PH1130 **In-class problems** **10/4/07**

Prob. 1 In an experimental radiation therapy, an equivalent dose of 0.900 rem is given by 0.800 MeV protons to a localized area of tissue with mass 0.150 kg.

(a) What is the absorbed dose in rad?

RBE = 10 for protons, so rem ≈ 10 × rad

$$\text{dose} \approx \frac{0.9}{10} = \boxed{0.09\ \text{rad}} = 9 \cdot 10^{-4}\ \text{J/kg}$$

(b) How many protons are absorbed by the tissue?

$$\text{energy absorbed} = (\#\ \text{protons})\left(\frac{\text{energy}}{\text{proton}}\right) = \left(9 \cdot 10^{-4}\ \frac{\text{J}}{\text{kg}}\right)(0.15\ \text{kg}) = 1.35 \cdot 10^{-4}\ \text{J}$$

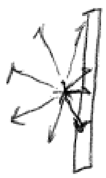
$$\#\ \text{protons} = \frac{1.35 \cdot 10^{-4}\ \text{J}}{(8 \cdot 10^{5}\ \text{eV})(1.6 \cdot 10^{-19}\ \frac{\text{J}}{\text{eV}})} \approx \boxed{1.06 \cdot 10^{9}}$$

(c) How many alpha particles of the same energy of 0.800 MeV are required to deliver the same equivalent dose of 0.900 rem?

RBE = 20 for α particles, so need only ½ the number of protons of same energy

Prob. 2 A 20 mCi radioactive source is emitting gamma rays of energy 5 MeV. Model your body as a rectangular solid 1 ft wide by 5 ft high, with a mass of 70 kg.

(a)Determine the dose rate you receive in rad/s and rem/s when you are very close to the source (say d = 0.2 ft).



Activity is $(2\cdot10^{-2})(3.7\cdot10^{10}\ s^{-1}) = 7.4\cdot10^{8}\ \frac{\text{disintegrations}}{s}$

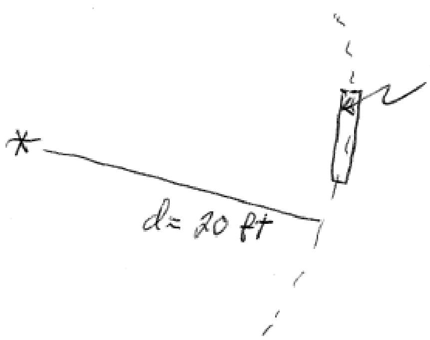
Approximately half the emitted γ particles strike the person

$$\frac{\text{energy absorbed}}{\text{time}} = \frac{7.4\cdot10^{8}\ s^{-1}}{2}(5\cdot10^{6}\ eV)(1.6\cdot10^{-19}\ \tfrac{J}{eV}) = 2.96\cdot10^{-4}\ \tfrac{J}{s}$$

$$\frac{\text{energy absorbed/mass}}{\text{time}} = \frac{(2.96\cdot10^{-4}\ J/s)}{70\ kg} = 4.23\cdot10^{-6}\ \frac{J/kg}{s} = \boxed{4.23\cdot10^{-4}\ \tfrac{rad}{s}}$$

also $4.23\cdot10^{-4}\ \frac{rem}{s}$

(b)Repeat the above if you are 20 ft from the source.



area = 5 ft^2

$$\text{Fraction absorbed} = \frac{A_{person}}{4\pi d^2} = \frac{5\ ft^2}{4\pi(20\ ft)^2} \cong 1\cdot10^{-3}$$

Using previous answer,

$$\frac{\text{energy absorbed/mass}}{\text{time}} = \left(\frac{1\cdot10^{-3}}{0.5}\right)(4.23\cdot10^{-4}) \cong \boxed{8.5\cdot10^{-7}\ \tfrac{rad}{s}}$$

(c)For each of the above, how long must you be exposed to the radiation to receive the maximum recommended total yearly dose of 200 mrem?

At 0.2 ft, $t = \frac{0.2\ rem}{4.2\cdot10^{-4}\ rem/s} \cong 480\ s \cong \boxed{8\ \text{minutes}}$

At 20 ft, $t = \frac{0.2\ rem}{8.5\cdot10^{-7}\ \frac{rem}{s}} = 2.35\cdot10^{5}\ s \cong \boxed{65\ \text{hours}}$