \frac{v}{\lambda_n} = \frac{n}{2\ell}\,\cancel{\ \ } = \sqrt{\frac{F_T}{\mu}}\left(\frac{n}{2\ell}\right)$$