PHY101 HW 7 Solutions Fall 2017

(1) Using pressure $P = \frac{F}{A}$, the baby applies a pressure of

$$P_B = \frac{F_B}{A} = \frac{m_B g}{\underset{\text{three-legged}}{3}\left(\pi\left(\frac{d_B}{2}\right)^2\right)} = \frac{4 m_B g}{3\pi d_B^2}.$$

The adult applies a pressure of

$$P_A = \frac{F_A}{A} = \frac{m_A g}{\underset{\text{four-legged}}{4}\left(\pi\left(\frac{d_A}{2}\right)^2\right)} = \frac{m_A g}{\pi d_A^2}.$$

The ratio of $\frac{P_B}{P_A} = \frac{4 m_B g}{3\pi d_B^2}\frac{(\pi d_A^2)}{m_A g} = \frac{4 m_B d_A^2}{3 m_A d_B^2} = \frac{4(10\,kg)(0.06\,m)^2}{3(60\,kg)(0.02\,m)^2} = 2.0,$

So the baby applies twice the pressure of the adult!

(2) Pascal's principle tells us that a change in pressure at any point in a confined fluid is transmitted everywhere throughout the fluid.

In other words, $\underbrace{P_L}_{\text{large}} = \frac{F_L}{A_L} = \frac{F_s}{A_s} = \underbrace{P_s}_{\text{small}}$.

(a) $$F_s = \frac{A_s F_L}{A_L} = \left(\frac{A_s}{A_L}\right) F_L = \frac{\pi r_s^2}{\pi r_L^2} F_L = \frac{(.025\,m)^2}{(.1\,m)^2}\left(10 \times 10^3\,N\right) = 625\,N.$$

(b) The work done by each piston must be equal because the fluid is not compressible, i.e. the volume of the fluid displaced by each piston is the same so $A_L d_L = A_s d_s$. Then start with

$$\frac{F_L}{A_L} = \frac{F_s}{A_s} \quad \text{and multiply the RHS by } \frac{A_s d_s}{A_L d_s} = 1,$$

or $$\frac{F_L}{A_L} = \frac{F_s}{A_s}\frac{A_s d_s}{A_L d_L} \Longrightarrow \frac{F_L \cancel{A_L} d_L}{\cancel{A_L}} = \frac{F_s}{\cancel{A_s}} \cancel{A_s} d_s \Longrightarrow \underbrace{F_L d_L}_{\substack{\text{work}\\\text{done}\\\text{by}\\\text{large}\\\text{piston}}} = \underbrace{F_s d_s}_{\substack{\text{work}\\\text{done by}\\\text{small}\\\text{piston.}}}$$

Then, $W_S = F_S d_S = (625\,N)(.1\,m) = 62.5\,J$. Since, $W_s = W_L = F_L d_L$,

we have $$\frac{W_S}{F_L} = d_L = \frac{62.5\,J}{10 \times 10^3\,N} = 6.25\text{ mm}.$$

(c) $$\frac{\text{Weight}}{F_S} = \frac{1 \times 10^4\,N}{625\,N} = 16.0$$

(3) Use Coulomb's law, or $F_e = \dfrac{k\,|q_1||q_2|}{r^2} = \dfrac{k\,|q|^2}{r^2}$. To find $|q|$,

$$|q| = \sqrt{\frac{F_e r^2}{k}} = \sqrt{\frac{(.036\,N)(.25\,m)^2}{8.9 \times 10^9\ \frac{N \cdot m^2}{C^2}}} = 5 \times 10^{-7}\,C.$$ Since the charge is

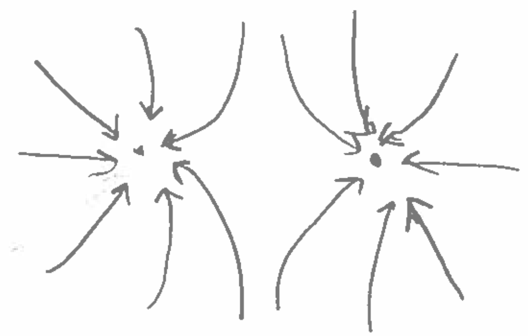
negative, $q = -5 \times 10^{-7}\,C$.

(4) $E_{x_1} = \dfrac{k|2q|}{(2d)^2}$ and points to the left so we need a minus sign.

$E_{x_2} = \dfrac{k|q|}{(d)^2}$ and points to the right so we need a plus sign.

$$E_{total,p} = -E_{x_1} + E_{x_2} = -\frac{k|2q|}{(2d)^2} + \frac{k|q|}{d^2} = \frac{k|q|}{2d^2}$$ to the right.

(5)



(6) (a) $F_y = eE_y = (-1.6\times10^{-19}\,C)(500\,N/C) = -8\times10^{-17}\,N$ (downward since electrons are negatively charged)

b) Use the work kinetic energy theorem, or $W = |F||d|\cos\theta = \Delta K$.

So $\Delta K = |F||d|\underbrace{\cos(0^\circ)}_{=1} = |F||d| = (8\times10^{-17}N)(.003\,m)$

$= 2.4\times10^{-19}\,J$.