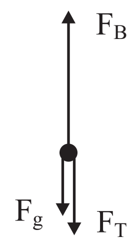
4. (a) $F_{g-apparatus} = F_{g-beaker} + F_{g-rubberball} + F_{g-water} = F_{g-beaker} + F_{g-rubberball} + \rho_{water} g V_{water}$

$F_{g-apparatus} = 2.0\text{ N} + 3.0\text{ N} + \left(1000\text{ kg/m}^3\right)\left(9.8\text{ m/s}^2\right)\left(5.0\text{ x }10^{-3}\text{ m}^3\right)$

$\boxed{F_{g-apparatus} = 54\text{ N}}$

(b)



(c) $F_B - F_g - F_T = 0$

$F_B - 3.0\text{ N} - 4.0\text{ N} = 0$

$\boxed{F_B = 7.0\text{ N}}$

(d) $P = \rho_{water} g h = \left(1000\text{ kg/m}^3\right)\left(9.8\text{ m/s}^2\right)\left(0.20\text{ m}\right)$

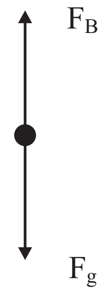
$\boxed{P = 1960\text{ Pa}}$

(e)

____ Higher _X_ Lower ____ The same

Some of the volume of the object that was displacing the water before the string was cut is now above the surface of the water, and therefore, not displacing the water. So the level of the water will fall as less water is now displaced by the rubber ball.

2. (a)



(b) $\Sigma F = F_B - F_g = 0 V_O$

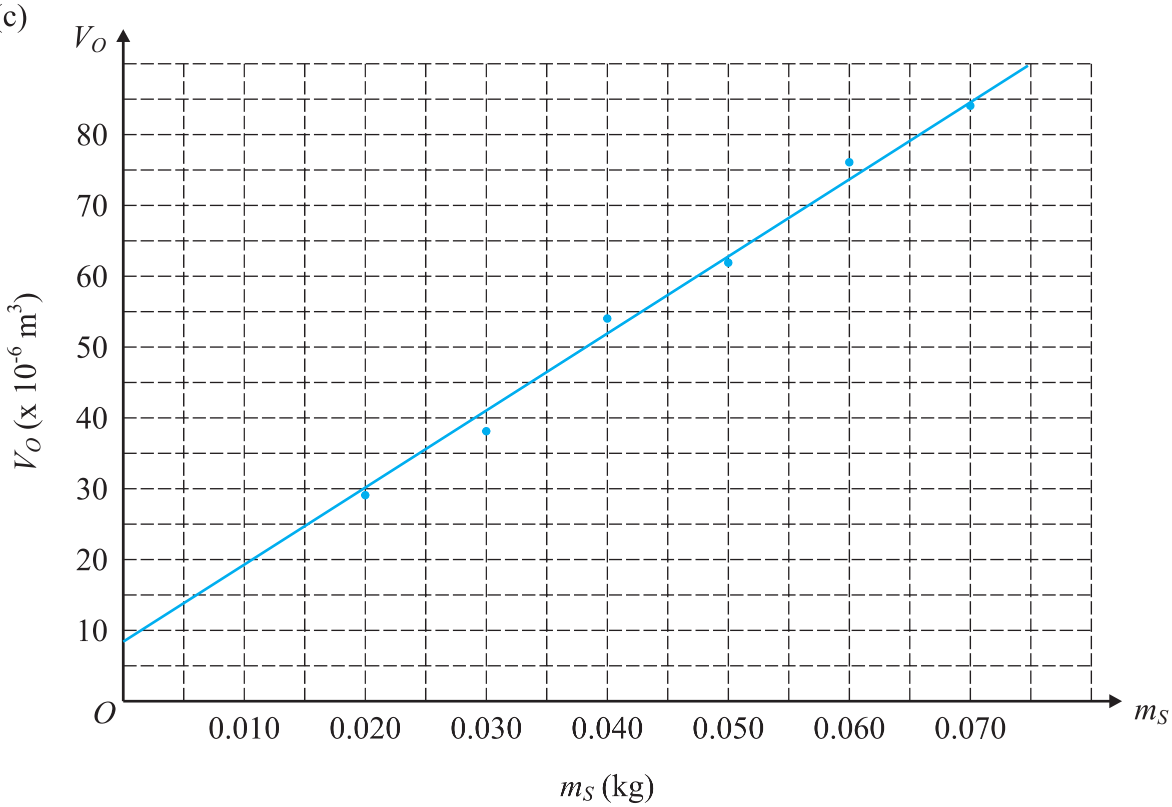
$\rho_O g V_O - m_S g = 0$

$\rho_O g V_O = (m_s + m_C) g$

$$\boxed{V_O = \frac{(m_s + m_C)}{\rho_O}}$$

Note: V_O, the volume of the overflow, is also the volume of the oil that is displaced by the cup.

(c)



(d) $V_O = \frac{(m_s + m_C)}{\rho_O}$, so $\rho_O = \frac{(m_s + m_C)}{V_O} = \frac{m_s}{V_O} + \frac{m_C}{V_O}$. The slope $= \frac{\Delta V_O}{\Delta m_s}$, so ρ_O is the reciprical of the slope.

$$\text{slope} = \frac{\Delta V_O}{\Delta m_s} = \frac{(90 \text{ x } 10^{-6} \text{ m}^3 - 8 \text{ x } 10^{-6} \text{ m}^3)}{(0.075 \text{ kg} - 0 \text{ kg})} = 0.00109 \text{ m}^3 / \text{kg}.$$

$$\boxed{\rho_O \text{ is } 1/\text{slope} = 915 \text{ kg} / \text{m}^3}$$

(e) the intercept of the line with the vertical axis is the volume of the oil displaced bythe mass of the cup.

4. (a) $e = \left|\frac{W}{Q}\right|$, so the rate of work (power) divided by the rate of heat delivered also gives the efficiency.

$$e = \left|\frac{W / \Delta t}{Q / \Delta t}\right|$$

$$0.12 = \frac{4.5 \text{ x } 10^6 \text{ W}}{\text{Q}}$$

$$\boxed{Q = 3.8 \text{ x } 10^7 \text{ W}}$$

(b) Since the locomotive is moving at a constant speed (no acceleration), the net force is zero. Therefore, the resistive forces are equal and opposite to the force from the engine.

$P_r = F \cdot v\cos\theta$

$4.5 \text{ x } 10^6 \text{ W} = F(7.0 \text{ m/s})\cos 180$

$$\boxed{F = -6.4 \text{ x } 10^5 \text{ N}}$$

(c)

i. The area bounded by the path *ABCDA* represents net work done (output) by the steam engine during each cycle.

ii. $W = A = l \cdot w = \left(3.0 \text{ x } 10^5 \text{ N/m}^2 - 1.0 \text{ x } 10^5 \text{ N/m}^2\right)\left(0.60 \text{ m}^3 - 0.20 \text{ m}^3\right) = 8.0 \text{ x } 10^4 \text{ J}$

$P = \left(8.0 \text{ x } 10^4 \text{ J}\right)\left(4 \text{ cycles/s}\right)$

$$\boxed{P = 3.2 \text{ x } 10^5 \text{ W}}$$

(d)

_X_ *AB* _X_ *BC* ____ *CD* ____ *DA*

4. (a) $n = \frac{m}{M} = \frac{2.2\text{ kg}}{0.018\text{ kg}} = 122\text{ moles}$

$PV = nRT_A$

$(3.0 \text{ x } 10^5\text{ Pa})(2.0\text{ m}^3) = (122\text{ moles})[8.31\text{ J}/(\text{mol}\cdot\text{K})]T_A$

$T_A = 592\text{ K}$

(b) $PV = nRT_C$

$(4.0 \text{ x } 10^5\text{ Pa})(2.5\text{ m}^3) = (122\text{ moles})[8.31\text{ J}/(\text{mol}\cdot\text{K})]T_C$

$T_C = 986\text{ K}$

(c)

_X_ Increase ___Decrease ___Remain the same

The temeprature at point *C* is greater than at point *A* as shown above. Therefore, the average kinetic energy, and thus the internal energy, increases.

(d) The work done for step $A \rightarrow B$ is zero since there is no change in volume (the gas has not done any work on the piston since there was no displacement of the piston). Therefore the work for step $B \rightarrow C$, calculated below, is the total work for the process $A \rightarrow B \rightarrow C$.

$W_{BC} = -P\Delta V = -(4.0 \text{ x } 10^5\text{ Pa})(2.5\text{ m}^3 - 2.0\text{ m}^3)$

$W_{BC} = -2.0 \text{ x } 10^5\text{ J}$

5. (a)

___ Yes _X_ No

Since the system is in equilibrium, the sum of the forces must be zero. There are three forces acting on each object (gravity down, tension up, and buoyant down). Since all three objects have the same mass, the force of gravity is the same for all three, but if they have different densities they will have different buoyant force since this force is directly proportional to density $\left(F_B = \rho_f g V_O\right)$. Therefore, the tension in each string may be different.

(b) $\sum F = F_T + F_B - F_g = 0$

$F_T + F_B - \rho_O V_O g = 0$

$F_B = \left(1300 \text{ kg/m}^3\right)\left(1.0 \text{ x } 10^{-5} \text{ m}^3\right)\left(9.8 \text{ m/s}^2\right) - 0.0098 \text{ N}$

$\boxed{F_B = 0.12 \text{ N}}$

(c) $F_B = \rho_f g V_O$

$0.12 \text{ N} = \rho_f \left(9.8 \text{ m/s}^2\right)\left(1.0 \text{ x } 10^{-5} \text{ m}^3\right)$

$\boxed{\rho_f = 1200 \text{ kg/m}^3}$

(d)

_X_ Increase ___ Decrease ___ Remain the same

The upward bouyant force depends on the volume of the object submerged in the fluid. Since only half of the object is now submerged in the fluid, the buoyant force will be half. The downward force due to gravity is unaffected by this change, so the tension will increase since the system remains in equilibrium (net force must equal zero).

4. (a) $v_y{}^2 = v_{yo}{}^2 + 2g(y - y_o)$

$0 = v_{yo}{}^2 + 2(-9.8\ \text{m/s}^2)(0.150\ \text{m}\ -\ 0\ \text{m})$

$v_{yo} = 1.71\ \text{m/s} = v_o \sin 50$

$\boxed{v_o = 2.24\ \text{m/s}}$

x	y
$v_{xo}=v_o\cos 50$	$v_{yo}=v_o\sin 50$
	y_o=0 m
	y=0.150 m
	g=-9.8 m/s2
	v_y=0 m/s

(b) $\dfrac{\Delta V}{\Delta t} = \dfrac{A\Delta x}{\Delta t} = Av = \pi r^2 v = \pi(4.00\ \text{x}\ 10^{-3}\ \text{m})^2(2.24\ \text{m/s})$

$\boxed{\dfrac{\Delta V}{\Delta t} = 1.13\ \text{x}\ 10^{-4}\ \text{m}^3/\text{s}}$

(c) $A_1 v_1 = A_2 v_2$

$\pi r_1{}^2 v_1 = \pi r_2{}^2 v_2$

$(7.00\ \text{x}\ 10^{-3}\ \text{m})^2 v_1 = (4.00\ \text{x}\ 10^{-3}\ \text{m})^2(2.24\ \text{m/s})$

$v_1 = 0.731\ \text{m/s}$

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

$P_1 + 0 + \frac{1}{2}(1000\ \text{kg/m}^3)(0.731\ \text{m/s})^2$

$= (1.01\ \text{x}\ 10^5\ \text{Pa}) + (1000\ \text{kg/m}^3)(9.8\ \text{m/s}^2)(3.00\ \text{m}) + \frac{1}{2}(1000\ \text{kg/m}^3)(2.24\ \text{m/s})^2$

$P_1 = 1.326\ \text{x}\ 10^5\ \text{Pa} = P_G + 1.01\ \text{x}\ 10^5\ \text{Pa}$

$\boxed{P_G = 3.16\ \text{x}\ 10^4\ \text{Pa}}$

5. (a)

Process	W	Q	ΔU
A $\rightarrow$ B	0	+	+
B $\rightarrow$ C	-	+	0
C $\rightarrow$ A	+	-	-

(b) There is no work done for process A $\rightarrow$ B because volume remains constant so no work is done on or by the helium gas. According to the ideal gas law, $PV = nRT$. During this process since pressure is increasing at a constant volume (with the number of moles remaining constant), so the temperature is increasing. Thus, heat is being added during this process as $Q = nC_V \Delta T$. Finally, according to the first law of thermodynamics, $\Delta U = Q + W$. Since Q is positive (heat is added to the system) and W is zero, ΔU must be positive.

(c) Since process B $\rightarrow$ C is an isothermic (constant temperature) process and the number of moles is constant, Boyle's law applies.

$P_B V_B = P_C V_C$

$(5 \text{ atm})(0.01 \text{ m}^3) = (1 \text{ atm})V_C$

$\boxed{V_C = 0.05 \text{ m}^3}$

4. (a) $\frac{\Delta V}{\Delta t} = \frac{7.2 \text{ x } 10^{-4} \text{ m}^3}{(2 \text{ min})(60 \text{ s/min})}$

$$\boxed{\frac{\Delta V}{\Delta t} = 6.0 \text{ x } 10^{-6} \text{ m}^3 \text{/s}}$$

(b) $\frac{\Delta V}{\Delta t} = \frac{A\Delta l}{\Delta t} = A\frac{\Delta l}{\Delta t} = Av$

$6.0 \text{ x } 10^{-6} \text{ m}^3 \text{/s} = (2.5 \text{ x } 10^{-6} \text{ m}^2) \cdot v$

$$\boxed{v = 2.4 \text{ m/s}}$$

(c) $P_1 + \rho g h_1 + \frac{1}{2}\rho {v_1}^2 = P_2 + \rho g h_2 + \frac{1}{2}\rho {v_2}^2$

$1 \text{ atm} + (1.1 \text{ x } 10^3 \text{ kg/m}^3)(9.8 \text{ m/s}^2) \cdot h + 0 = 1 \text{ atm} + 0 + \frac{1}{2}(1.1 \text{ x } 10^3 \text{ kg/m}^3)(2.4 \text{ m/s})^2$

$$\boxed{h = 0.29 \text{ m}}$$

(d)

____X Left of the beaker   ____ In the beaker   ____ Right of the beaker

Since the hole is at the same height above the table, the time it takes for gravity to pull the liquid to the table below will be the same. However, a decrease in the height of the liquid will decrease the speed of the liquid as it exits the hole as shown by the Bernoulli Equation above. A decrease in this horizontal speed means the liquid will not travel as far horizontally in this time it takes for the liquid to hit the table.

5. (a) $P = \frac{F}{A}$

$$F = PA = P\pi r^2 = \left(4.0 \text{ x } 10^5 \text{ Pa}\right)\pi\left(0.10 \text{ m}\right)^2$$

$$\boxed{F = 1.3 \text{ x } 10^4 \text{ N}}$$

(b) $PV = nRT$

$$\left(4.0 \text{ x } 10^5 \text{ Pa}\right)V = \left(2.0 \text{ moles}\right)\left(8.31 \text{ J}/\left(\text{mol}\cdot\text{K}\right)\right)\left(300 \text{ K}\right)$$

$$\boxed{V = 0.012 \text{ m}^3}$$

(c) $W = F \cdot d = PA\Delta x = P\pi r^2 \Delta x = \left(4.0 \text{ x } 10^5 \text{ Pa}\right)\pi\left(0.10 \text{ m}\right)^2\left(0.15 \text{ m}\right) = P\Delta V$

$$\boxed{W = 1900 \text{ J}}$$

(d)

__x__ Heat is transferred to the gas.

____ Heat is transferred from the gas.

____ No heat is transferred in the process.

This gas expanded at constant pressure which means the temperature must increase according to the ideal gas law, $PV = nRT$, since volume is increasing. Therefore, heat would have to be added to the gas to increase its temperature so it can maintain the same pressure in a larger volume.

5. (a) i. $PV = nRT$, so $n = \frac{P_1V_1}{RT_2} = \frac{(1.0 \text{ x } 10^5 \text{ Pa})(0.25 \text{ m}^3)}{[8.31 \text{ J}/(\text{mol}\cdot\text{K})](373 \text{ K})} = 8.07$ moles

$P_2V_2 = nRT_2$

$(1.0 \text{ x } 10^5 \text{ Pa})(0.50 \text{ m}^3) = (8.07 \text{ moles})[8.31 \text{ J}/(\text{mol}\cdot\text{K})]T_2$

$T_2 = 746$ K

ii. $P_3V_3 = nRT_3$

$(1.5 \text{ x } 10^5 \text{ Pa})(0.25 \text{ m}^3) = (8.07 \text{ moles})[8.31 \text{ J}/(\text{mol}\cdot\text{K})]T_3$

$T_3 = 560$ K

(b) The net work done will equal the negative of the area of the triangle bounded by the three states in the *P*-*V* diagram.

$W_{\text{NET}} = -\frac{1}{2}bh = -\frac{1}{2}\Delta P\Delta V = -\frac{1}{2}(0.5 \text{ x } 10^5 \text{ Pa})(-0.25 \text{ m}^3)$

$W_{\text{NET}} = +6250$ J

(c)

____ Added   **X** Removed   ____ Neither added nor removed

Mathematical Justification: The change in internal energy during a complete cycle is zero since the cycle ends at the same state at which it starts. Further, $\Delta U = 0 = Q + W$, therefore, $Q = -W = -6250$ J. Since, Q is negative, heat is removed from the system.
Conceptual Justification: The positive work calculated above indicates that work was done on the system by the environment which tends to increase the internal energy during the cycle. However, the change in internal energy is zero for a complete cycle as mentioned above. Therefore, any work done on the system by the environment must have been countered by an equal loss of heat so the change in internal energy would be zero during a complete cycle.

5. (a) $\Sigma F = F_B - F_g = m_o a$

$\rho_f g V_o' - m_o g = 0$

$\rho_f g V_o' = \rho_o g V_o$

$\rho_f \not{g} \not{A} h_o' = \rho_o \not{g} \not{A} h_o$

$\frac{h_o'}{h_o} = \frac{\rho_o}{\rho_f}$

$\frac{h_o'}{0.22 \text{ m}} = \frac{650 \text{ kg/m}^3}{1000 \text{ kg/m}^3}$

$h_o' = 0.14$ m

Now, $h_o = h_o' + h$

$0.22 \text{ m} = 0.14 \text{ m} + h$

Note: V_o is the volume of the raft, while V_o' is the volume of the raft that is under the surface of the water.

Note: $\rho = \frac{m}{V}$, so $m = \rho V \begin{bmatrix} \rho_f = \text{density of the fluid (water)} \\ \rho_o = \text{density of the object (raft)} \end{bmatrix}$

Also, $V_o = Ah_o$, so $1.80 \text{ m}^3 = (8.2 \text{ m}^2)h_o$, thus $h_o = 0.22$ m

Finally, $V_o' = Ah_o'$.

$\boxed{h = 0.08 \text{ m}}$

(b) $F_B = \rho_f g V_o' = \rho_f g A h_o' = (1000 \text{ kg/m}^3)(9.8 \text{ m/s}^2)(8.2 \text{ m}^2)(0.14 \text{ m})$

$\boxed{F_B = 11,250 \text{ N}}$

(c) $\Sigma F = F_B - F_g - F_{gp} = m_o a$

$F_B - m_o g - n m_p g = 0$ where n = number of people

$F_B - \rho_o g V_o' = n m_p g$

$F_B - \rho_o g A h_o' = n m_p g$

$11{,}250\text{N} - (650 \text{ kg/m}^3)(9.8 \text{ m/s}^2)(8.2 \text{ m}^3)(0.14 \text{ m}) = n(75 \text{ kg})(9.8 \text{ m/s}^2)$

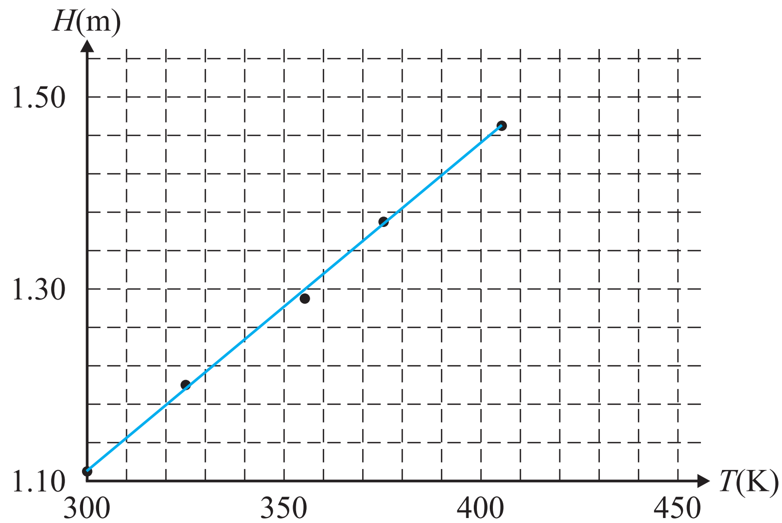
$\boxed{n = 5}$

6. (a) PV = nRT

$PAH = n\mathrm{R}T$

$$\boxed{H = \frac{n\mathrm{R}}{PA}T}$$

(b)



(c) Slope of graph, $m = \frac{\Delta y}{\Delta x} = \frac{\Delta H}{\Delta T} = \frac{H_2 - H_1}{T_2 - T_1} = \frac{1.47\ \mathrm{m} - 1.11\ \mathrm{m}}{405\ \mathrm{K} - 300\ \mathrm{K}} = 3.43 \times 10^{-3}\ \mathrm{m/K}$

From the relationship established in part (a) above, $H = \frac{n\mathrm{R}}{PA}T$, the slope $m = \frac{n\mathrm{R}}{PA}$.

$$3.43 \times 10^{-3}\ \mathrm{m/K} = \frac{n\left[8.31\ \mathrm{J/(k \cdot mol)}\right]}{\left(1.01 \times 10^{5}\ \mathrm{J}\right)\left(0.027\ \mathrm{m^2}\right)}$$

$$\boxed{n = 1.13\ \text{moles}}$$

2. (a) $P = P_a + P_G$

$413 \text{ atm} = 1 \text{ atm} + P_G$

$\boxed{P_G = 412 \text{ atm}}$

(b) $P_G = \rho g h$

$(412 \text{ atm})\bullet(1.0 \times 10^5 \text{ Pa/atm}) = (1025 \text{ kg/m}^3)\bullet(9.8 \text{ m/s}^2)\bullet D$

$\boxed{D = 4100 \text{ m}}$

(c) $P = \dfrac{F}{A}$, so $F = PA = (412 \text{ atm})\bullet(1.0 \times 10^5 \text{ Pa/atm})\bullet(0.0100 \text{ m}^2)$

$\boxed{F = 4.12 \text{ X } 10^5 \text{ N}}$

(d) $a = \dfrac{v - v_0}{t} = \dfrac{10.0 \text{ m/s} - 0 \text{ m/s}}{30.0 \text{ s}}$

$\boxed{a = 0.333 \text{ m/s}^2}$

(e) $x = x_0 + v_0 t + \frac{1}{2}at^2$

$x = 0 + 0 + \frac{1}{2}(0.333 \text{ m/s}^2)\bullet(30.0 \text{ s})^2$

$\boxed{x = 150 \text{ m}}$

(f) For the first 30.0 s (150 m), the ocean liner was accelerating. After this time, the ocean liner was falling at a constant speed of 10.0 m/s. It fell to a final depth of 4100 m [see answer to part (b) above].

$v = \dfrac{x - x_0}{t}$

$10.0 \text{ m/s} = \dfrac{4100 \text{ m} - 150 \text{ m}}{t}$

$t = 395 \text{ s}$

Therefore, the total time it took the ocean liner to sink from the surface to the bottom of the ocean is $t_T = 30.0 \text{ s} + 395 \text{ s}$

$\boxed{t_T = 425 \text{ s}}$

5. (a) i. $W = -P\Delta V = -(600\ N/m^2)(9.0\ m^3 - 3.0\ m^3)$

$W = -3600\ J$

ii. $PV_A = nRT_A$ $PV_B = nRT_B$

Subtracting these two equations of state give $P(V_B - V_A) = nR(T_B - T_A)$

$P\Delta V = nR\Delta T = 3600$ J because $P\Delta V = -W = -(-3600\ J) = 3600$ J

$$\Delta U = \frac{3}{2}nR\Delta T = \frac{3}{2}(3600\ J)$$

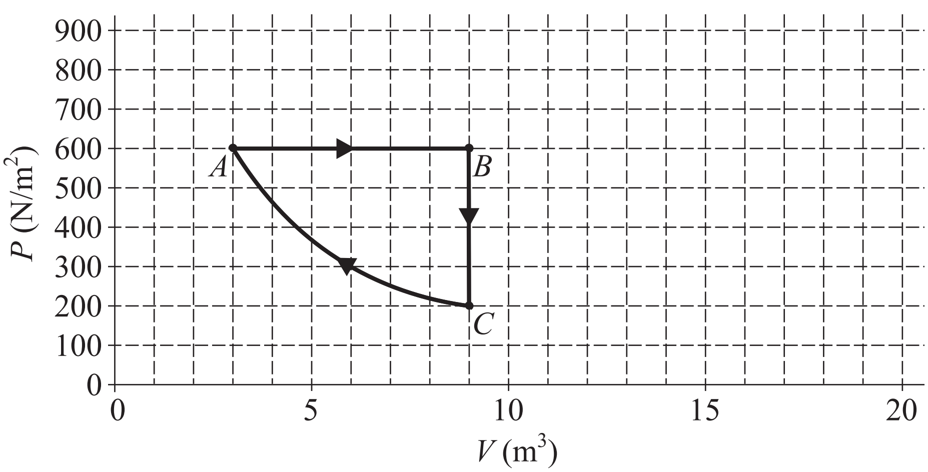
$\Delta U = 5400\ J$

iii. $\Delta U = Q + W$

$5400\ J = Q + (-3600\ J)$

$Q = 9000\ J$

(b)



(c) i.

ii.

_____ added to **X** _____ removed from

Since this compression is isothermal (no change in temperature), there is no change in internal energy. Therefore, since $\Delta U = Q + W$ and $\Delta U = 0$, then $Q = -W$. W is positive during a compression (because $W = -P\Delta V$ and ΔV is negative as the gas is compressed), so, Q has to be negative which means heat is removed from the system (gas).

5. (a) $\Delta U_{c\to a} = U_a - U_c = Q_{c\to a} + W_{c\to a} = 685\text{ J} + (-120\text{ J})$

$$\boxed{\Delta U_{c\to a} = 565\text{ J}}$$

(b) i.

____ added to the gas __X__ removed from the gas

ii. $\Delta U_{a\to b\to c} = Q_{a\to b\to c} + W_{a\to b\to c}$ Note: $\Delta U_{a\to b\to c} = -\Delta U_{c\to a} = -565\text{ J}$

$-565\text{ J} = Q_{a\to b\to c} + 75\text{ J}$

$$\boxed{Q_{a\to b\to c} = -640\text{ J}}$$

(c) $W_{c\to d\to a} = W_{c\to d} + W_{d\to a} = -P(\Delta V_{c\to d}) + [-P(\Delta V_{d\to a})]$

$W_{c\to d\to a} = 0\text{J} + \left\{-(6.0 \text{ x } 10^{-5}\text{ Pa})\left[(1.0 \text{ x } 10^{-3}\text{ m}^3) - (0.75 \text{ x } 10^{-3}\text{ m}^3)\right]\right\}$

$W_{c\to d\to a} = -150\text{ J}$

(d)

__X__ added to the gas ____ removed from the gas

The change in internal energy for path cda is positive (565 J) and the work is negative (-150 J) so the heat must be positive which means heat is added to the gas (715 J).

$\Delta U_{c\to d\to a} = Q_{c\to d\to a} + W_{c\to d\to a}$

$565\text{ J} = Q_{c\to d\to a} + (-150\text{ J})$

$Q_{c\to d\to a} = 715\text{ J}$

6. (a) $P_G = \rho g h = (1.025 \times 10^3 \text{ kg/m}^3)(9.8 \text{ m/s}^2)(35 \text{ m})$

$$\boxed{P_G = 3.5 \times 10^5 \text{ Pa}}$$

(b) $P_a = P_G + P_{atm} = 3.5 \times 10^5 \text{ Pa} + 1.0 \times 10^5 \text{ Pa}$

$$\boxed{P_a = 4.5 \times 10^5 \text{ Pa}}$$

(c) $\Sigma F = F_T + F_B - F_g = ma$ $\qquad \rho = \dfrac{m}{V}$ so $m = \rho V$

$F_T + \rho_f g V - mg = 0$ $\qquad V = l \times w \times h = (1.0 \text{ m})(2.0 \text{ m})(0.03 \text{ m}) = 0.06 \text{ m}^3$

$F_T + \rho_f g V - \rho_o V g = 0$

$F_T + (1.025 \times 10^3 \text{ kg/m}^3)(9.8 \text{ m/s}^2)(0.06 \text{ m}^3) - (2.7 \times 10^3 \text{ kg/m}^3)(0.06 \text{ m}^3)(9.8 \text{ m/s}^2) = 0$

$$\boxed{F_T = 985 \text{ N}}$$

(d)

__**X**__ increase ____ decrease ____ remain the same

The pull upward would have to increase to accelerate the plate upward. The acceleration would change from zero to a $+0.05 \text{ m/s}^2$.

$\Sigma F = F_T + F_B - F_g = ma$ $\qquad \rho = \dfrac{m}{V}$

$F_T + \rho_f g V - mg = ma$ $\qquad$ so $m = \rho V = (2.7 \times 10^3 \text{ kg/m}^3)(0.06 \text{ m}^3) = 162 \text{ kg}$

$F_T + \rho_f g V - \rho_o V g = ma$

$$F_T + (1.025 \times 10^3 \text{ kg/m}^3)(9.8 \text{ m/s}^2)(0.06 \text{ m}^3) - (2.7 \times 10^3 \text{ kg/m}^3)(0.06 \text{ m}^3)(9.8 \text{ m/s}^2) = (162 \text{ kg})(0.05 \text{ m/s}^2)$$

$$\boxed{F_T = 993 \text{ N}}$$

6. (a) Method One-With the metric ruler measure the position of the bottom of the spring in relation to the table top. Hang the mass, *m*, from the spring allowing the spring to stretch to an equilibrium position, and measure the new position of the bottom of the spring with respect to the table top. Subtract this new position of the bottom of the spring from its original position to determine the distance the spring stretched which will be called Δx. Use the following mathematical argument to determine the spring constant:

$\Sigma F = F_s - F_g = ma$

$\Sigma F = k\Delta x - mg = 0$

$$k = \frac{mg}{\Delta x}$$

Method Two-Hang the mass, *m*, from the spring allowing the spring to stretch to an equilibrium position, pull the mass a small additional distance and release such that the mass oscillates in simple harmonic motion, and measure the time for ten oscillations using the stopwatch. Determine the period, T, of the system by dividing the time for ten oscillations by ten. Determine the spring constant from the relationship

$$T = 2\pi\sqrt{\frac{m}{k}}.$$

(b) The distance the spring stretches, Δx_f, due to the weight will be less when the object is in the fluid than out of the fluid due to the buoyant force from the liquid on the object. Furthermore, the fluid that is displaced by the mass will rise in the beaker.

(c) The volume of the object can be determined in one of two ways. First, measure the change in volume of fluid in the beaker caused by the immersion of the object in the fluid. This measurement of volume change can be determined by using the equation for the voulme of a cylinder ($V = \pi r^2 \Delta h$), measuring the diameter of the beaker (r = ½ of this diameter), and the distance the fluid rose, Δh, in the beaker using the metric ruler. The change in volume of the liquid is caused by the displacement of the volume of the object. Secondly, the volume of the object can be calulated from the definition of density, $D = \frac{m}{V_o}$, to be $V_o = \frac{m}{D}$.

From the spring constant determined above and the distance the spring stretches, Δx_f, the apparent mass, *m'*, and apparent weight, *m'*g, can be determined using the following mathematical argument:

$\Sigma F = F_s - F_g' = ma$ (where F_g' is apparent weight)

$\Sigma F = k\Delta x_f - m'g = 0$

$m'g = k\Delta x_f$ - apparent weight

$m' = \frac{k\Delta x_f}{g}$ - apparent mass

Note: $F_g' = F_g - F_B$

$\Sigma F = F_s + F_B - F_g = ma$

$\Sigma F = k\Delta x_f + \rho_f g V_o - mg = 0$

$\rho_f g V_o = mg - k\Delta x_f$

$\rho_f g V_o = mg - m'g$ (where, $k\Delta x_f = m'g$)

$\rho_f g V_o = (m - m')g$

$\rho_f g \frac{m}{D} = (m - m')g$ $\left(\text{where } V_o = \frac{m}{D}\right)$

$$\boxed{\rho_f = D\left(\frac{m - m'}{m}\right)}$$

(d)

Symbol	Physical quantity
r	Radius of beaker (½ the diameter of the beaker)
Δh	Height of fluid rise in beaker
V_o	Volume of object (volume of fluid displaced)
Δx_f	Distance the spring stretches from the hanging mass while in the fluid
m	Mass of the object
m'	Apparent mass of the object when in the fluid
D	Density of the object
ρ_f	Density of the fluid

Use the equations described above to calculate density of the fluid.

6. (a) $P_2 = P_1 + \frac{F_g}{A}$ = 1.02 x 10^5 Pa + $\frac{(2.50kg)(9.8m/s^2)}{1.20x10^{-2}m^2}$

P_2 = 1.04 x 10^5 Pa

(b) $P_1V_1 = P_2V_2$
(1.02 x10^5 Pa)(1.50 x 10^{-3} m^3) = (1.04 x 10^5 Pa)V_2

V_2 = 1.47 x 10^{-3} m^3

(c) **X** Isobaric because the pressure on top of the piston has not changed. This must be equal in pressure to that of the gas in the cylinder. Therefore, the pressure of the gas in the cylinder has not chnaged during this process so it is isobatic. Furthermore, the temperature increases from 0°C to 100°C so it is **NOT** isothermal and heat is added to the gas from the boiling-water bath so it is **NOT** adiabatic.

(d) **X** No because the pressure on top of the piston has been reduced so the pressure of the gas within the cylinder is reduced to equalize the external pressure.

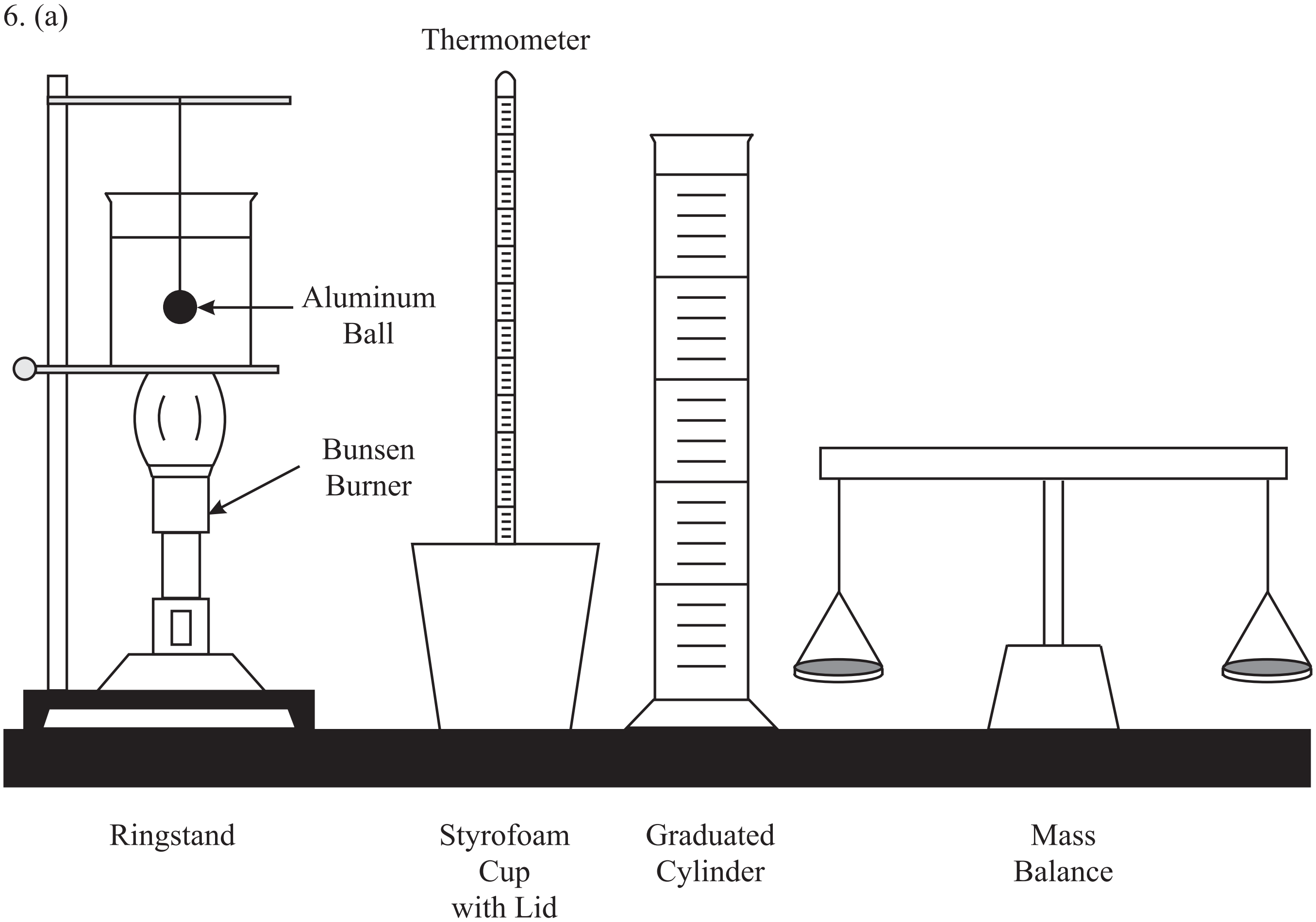
(e) The pressure is the same as stage 1. Use Charles' Law.

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$\frac{1.50X10^{-3}m^3}{273K} = \frac{V_2}{373K}$$

V_2 = 2.05 x 10^{-3} m^3

6. (a)



(b) m_B = mass of empty beaker
m_{BL} = mass of beaker and unknown liquid
m_{Al} = mass of aluminum ball
t_B = temperature of unknown liquid before adding hot aluminum ball
t_A = temperature of unknown liquid after adding hot aluminum ball when temperature is no longer rising

(c) $m_L = m_{BL} - m_B$
Heat Gained (Q_G) = - Heat Lost (Q_L)
$m_L c_L \Delta T_L = m_{AL} c_{AL} \Delta T_{Al}$
$m_L c_L (t_A - t_B) = m_{AL} c_{AL} (100° - t_A)$

(d) One possible source of error is the fact that the thermometer will absorb a small quantity of heat. This error will result in the calculated value for the specific heat for the unknown liquid (c_L) to be higher than the actual value. The thermometer is made of glass and alcohol, with most of its mass being the glass component. Furthermore, the majority of the heat absorbed by the thermometer is due to the glass. Therfore, to reduce this error, the mass of the thermometer could be taken and the specific heat of glass can be researched so that the heat absorbed by the thermometer can be determined and included in the calulations.

A second source of error is that the styrofoam is not a perfect insulator, thus, it will absorb some heat. To reduce this error, the mass of the the styrofoam cup could be taken and the specific heat of styrofoam cup can be researched so that the heat absorbed by the styrofoam cup can be determined and included in the calulations.