3.11

$\vec{E}(x,y,z,t) = E_0 \hat{i}\, e^{i(Ky - \omega t)}$ → propaga na $\hat{j}$

$\vec{B}$ = Campo magnético

Diagrama $\vec{E}_0, \vec{B}_0, \vec{K}$

$\boxed{E = cB}$ $\qquad B_0 = \dfrac{E_0}{c}$

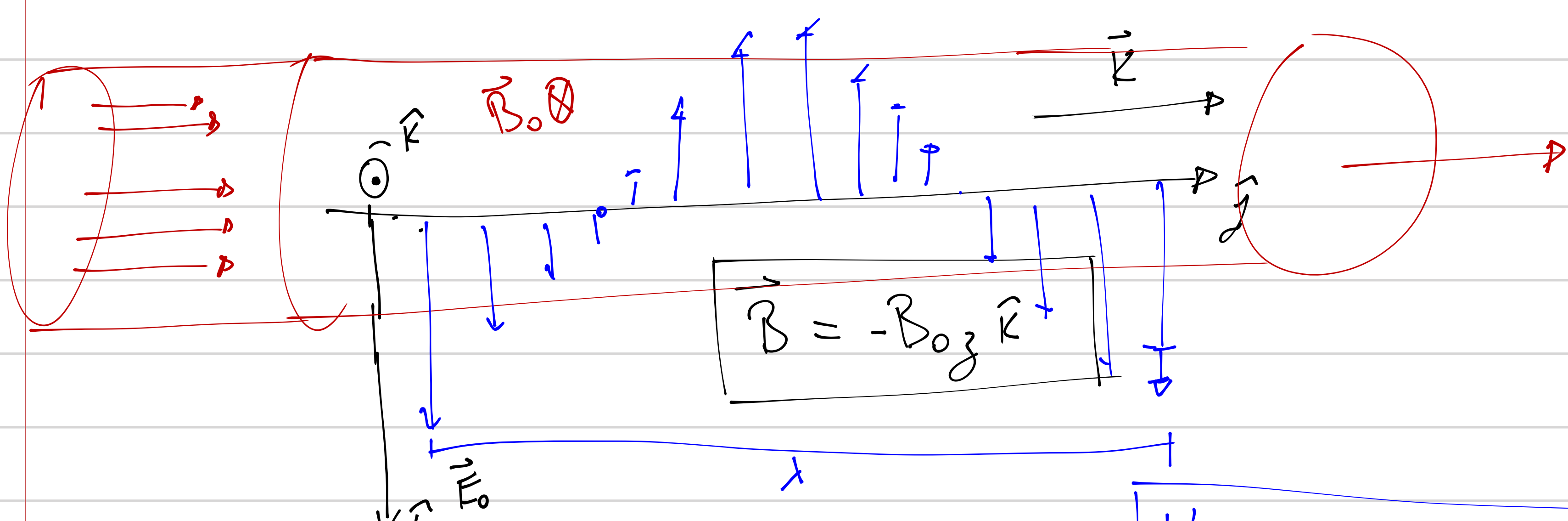
$\vec{E}_0 = E_{0x}\hat{i} + \cancel{E_{0y}\hat{j}} + \cancel{E_{0z}\hat{k}} =$ geral $\qquad$ se $\boxed{\vec{K} \Rightarrow \hat{j}}$

$\boxed{\vec{E}_0 = E_{0x}\hat{i}}$ particular

$\vec{B}_0 = B_{0x}\hat{i} + B_{0y}\hat{j} + B_{0z}\hat{k} =$ geral

$\vec{S} = \dfrac{1}{\mu_0}\vec{E}\times\vec{B}$ Vetor de poynting

→ Direção de propagação



$\boxed{K_y = \dfrac{2\pi}{\lambda} \; \dfrac{rad}{m}}$

$\vec{K} = \cancel{K_x\hat{i}} + K_y\hat{j} + \cancel{K_z\hat{k}} =$

$\boxed{\vec{K} = K_y\hat{j}}$

$\boxed{\vec{B}(x,y,z,t) = -B_0\hat{k}\, e^{i(K_y y - \omega t)}}$

3.19* A 1.0-mW laser produces a nearly parallel beam $\boxed{1.0\ \mathrm{cm}^2}$ in cross-sectional area at a wavelength of 650 nm. Determine the amplitude of the electric field in the beam, assuming the wavefronts are homogeneous and the light travels in vacuum.

$\boxed{E_o}$

$$I = \frac{c\,\varepsilon_o E_o^2}{2} \qquad I = \langle S(t)\rangle_T$$

→ Irradiância, Densidade de potência

→ $\left[\frac{W}{m^2}\right]$

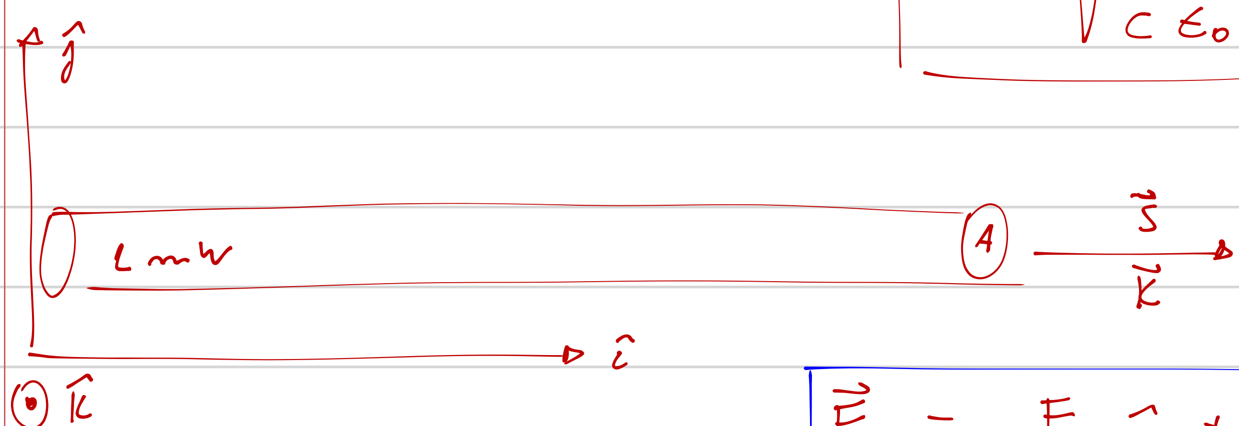
$P = 10^{-3}$ W

$A = 1\ \mathrm{cm}^2$

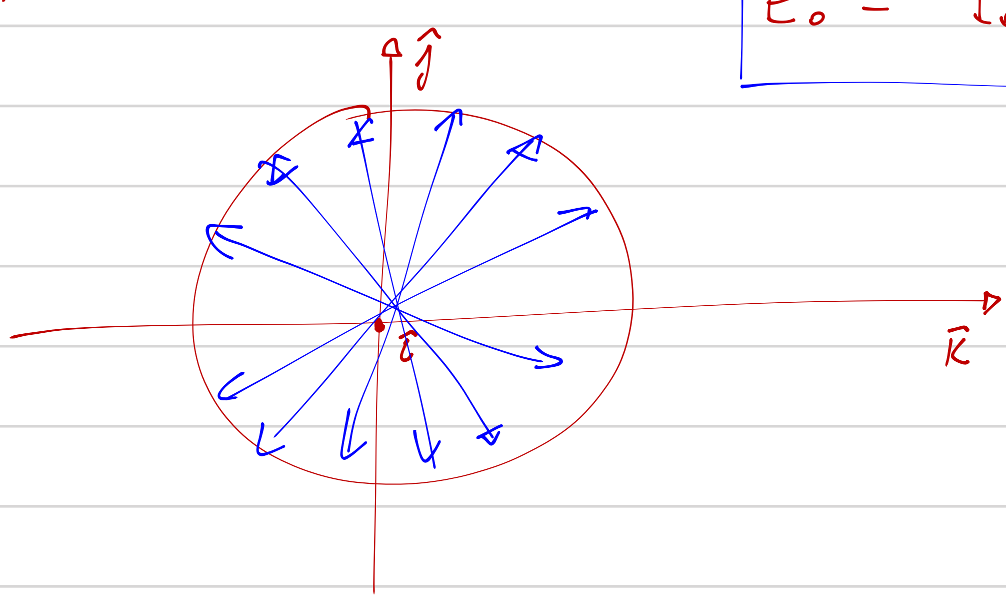
$$\boxed{I = 10^{-3}\ \frac{W}{cm^2}}$$

→ experimental

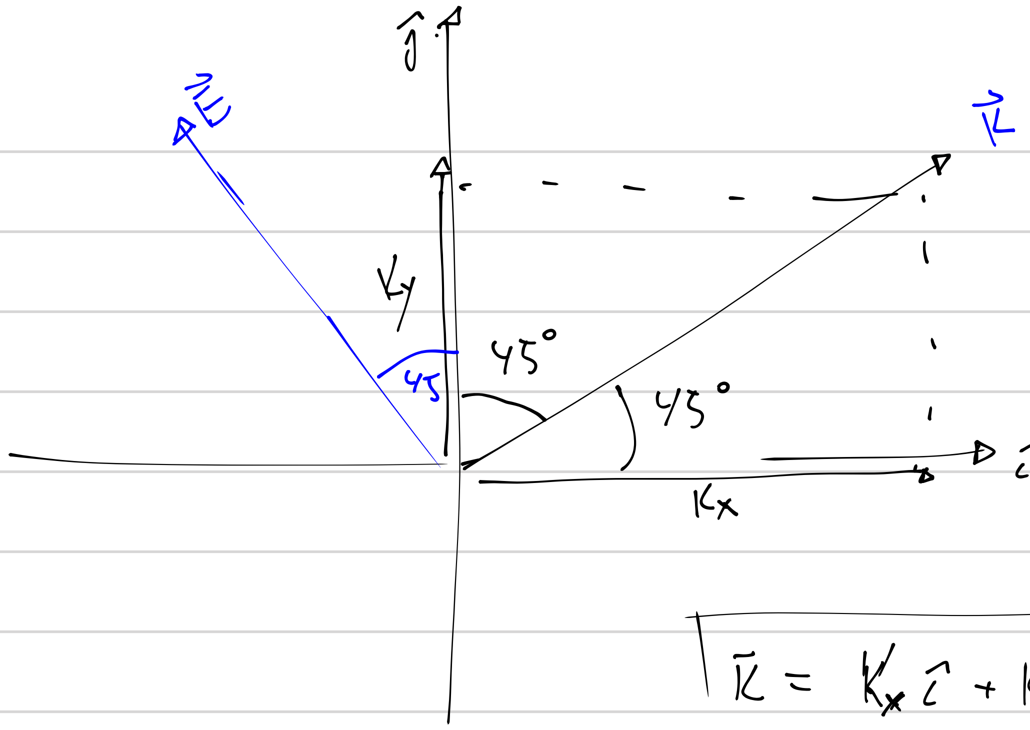
$$\boxed{E_o = \sqrt{\frac{2I}{c\,\varepsilon_o}}}$$



$$\boxed{\vec{E}_o = E_{oy}\,\hat{j} + E_{oz}\,\hat{k}}$$



3.25 A linearly polarized harmonic plane wave with a scalar amplitude of 8 V/m is propagating along a line in the xy-plane at ~~45~~° 45° to the x-axis with the xy-plane as its plane of vibration. Please write a vector expression describing the wave assuming both k_x and k_y are positive. Calculate the flux density, taking the wave to be in vacuum.



$K_x = K \cos 45°$

$K_y = K \cos 45°$

$$\boxed{K_x = K \frac{1}{\sqrt{2}} = K_y}$$

$$\boxed{\vec K = K_x \hat i + K_y \hat j}$$

$$\vec E_0 = -E_{0x}\,\hat i + E_{0y}\,\hat j = +E_0 \left(-\hat i + \hat j\right)$$

$$\frac{\text{fluxo} \left[\frac{J}{s}\right]}{\left[m^2\right]} = \frac{J}{s \cdot m^2} = \left[\frac{W}{m^2}\right] \Rightarrow \text{Irradiância}$$

densidade de fluxo ou irradiância

$$\boxed{I = \frac{c\,\epsilon_0}{2} \cdot E_0^2}$$

Vácuo $\Rightarrow$ $v \Rightarrow c$ $\quad \epsilon \Rightarrow \epsilon_0$

3.32 A 4.0-V incandescent flashlight bulb draws 0.25 A, converting about 1.0% of the dissipated power into light ($\lambda \approx 550$ nm). If the beam has a cross-sectional area of 10 cm^2 and is approximately cylindrical,

(a) How many photons are emitted per second?

(b) How many photons occupy each meter of the beam?

(c) What is the flux density of the beam as it leaves the flashlight?

4 V , 0,25 A $\qquad P_e = IV = \left(\frac{1}{4}\right)(4) = 1\,W$ (elétrico)

$P_e = 0{,}01\ W$ de radiação $\boxed{\text{visível}}$

luz

$A = 10\ cm^2$

$\lambda = 550 \times 10^{-9}\ m$

h = cte de planck

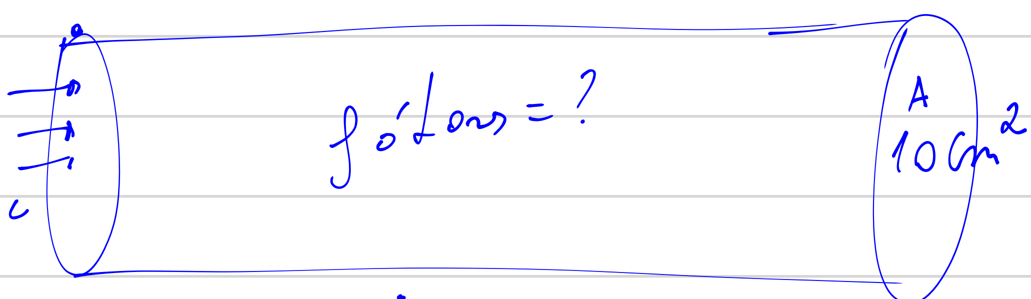
a) $\dfrac{\text{fótons}}{s}$ $\qquad E_f = \dfrac{hc}{\lambda}$ $\qquad h = 6{,}6 \times 10^{-34}\ \dfrac{m^2}{Kg \cdot s}$

$c = 3 \times 10^{8}\ m/s$

$$\boxed{E_f = 3{,}6 \times 10^{-19}\ J}$$

$$\frac{N^{\circ}\ \text{fótons}}{s} = \frac{P}{E_f} = \frac{E_T}{t \cdot E_f} = \frac{0{,}01\ \cancel{J}/s}{3{,}6 \times 10^{-19}\ \cancel{J}} = 3 \times 10^{16}\ \frac{\text{fótons}}{s}$$

b)



$2\ m = \Delta x = c \Delta t$ $\qquad v = c = \dfrac{\Delta x}{\Delta t}$

$$\Delta t = \frac{\Delta x}{c} = \frac{1}{3} \times 10^{-8}\ s$$

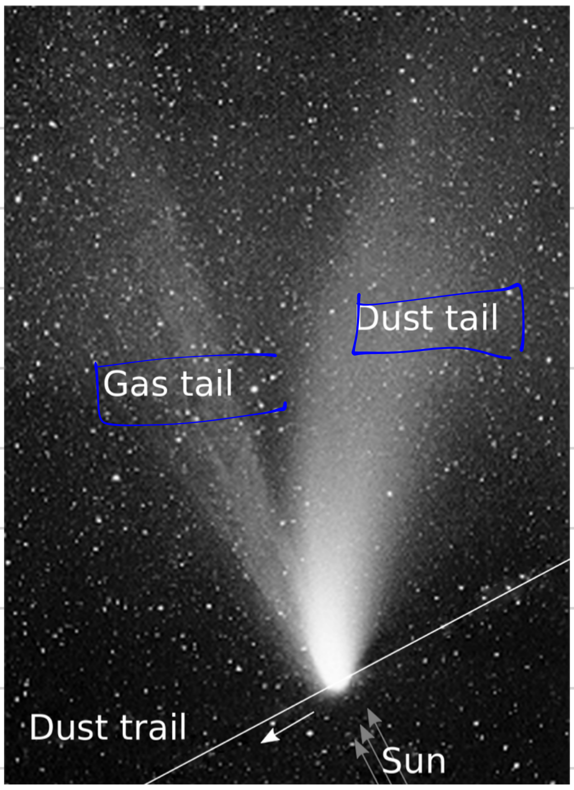
c) $$I = \frac{W}{m^2} = \frac{J}{m^2 \cdot s} = \frac{0{,}01\ W}{10\ (10^{-2}\ m)^2} = \frac{10^{-2}}{10^{-3}} = \frac{10\ J}{m^2 \cdot s}$$

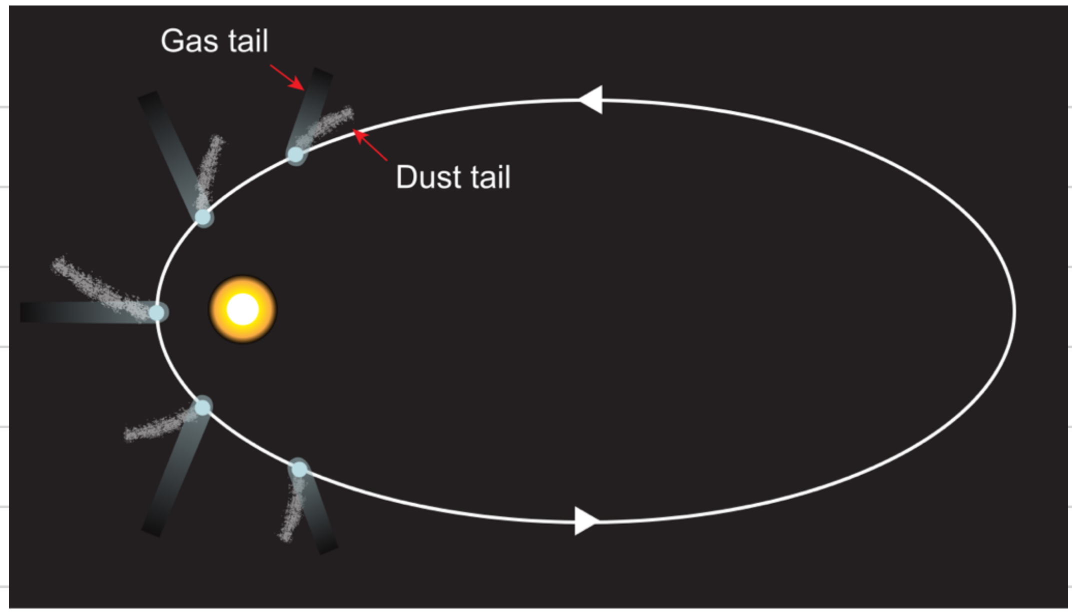
$$\boxed{I = 10\ \frac{J}{m^2 \cdot s}}$$

(s)

b) $$(I \cdot A \cdot t) = \left(10\ \frac{J}{\cancel{m^2} \cdot \cancel{s}}\right) \cdot \overset{10^{-3}\ m^2}{[\cancel{A}]} \cdot \overset{\Delta x}{\left[\frac{1}{3} \times 10^{-8}\ \cancel{s}\right]} = \underbrace{\boxed{\frac{1}{3} \times 10^{-10}\ J}}_{E_T}$$ naquele volume

$$\text{fótons} = \frac{E_T}{E_f} = \boxed{9 \cdot 10^{7}\ \text{fótons}}$$





Johann Kepler 1672

→ Origem da cauda do Cometa ⇒ pressão da radiação solar

Maxwell → 1843

└→ mostrou matematicamente.

P_r = pressão = $\left[\frac{N}{m^2}\right]$ Δp = momento

radiação → $\frac{J}{m^2 \cdot s} = \left[\frac{W}{m^2}\right] = I$

$\boxed{P_r = u}$ u = energia da onda eletromagnética $= \left[\frac{J}{m^3}\right]$

$S = u \cdot c$ $\boxed{u = \frac{S}{c}}$ $\langle S(t) \rangle_T \equiv I$

$P_r = \frac{S}{c}$ $\langle P_r(t) \rangle = \frac{\langle S(t) \rangle}{c}$

$\overline{P_r}$ = pressão média da radiação

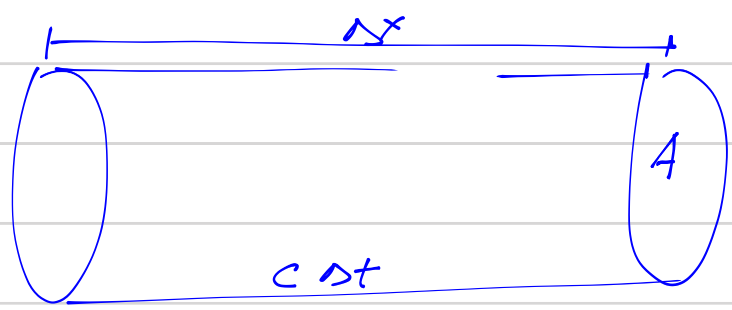
$$\boxed{\bar{P}_r = \frac{I}{c}}$$

$\Delta P =$ momento (variação) de uma F, sobre uma area A, por um tempo Δt

$$F = \frac{\Delta P}{\Delta t} \qquad \bar{P}_r = \frac{F}{A} \qquad F = \bar{P}_r \cdot A$$

$$c = \frac{\Delta x}{\Delta t}$$

$$\bar{P}_r \cdot A = \frac{\Delta P}{\Delta t}$$



Volume $= A \cdot c\Delta t$

ΔP_v = densidade volumetrica de momento

$$\Delta P_v = \frac{\Delta P}{\Delta V} \qquad \Delta P = \Delta P_v \cdot \Delta V = \Delta P_v \cdot A \cdot c\Delta t$$

$$\bar{P}_r \cdot \cancel{A} = \frac{\Delta P_v \cdot \cancel{A} \cdot c\,\cancel{\Delta t}}{\cancel{\Delta t}} \qquad \Delta P_v = \frac{\bar{P}_r}{c}$$

$$\boxed{\Delta P_v = \frac{I}{c^2}} \qquad \boxed{\bar{P}_r = \frac{I}{c}}$$