1. **(5 points)** How thick should a lead shield be to reduce the intensity of 600keV gamma radiation by a factor of 1000? Take $\rho = 11.35$ g/cm³ and $\mu = 0.125$ cm²/g.

\[
I(x) = I_0 e^{-\mu x} = I_0 e^{-\left(\frac{0.125}{11.35}\right) x}
\]

\[
-3 \ln 10 = \left(\frac{0.125}{11.35}\right) x \Rightarrow \]

\[
x = 4.87 \text{ cm} = \left(\frac{4.9 \text{ cm}}{x}\right)
\]

2. **(5 points)** If concrete has a half-value of 25.0 mm for 200keV x-rays, what is the thickness of concrete required to reduce the intensity of these x-rays produced by a nuclear blast by a factor of 10?

\[
I = I_0 e^{-\lambda x} \Rightarrow \frac{I}{I_0} = e^{-\lambda x} \Rightarrow \frac{1}{2} = e^{-25} \Rightarrow -25 = -\ln 2 \Rightarrow \lambda = 0.0277 \text{ mm}^{-1}
\]

\[
\Rightarrow \frac{I}{I_0} = e^{-\lambda x} \Rightarrow x = ? \Rightarrow \frac{1}{10} = e^{-\left(0.0277 \text{ mm}^{-1}\right) x} \Rightarrow -\ln 10 = -\left(0.0277 \text{ mm}^{-1}\right) x \Rightarrow x = 8.3 \text{ mm} = 8.3 \text{ cm}
\]
3. (5 points) The exposure rate from a 100 Ci (curies) source of Co\textsuperscript{60} at 2.0 meters is 32 R/hr (roentgens/hr). What is the exposure rate 8.0 meters away? Is this dangerous (backup your answer)?

\[
I = \frac{32 \text{ R/hr}}{2} = \frac{I_8}{8} \Rightarrow I_8 = (32 \text{ R/hr}) \left(\frac{2^2}{8^2}\right) = (32 \text{ R/hr}) \left(\frac{4}{64}\right) = 2 \text{ R/hr} = I_8
\]

Yes! This is extremely dangerous. 100 mR/hr is considered safe. This is dangerously above that.

4. (5 points) The highest recommended limit for radiation exposures is for astronauts - 25 rems per Space Shuttle mission, principally from cosmic rays. Suppose that the radiation level for astronauts living in outer space is: 1.5 millirem/hr. How many days could they spend in space before the received dose would be harmful?

\[
25 \text{ rem} = \left(\frac{1.5 \text{ mrem}}{\text{hr}}\right) T \Rightarrow T = \frac{25 \text{ rem}}{1.5 \times 10^{-3} \text{ (rem)} = 16,700 \text{ hrs}}
\]

\[
= \frac{25,000}{15} = \frac{50,000}{3} = 16,700 \text{ hrs}
\]

\[
= 16,700 \times \left(\frac{1 \text{ day}}{24 \text{ hrs}}\right) = 694.4 \text{ days} \Rightarrow 1.9 \text{ years}
\]