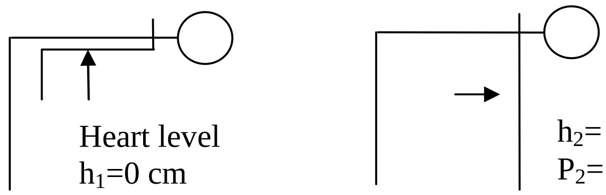
Freshman Clinic II
Hands on the Human Body!

CARDIOVASCULAR SYSTEM SUPPLEMENTAL HANDOUT

SAMPLE CALCULATIONS

1) Hydrostatic Pressure
   a) Stick Figures



   b) Calculate average blood pressure.

$$BP_{avg} = \frac{115\ \text{mmH}g + 2*60\ \text{mmH}g}{3} = 78.3\ \text{mmH}g$$

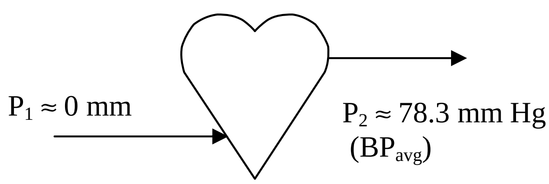
   c) Calculate predicted P_2.

$$P_2 - P_1 = -\rho g\left(h_2 - h_1\right)$$

$$P_2 = 78.3\ \text{mm Hg} - 1.056\frac{\text{g}}{\text{ml}}980\frac{\text{cm}}{\text{s}^2}\left(-30.48\ \text{cm} - 0\ \text{cm}\right)\left[\frac{7.5e-4\ \text{mm Hg}}{1\ \text{g/cm s}^2}\right]\left[\frac{1\ \text{ml}}{1\ \text{cm}^3}\right]$$

$$P_2 = 101.9\ \text{mm Hg}$$

2) Pump Work
   Note that the energy balance equation is for the work done by the circulation system on the surroundings. You are asked to calculate the work done by the heart on the circulation system.



   a) Pump Work

$$-\dot{W} = Q\Delta P$$

$$-\dot{W} = 4.9\frac{\text{L}}{\text{min}}\left(78.3\ \text{mm Hg} - 0\ \text{mm Hg}\right)\left[\frac{1\ \text{g/cm s}^2}{7.5e-4\ \text{mm Hg}}\right]\left[\frac{1000\ \text{cm}^3}{\text{L}}\right]\left[\frac{\text{min}}{60\ \text{s}}\right]$$

$$-\dot{W} = 8.529\ \text{x}10^6\ \frac{\text{g cm}^2}{\text{s}^3}$$

   Work done by heart is $+8.529\ \text{x}10^6\ \frac{\text{g cm}^2}{\text{s}^3}$

b) Unit Conversion

$$8.529 \text{ x}10^6 \frac{\text{g cm}^2}{\text{s}^3}\left[\frac{8.6 \text{ x } 10^{-8} \text{ kcal/h}}{\text{g cm}^2/\text{s}^3}\right] = 0.734\frac{\text{kcal}}{\text{h}}$$

c) Energy

$$\eta = \frac{\text{Mechanical work}}{\text{Energy expended}}$$

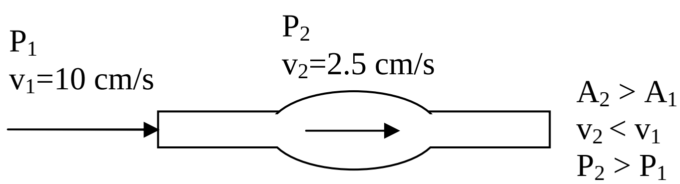
$$\eta \cong 0.1 \cong \frac{0.734 \text{ kcal/h}}{\text{EE}_\text{h}}$$

$$\text{EE}_\text{h} = 7.34 \text{ kcal/h}$$

Note: Could compare the heart's energy requirement to the total resting energy requirement from the Metabolism lab. The resting energy expenditure was on the order of 70 kcal/h (with person-to-person variations). The heart uses about 10% of the resting energy.

3) Interconversion of Kinetic energy and Pressure

a) Aneurysm



$$\frac{1}{2\alpha}\Delta v^2 \quad + \quad \frac{\Delta P}{\rho} \quad = 0$$

$$\frac{\rho}{2\alpha}\left(v_2^2 - v_1^2\right) \quad = \quad P_1 - P_2$$

$$\frac{1.056 \text{ g/cm}^3}{2(0.5)}\left[\left(2.5\frac{\text{cm}}{\text{s}}\right)^2 - \left(10\frac{\text{cm}}{\text{s}}\right)^2\right]\left[\frac{7.5e-4 \text{ mm Hg}}{1 \text{ g/cm s}^2}\right] = 78.3 \text{ mm Hg - } P_2$$

$$P_2 = 78.4 \text{ mm Hg}$$

Note: Hardly any increase in pressure during resting conditions.

b) If you expect the value of P2 to be much larger in part (b), you might be surprised. But it will increase somewhat; you will have a chance to think about the effect of this in Follow- up Question #1.