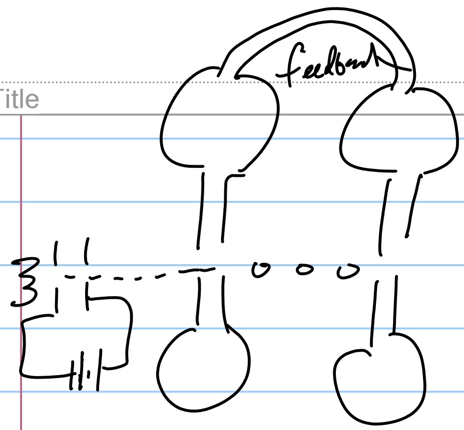
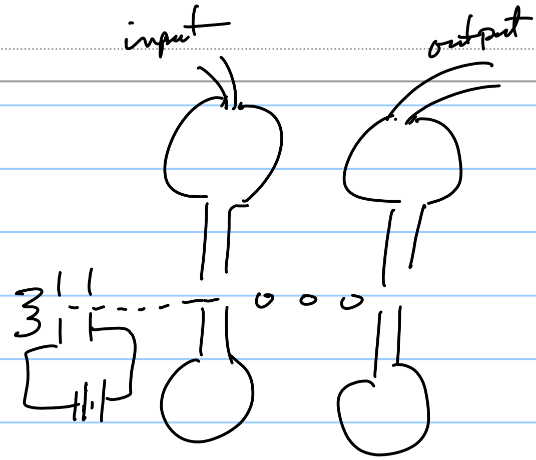
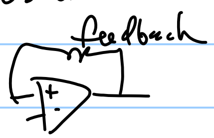
Note Title 6/20/2006

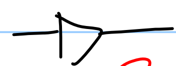



oscillator




amplifier



30 dB of gain two stage (Power) klystron

65 dB " 4 " "

$$dB = 10 \log_{10}\left(\frac{P_o}{P_{in}}\right)$$

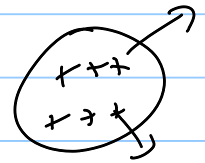
$$30\,dB = 10 \log_{10}\left(\frac{P_o}{P_{in}}\right)$$

$$\log_{10}\frac{P_o}{P_{in}} = 3 \qquad \frac{P_o}{P_{in}} = 10^3$$

Cons. charge

$$\vec{\nabla}\cdot\vec{J} = -\frac{\partial}{\partial t}\rho$$

$$\int \vec{\nabla}\cdot\vec{J}\,d\tau = \oint \vec{J}\cdot d\vec{a} = -\frac{\partial}{\partial t}\underbrace{\int \rho\, d\tau}_{Q_{enc}}$$



$\vec{J}\cdot d\vec{a}$

$$= -\frac{dQ_{enc}}{dt}$$


① $\displaystyle\int \frac{dJ_x}{dx}\,dx = -\frac{d}{dt}\int \lambda\, dx$

③ $\displaystyle\int \frac{dJ_x}{dx}\,dx = \frac{d}{dt}\int \lambda\, dx$

② $\displaystyle\int \frac{d\lambda}{dx}\,dx = -\frac{d}{dt}\int J\, dx$

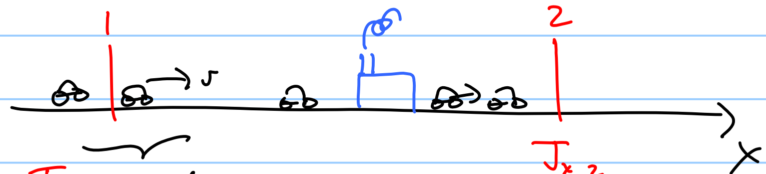
④ $\displaystyle\int \frac{d\lambda}{dx}\,dx = \frac{d}{dt}\int J\, dx$

⑤ None

$$\vec{\nabla}\cdot\vec{J} = -\frac{\partial\rho}{\partial t} \qquad \frac{dJ_x}{dx} + \underbrace{\cancel{\frac{dJ_y}{dy}}}_{0} + \underbrace{\cancel{\frac{dJ_z}{dz}}}_{0} = -\frac{\partial\rho}{\partial t}$$

$$\int \frac{dJ_x}{\cancel{dx}}\,\cancel{dx} = \int -\frac{\partial\lambda}{\partial t}\,dx = -\frac{d}{dt}\int \underbrace{\lambda}_{\text{cars}/\text{m}}\,dx$$

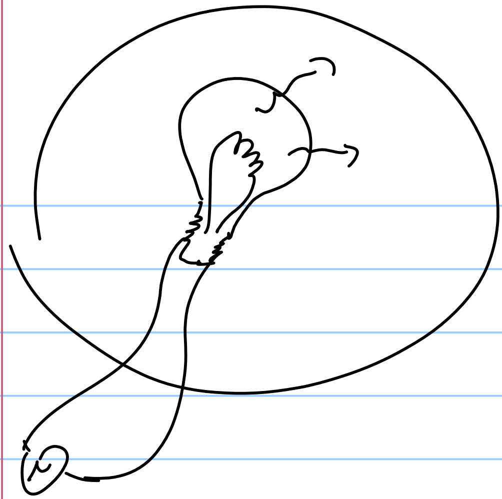
$$J_{x,2} - J_{x,1} = -\frac{d}{dt}\left(\#\,\text{cars within } 1,2\right)$$



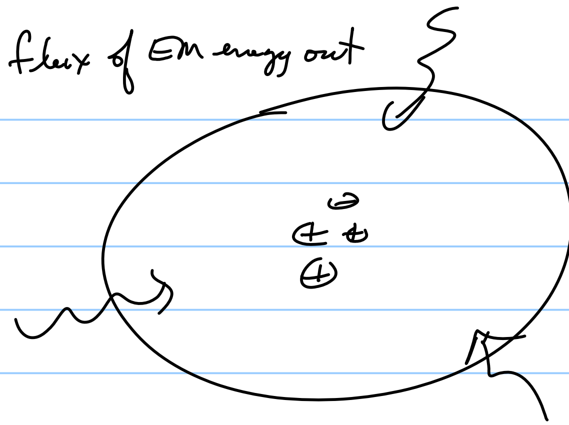

$J_{x,1}$ $\quad \lambda \ \frac{\text{cars}}{\text{m}}$ $\qquad\qquad J_{x,2}$

$$\lambda_1 v_1 \quad - \quad \lambda_2 v_2 = -\frac{d\,\text{cars}}{dt} + \text{Source term}$$

$$\vec{\nabla}\cdot\vec{J} = -\frac{\partial\rho}{\partial t} + S$$



flux of EM energy out



Matter inside our volume

$$\vec F = q\vec E + q\vec v\times\vec B \; : \; \int \vec F\cdot \underbrace{d\vec l}_{\vec{dt}} \; : \; \text{Power} = \overset{q\vec E}{\overset{\parallel}{\vec F}}\cdot\vec v$$

delivered to charge

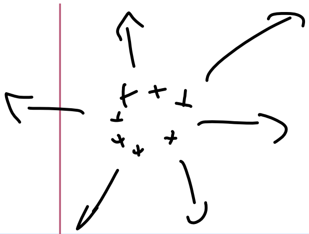
Power $= \vec E\cdot\vec v\, q$ for $\frac{N \text{ particles}}{\text{vol}} \Rightarrow \frac{\text{rate of work}}{\text{sec vol}}$

uses ME to eliminate $\vec J$ in favor of $E$ & $B$

lots of charge $\vec E\cdot \underbrace{N q\vec v}_{\vec J} = \vec E\cdot\vec J = -\frac{\partial}{\partial t}\left(\frac{\epsilon_0 c^2}{2}\vec B\cdot\vec B + \frac{\epsilon_0}{2}\vec E\cdot\vec E\right) - \vec\nabla\cdot(\epsilon_0 c^2\vec E\times\vec B)$

energy density in B

energy density in E



$\int u_E \, d\tau$

energy density

$\underbrace{\vec{E}\cdot\vec{J}}_{\text{Power}} = -\frac{\partial}{\partial t} u - \vec{\nabla}\cdot\vec{S}$

sink or source

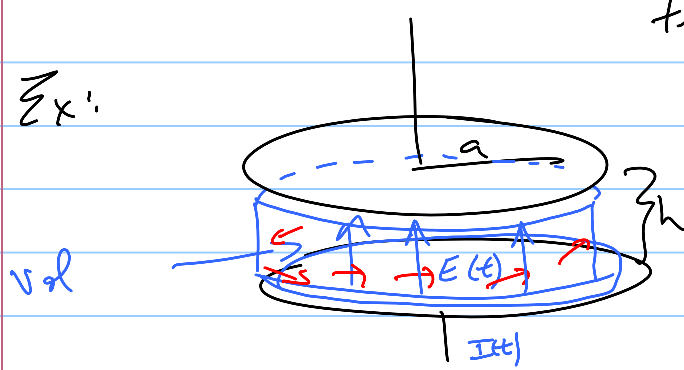
$\vec{\nabla}\cdot\vec{J} = -\frac{\partial \rho}{\partial t} + S$

$\vec{\nabla}\cdot\vec{J} + \frac{\partial \rho}{\partial t} = S$

$$\underbrace{\int \vec{E}\cdot\vec{J}\, d\tau}_{\text{sink or source of EM energy}} = \underbrace{-\frac{\partial}{\partial t}\int u \, d\tau}_{\text{Change of EM within surface}} - \underbrace{\int \vec{\nabla}\cdot\vec{S}\, d\tau}_{-\oint \vec{S}\cdot d\vec{a}}$$

$-\oint \vec{S}\cdot d\vec{a}$ flux of EM energy Thru surface

Ex:




$a \gg h$

$E(t)$ not

$\vec{\nabla} \times \vec{B} = \mu_0 \epsilon_0 \underbrace{\frac{\partial \vec{E}}{\partial t}}_{I_d}$

$\oint \underbrace{\vec{B} \cdot d\vec{l}}_{2\pi a B} = \mu_0 \epsilon_0 \frac{d}{dt} \Phi_E = \frac{1}{c^2} \pi a^2 \frac{\partial E}{\partial t}$

$\Phi_E = \int \vec{E} \cdot d\vec{a} = E \pi a^2$

$\int \vec{\nabla} \times \vec{B} \cdot d\vec{a} = \mu_0 \epsilon_0 \frac{\partial}{\partial t} \underbrace{\int \vec{E} \cdot d\vec{a}}_{\Phi_E}$

$= \oint \vec{B} \cdot d\vec{l}$

amperian path at radius $r$ — $B(r)$

$u = \frac{1}{2\mu_0} B(r)^2$

tot energy $B = \int u \, d\tau$

$\boxed{B(\text{at } r=a) = \frac{a}{2c^2} \frac{\partial E}{\partial t}}$

$u_B = \frac{1}{2\mu_0} B^2 = \frac{\epsilon_0 c^2}{2} B^2 = \frac{\epsilon_0 \cancel{c^2}}{2} \frac{a^2}{4 c^{\cancel{4}\,2}} \left(\frac{\partial E}{\partial t}\right)^2$

$u_E = \frac{1}{2} \epsilon_0 E^2 \gg \frac{\epsilon_0}{2} \frac{a^2}{4c^2} \left(\frac{\partial E}{\partial t}\right)^2$ neglect $u_B$

$\int \frac{1}{2} \epsilon_0 E^2 \, d\tau =$ field energy $= \frac{1}{2} \epsilon_0 E^2 \pi a^2 h = U$

$\text{Power} = \frac{dU}{dt} = \epsilon_0 \pi a^2 h E \frac{dE}{dt}$ = time rate of EM energy change within vol

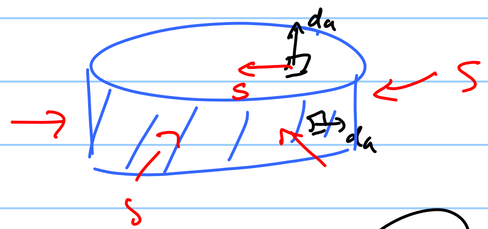
← volume has no charge in it so LHS = 0

$$\int \vec{E}\cdot\vec{J}\, d\tau = -\frac{\partial}{\partial t}\int u\, d\tau - \int \vec{\nabla}\cdot\vec{S}\, d\tau$$

some

$$0 = \underline{\qquad\qquad} - \oint \vec{S}\cdot d\vec{a}$$

$$\vec{S} = \frac{(\vec{E}\times\vec{B})}{\mu_0}$$



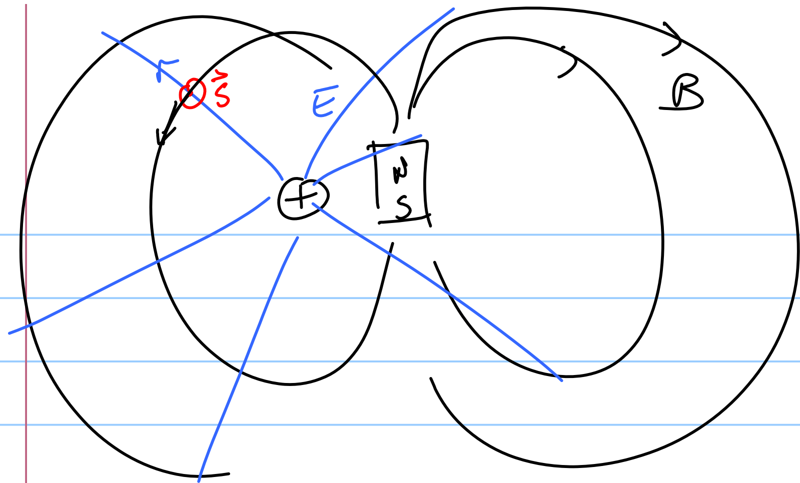

$$\frac{EB}{\mu_0} = \frac{E}{\mu_0}\frac{a}{2c^2}\frac{\partial E}{\partial t}$$

$$\int \vec{S}\cdot d\vec{a} = \int \frac{Ea}{\mu_0 2c^2}\frac{\partial E}{\partial t}\, da$$

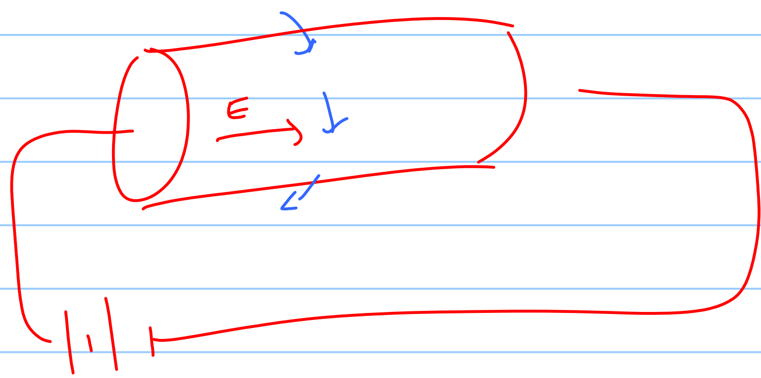
neg

$$= \frac{Ea}{\mu_0 2c^2}\frac{\partial E}{\partial t}\, 2\pi a h$$

$$B(\text{at } r=a) = \frac{a}{2c^2}\frac{\partial E}{\partial t}$$




$$\vec{S} = \frac{\vec{E} \times \vec{B}}{\mu_0}$$




$$\vec{J} = \sigma \vec{E}$$

ohms