Problem 1

a) $V = \frac{NkT}{p}$, $V_{NEW} = \frac{NkT}{10} = \frac{10}{3} \cdot \frac{NkT}{p}$, $\Rightarrow$ $V$ goes up

b) (i) $F = mg = 8(10) = 80N$
(ii) $F_{Buoy} = (1000)(0.002)(10) = 20N$
$\therefore F = 80 - 20 = 60N$

c) Velocity goes down, pressure goes up.

Problem 2

a) Equilibrium, so $F_{Buoyant} - w = 0 \Rightarrow F_B = w$. $F_B = V_f \rho_f g = (\pi r^2 d)\rho g = w$, $d = \frac{w}{\pi r^2 \rho g}$

b) $F_{TOT} = Ma = F_B - w$, $F_B = \pi r^2 (\frac{d}{2})\rho g = d(\frac{\pi r^2 \rho g}{2})$
From (a), $d = \frac{w}{\pi r^2 \rho g} \Rightarrow F_B = \frac{w}{\pi r^2 \rho g} (\frac{\pi r^2 \rho g}{2}) = \frac{w}{2}$
Half as deep $\Rightarrow$ half as large buoyancy force. $F_{TOT} = Ma = \frac{w}{2} - w = -\frac{w}{2}$, $a = \frac{-w}{2m}$, but $w = Mg$.
$\Rightarrow a = \frac{-g}{2}$, accelerating downward at $\frac{g}{2}$.

Problem 3

a) $P + \rho g y = \text{constant}$, $P_1 + \rho g(0) = P_2 + \rho g(6500)$ $P_2 = P_1 - \rho g(y_2) = 1.013 \times 10^5 - (0.95)(9.8)(6500)$, $P_2 = 4.08 \times 10^4 N/m^2 = 0.40\ atm$

b) $N = \text{const, } V = \text{const, } PV = NkT$
$\Rightarrow \frac{P_2}{T_1} = \frac{P_2}{T_2}$, $T_1 = 293$, $P_1 = 1.5 \times 10^7$, $T_2 = 253$, $P_2 = \frac{P_1 T_2}{T_1} = 1.30 \times 10^7 N/m^2$

Problem 4

ii) $f$ exerts torque around center of mass, so you fall over.
iii) Now $N$ exerts torque which can balance torque due to friction.

Problem 5
a) 

b) Take torques around toes: $MgL\cos(\theta) - F\left(\frac{2L}{3}\right)\cos(\theta) = 0$, $F = \frac{3}{4}Mg$

c) $T + F = Mg$, $T = \frac{1}{4}Mg$.

Problem 6
a) $3Mg + Mg = 4Mg$.
b) Take torques about left end: $4MgD - LMg = 0$, $D = \frac{L}{4}$.
Check torque around weight: $0 = D(3Mg) - Mg(L - D)$, $D(4Mg) = MgL$, $D = \frac{L}{4}$.

Problem 7
a) 

b) $\sum F_x = N_2 + N_1 \sin(\theta) - f_1 \cos(\theta) = 0$
$\sum F_y = f_2 - Mg + N_1 \cos(\theta) + f_1 \sin(\theta) = 0$

c) $\sum \tau = Mg\left(\frac{L}{4}\cos(\theta)\right) - N_1L = 0$.
d) $\sum \tau = N_2L \sin(\theta) + f_2L \cos(\theta) - Mg\frac{L}{4}\cos(\theta) = 0$.

Problem 8
a) $\tau = I\alpha$, take torques about hinge.
$(Mg)\left(\frac{L}{2}\right)(\sin(90^\circ)) = (\frac{ML^2}{4})(\alpha) \Rightarrow \alpha = \frac{2\tau}{\frac{L}{2}} = \frac{3g}{2L}$, $\alpha = \frac{3g}{2L}$.
b) $F = Ma_{cm}, \ a_{cm} = \alpha (\frac{L}{2})$, downward.

All forces and acceleration are vertical $\Rightarrow F_H = 0$.

$F_V = Mg = -Ma = -M\alpha (\frac{L}{2}) = -M(\frac{3g}{4})(\frac{L}{2}) = -\frac{3Mg}{4}$

$c) $Used fixed pivot:

$KE_I = 0, \ PE_I = MgL, \ KE_F = \frac{1}{2}I_{end}\omega^2, \ PE_F = Mg(\frac{L}{2})$. Work = 0.

$\frac{1}{2}(\frac{ML^2}{3})\omega^2 + Mg\frac{L}{2} = MgL, \ \frac{ML^2\omega^2}{6} = \frac{MgL}{2}, \ \omega^2 = \frac{3g}{L} \ or \ \omega = \sqrt{\frac{3g}{L}}$.

Used center of mass:

$KE_I = 0, \ KE_F = \frac{1}{2}Mv_{CM}^2 + \frac{1}{2}I_{CM}\omega^2, \ v_{CM} = \omega (\frac{L}{2})$

$KE_F = \frac{1}{2}M(\frac{L}{2})^2\omega^2 + \frac{1}{2}(\frac{ML^2}{12})\omega^2 = ML^2\omega^2(\frac{1}{8} + \frac{1}{24}) = ML^2\omega^2(\frac{3}{24} + \frac{1}{24}) = ML^2\omega^2(\frac{1}{6}) \Rightarrow$ Same answer.

**Problem 9**

a) $L$ is conserved: $mvR = (I_0 + mR^2)\omega_f$

$\omega_f = \frac{mvR}{I_0 + mR^2}$

b) $KE_I = \frac{1}{2}mv^2, \ KE_F = \frac{1}{2}(I_0 + mR^2)(\frac{mvR}{I_0 + mR^2})^2 = \frac{1}{2}(\frac{mv^2R^2}{I_0 + mR^2})$

$\frac{KE_F}{KE_I} = \frac{mR^2}{I_0 + mR^2}$

**Problem 10**

a) Left

b) Yes, gravity.

c) Out of the page; Counter-clockwise.

d) Yes, pivot force.

e) Out of the page; Counter-clockwise.

f) Out of the page.

**Problem 11**

Take clockwise to be positive. Angular momentum is conserved: $I\omega_I - mvfd = I\omega_f + mvfd$

$0.30\omega - 0.15(50)(0.8) = 0.3(0.35\omega) + 0.15(40)(0.8)$

$0.20\omega = 6 + 4.8 \Rightarrow \omega = 54rad/s$. Period = 0.12 sec.

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