1. A Radiological Health Technician at TVA is asked to see if the lead shielding around a $\gamma$ ray source in a hot room is sufficient to protect workers outside the room from exposure to Gamma radiation. If the safe exposure limit is 200 $\gamma$ rays per second, is a lead shield 5.6-mm thick sufficient to protect the workers? The attenuation coefficient is 2.3 mm and the intensity of the gamma ray source in the hot room is $5.67 \times 10^9 \gamma$ rays per second.

Solution:

(1) \[ I = I_o \ e^{[-X / X_o]} \]

(2) \[ X / X_o = 5.6\text{mm}/2.3\text{mm} = 2.43 \]

(3) \[ e^{-2.43} = 0.0876 \]

(4) \[ I = (5.67 \times 10^9 \gamma/s) \times 0.0876 = 496,787,211 \gamma/s \]

(5) The answer is no.

2. How thick will the shield have to be, to reduce the exposure to 200 $\gamma$/s?

(1) \[ I = I_o \ e^{[-X / X_o]} \]

(2) Divide both side of the equation by $I_o$.

\[ I / I_o = e^{[-X / X_o]} \]

(3) Take the Natural Log of both side of the equation:

\[ \ln(I / I_o) = \ln(e^{-X / X_o}) \]

\[ \ln(I / I_o) = -X / X_o \]

(4) \[ \ln(200\gamma/s /5.67 \times 10^9 \gamma/s) = -X/2.3 \text{ mm} \]

(5) \[-17.16 = -X/2.3 \text{ mm} \]
2. An Inspector from the Tennessee Division of Radiological Health is inspecting the x-ray machine in a dentists office to make sure that patients and office workers are not exposed to too high a dose of radiation when x-rays of a patient's teeth are taken. The intensity and energy of the x-rays is determined by the voltage used on the x-ray machine.

The inspector records a x-ray intensity in the patient chair at 500 Severits (Do not worry about the units) for each patient.

How thick would the lead apron the x-ray technician wears have to be to keep her exposure to 5 Severits per patient? The absorption coefficient of lead is 2.3 mm

\[
    I = I_0 e^{-\frac{X}{X_0}}
\]

(2) Divide both side of the equation by \( I_0 \).

\[
    \frac{I}{I_0} = e^{-\frac{X}{X_0}}
\]

4. Take the Natural Log of both side of the equation:

\[
    \ln\left(\frac{I}{I_0}\right) = \ln\left(e^{-\frac{X}{X_0}}\right)
\]

\[
    \ln\left(\frac{I}{I_0}\right) = -\frac{X}{X_0}
\]

4. \( \ln(5 \text{ Severits} /500 \text{ Severits}) = -\frac{X}{2.3} \text{ mm} \)

5. \( -4.6 = -\frac{X}{2.3} \text{ mm} \)
7. \[ X = (4.6)(2.3\text{mm}) = 10.6 \text{ mm} \] (approx. 0.4 inch)

3. A piece of lead 50.0 mm thick \((X_o = 2.3 \text{ mm})\) can reduce the intensity of the exposure to a gamma ray source from \(9.87 \times 10^{12} \gamma/s\) to approximately \(3,500 \gamma/s\). How thick would a piece of aluminum have to be to reduce the gamma ray intensity level to the same amount? \((X_o \text{ for aluminum is 50.0mm})\)

\[
I = I_o e^{-X/X_o}
\]

(1) Divide both sides of the equation by \(I_o\).

\[
I/I_o = e^{-X/X_o}
\]

(2) Take the Natural Log of both sides of the equation:

\[
\ln(I/I_o) = -X/X_o
\]

5. \[ \ln(I/I_o) = -X/X_o \]

Answer:
\[ X \approx 1088.0 \text{ mm} \]

4. How thick would solid cement block material have to be to reduce the exposure to \(3500 \gamma/s\) if \(X_o \text{ for cinder blocks is 120.0 mm}\) ?

Answer:
\[ X \approx 2600 \text{ mm (102 inches, 8.5 feet)} \]