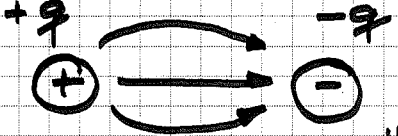


Biomedical Imaging - Intro

1

Electromagnetic radiation

- Electric field \vec{E}

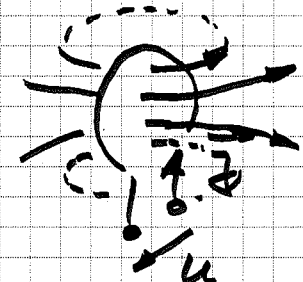


A diagram showing two point charges, a positive charge (+q) on the left and a negative charge (-q) on the right. Two curved arrows represent the electric field lines pointing from the positive charge to the negative charge.

$$\vec{\nabla} \cdot \vec{E} = \frac{\rho_q}{\epsilon_0}$$

"charge density"
"permittivity"
(ability to polarize)

- Magnetic field \vec{B}

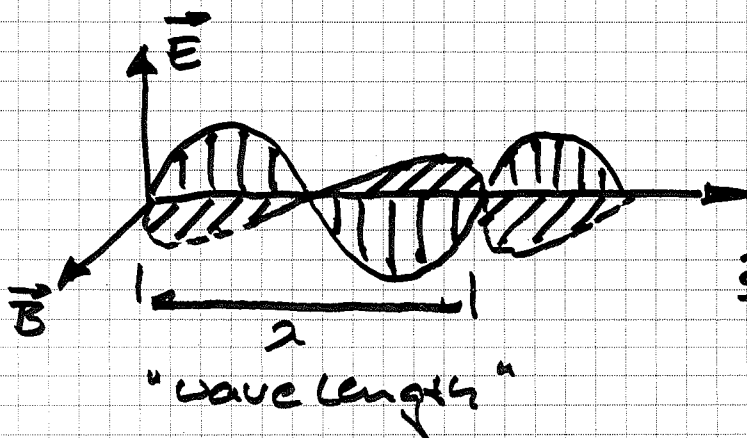


A diagram showing a circular loop of current. Arrows on the loop indicate the direction of current flow. Concentric dashed circles around the loop represent the magnetic field lines, with arrows indicating a clockwise direction when viewed from above.

$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$$

"permeability"
(ability to magnetize) "current density"

$$[\vec{\nabla} \times \vec{B} = \mu_0 \vec{J} + \epsilon_0 \mu_0 \frac{\partial \vec{E}}{\partial t}]$$



$$\frac{\partial^2 \vec{E}}{\partial t^2} - c_0^2 \vec{\nabla}^2 \vec{E} = 0$$

$$\frac{\partial^2 \vec{B}}{\partial t^2} - c_0^2 \vec{\nabla}^2 \vec{B} = 0$$

- Wave speed c_0

$$c_0 = \frac{1}{\sqrt{\mu_0 \epsilon_0}} = 3 \cdot 10^8 \frac{m}{s}$$

EM radiation in biological tissue

②

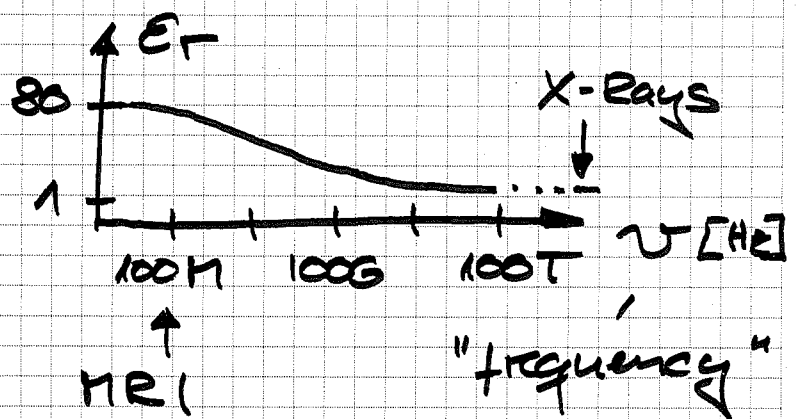
- Permeability μ

$$\mu = \mu_r \mu_0$$

→ $\mu_r \sim 1$ in tissue

- Permittivity ϵ

$$\epsilon = \epsilon_r \epsilon_0$$



- Photon energy E

$$E = h \cdot f = h \cdot \nu$$

"Planck's constant"

$$[h = 6.6 \cdot 10^{-34} \text{ J s}]$$

with $c = \lambda \cdot f = \lambda \cdot \nu$

$$\boxed{E = h \cdot \frac{c}{\lambda}} \quad \boxed{c = \frac{1}{\mu \epsilon}}$$

EM attenuation in biological tissue

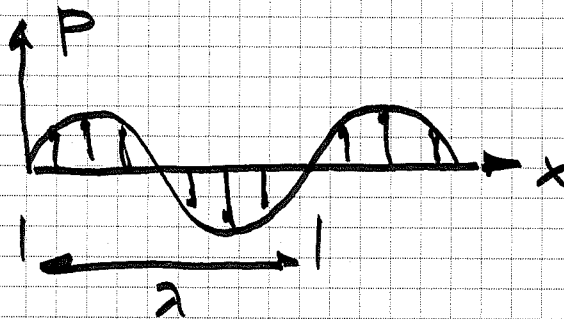
- Attenuation law $|\vec{E}| = |\vec{E}_0| e^{-\mu(z)z}$

"linear attenuation coefficient"

Acoustic or mechanical waves

- Acoustic waves require medium to propagate (EM waves do not)!

- Pressure p $p = \rho \cdot c \cdot u$ - "velocity of displacement"
- "density" "speed of sound"



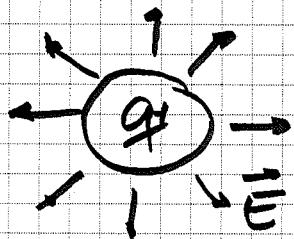
$$\frac{\partial^2 p}{\partial t^2} - c^2 \nabla^2 p = 0$$

$$C = \frac{1}{f \cdot \lambda_g} \approx 1500 \frac{\text{m}}{\text{m}}.$$

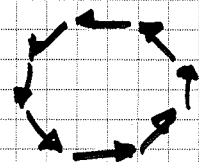
"tissue compressibility"

$$\frac{\partial \pi}{\partial x} = \frac{\partial \pi}{\partial x} + \frac{\partial \pi}{\partial y} + \frac{\partial \pi}{\partial z}$$

$$\vec{A} \times \vec{B} = \left(\frac{\partial B_z}{\partial y} - \frac{\partial B_y}{\partial z} \right) \vec{e}_x + \dots$$



△ 100 100 100



$$\vec{v} \cdot \vec{B} = 0$$