PHOTON ATTENUATION COEFFICIENTS

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FUNDEMANTAL OF MEDICAL PHYSICS
spring semester

Week 5

Date June 7th 2026

Outline

- Linear attenuation coefficient
- Exponential attenuation
- Mass attenuation coefficient
- Energy absorption coefficient

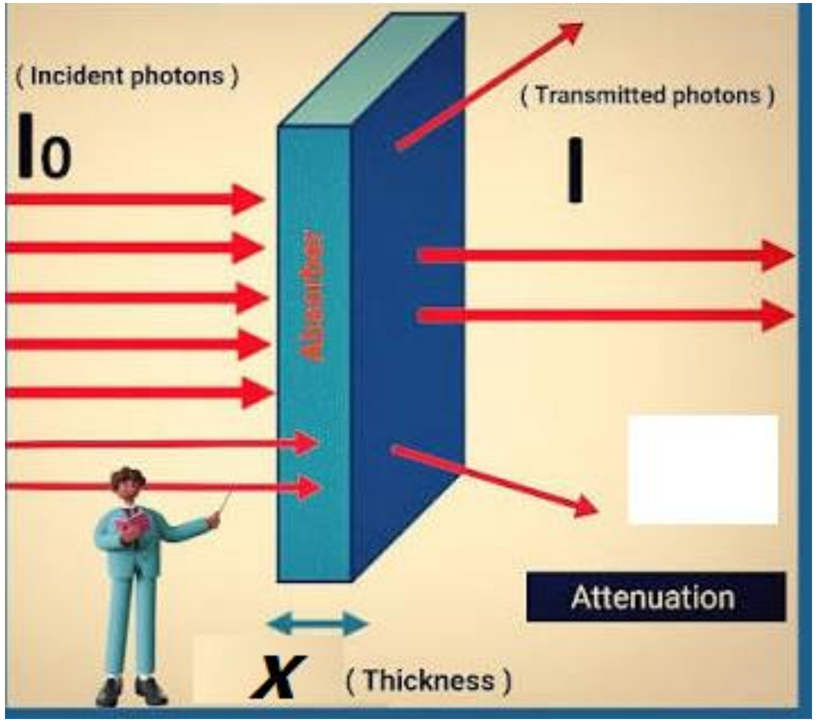
Objectives

The student should be able to do the followings;

- Explain Linear attenuation coefficient
- Draw the exponential attenuation for photons
- Find the mass attenuation coefficient for definite energy
- Define energy absorption coefficient

Linear Attenuation Coefficient

- The linear attenuation coefficient (μ) describes the fraction of a beam of x-rays or gamma rays that is absorbed or scattered per unit thickness of the absorber.
- As an energy wave or beam passes through a substance, it collides with particles and loses energy (via scattering or absorption).

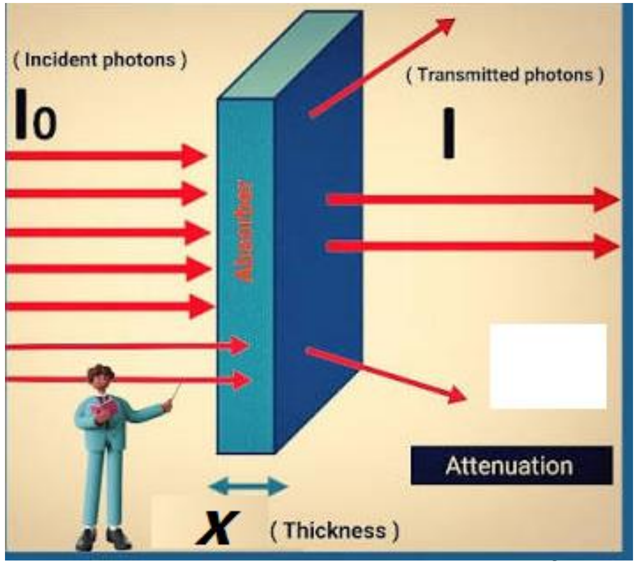


Linear Attenuation Coefficient

- The rate at which this weakening happens follows a negative exponential relationship, calculated with the following formula:

$$I = I_0 \, e^{-\mu . x}$$

- I : The intensity of the energy after passing through the material
- I_0 : The initial intensity of the energy.
- e : Euler's number (approx. 2.718)
- μ : The attenuation coefficient.
- x : The distance the wave travels through the material.

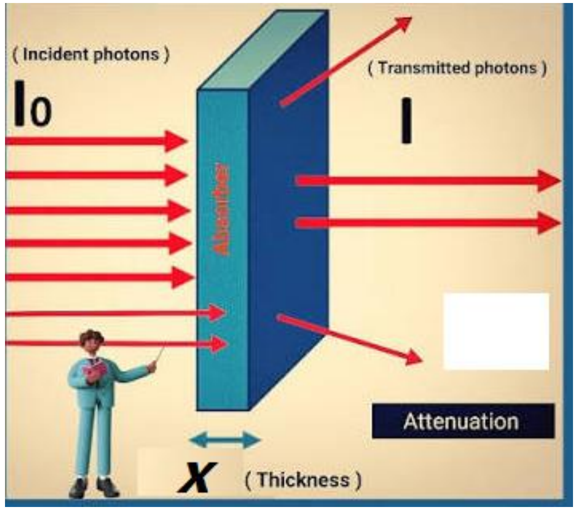


Linear Attenuation Coefficient

- Example:

Find the transmitted intensity of gamma radiation If initial intensity (1000 Sv/hr), the linear attenuation coefficient ($\boldsymbol{\mu}$) for lead at 1 MeV is approximately 0.693 cm^{-1} and the thickness of the absorber is 1 cm

$$I = I_0 \, e^{-\mu . x}$$

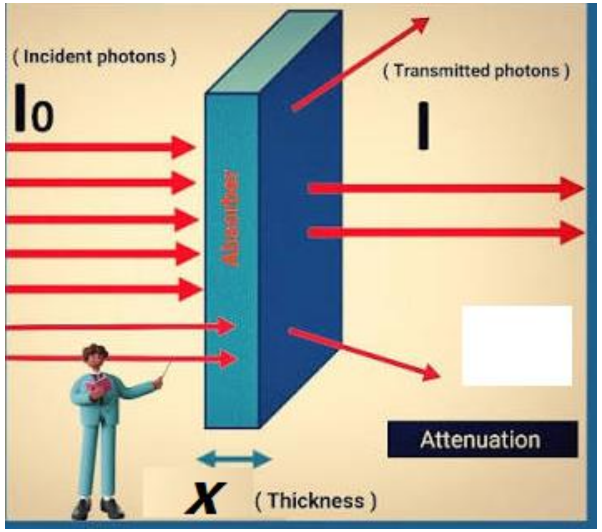


Linear Attenuation Coefficient

- Example:

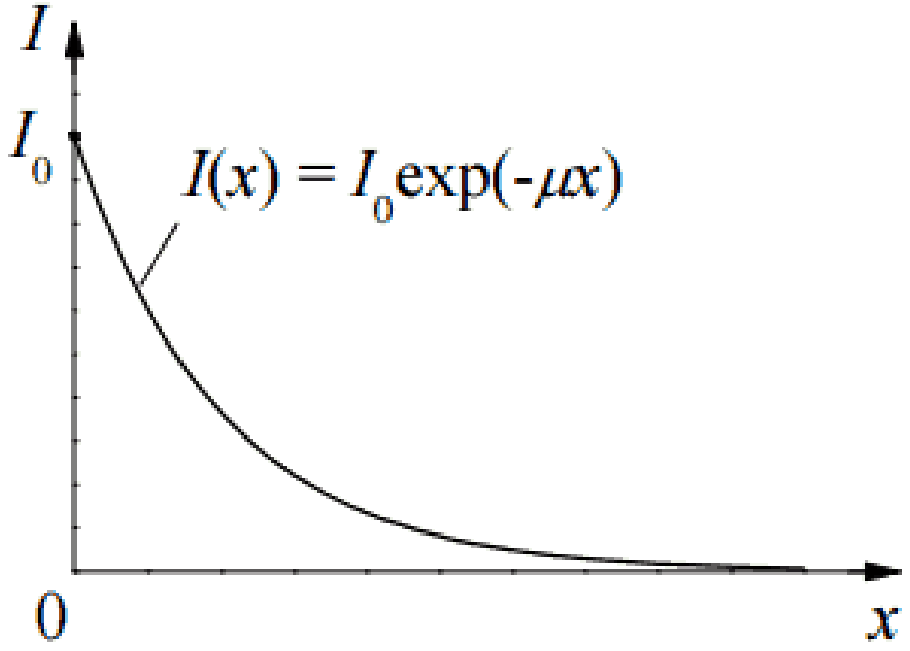
Find the transmitted intensity of gamma radiation If initial intensity (1000 Sv/hr) , the linear attenuation coefficient (μ) for steel at 1 MeV is approximately 0.47 cm^{-1} and the thickness of the absorber is 2 cm

$$I = I_0 \, e^{-\mu . x}$$



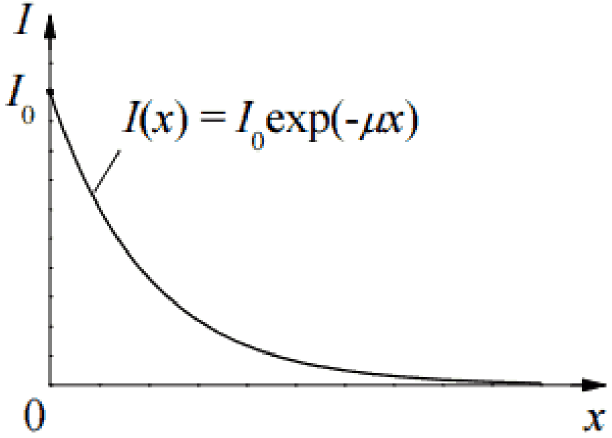
The Exponential Attenuation

- Exponential attenuation is the gradual decrease in the intensity of a beam of radiation or particles (such as X-rays, gamma rays, or light) as it passes through a medium.
- The reduction happens at a rate proportional to the current intensity, meaning a constant percentage of energy is absorbed or scattered per unit of thickness.



Mass Attenuation Coefficient

- The mass attenuation coefficient (MAC) quantifies how easily a material can be penetrated by a beam of radiation (such as X-rays or gamma rays).
- It is defined ($\frac{\boldsymbol{\mu}}{\boldsymbol{\rho}}$) as the linear attenuation coefficient ($\boldsymbol{\mu}$) divided by the material's density ($\boldsymbol{\rho}$).
- Unit: Usually expressed in $\mathbf{cm^2/g}$



Energy Absorption Coefficient

- The mass energy-absorption coefficient quantifies the fraction of incident photon energy absorbed in a material per unit mass, excluding the energy carried away by scattered photons. This makes it an important parameter in dose calculation.
- The mass energy-absorption coefficient is defined as: $\boldsymbol{\mu_{en}/\rho}$
- μ_{en} = energy-absorption coefficient (cm^{-1}), which accounts for only the energy deposited in the material.
- ρ = material density (g/cm^3)
- Unit: Usually expressed in **cm^2/g**

Photon Energy (keV)	Al	Fe	Pd
	Mass Absorption Coefficient $(\frac{cm^2}{g})$		
10	26.346528	172.72794	132.93711
15	7.930296	55.84579	114.97185
20	3.408264	25.546444	85.515219
30	1.120464	8.127042	29.515219
40	0.5667048	3.61512	13.971042
50	0.3689496	1.943634	7.814016
60	0.280116	1.203048	4.0866318
80	0.203352	0.595056	2.331414
100	0.171306	0.369754	1.4049851
150	0.13822776	0.1964116	1.0706553

References

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- Hendee W., and Ritenour E.,. (2002). *Medical Imaging Physics*. Willy-Liss,Inc
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