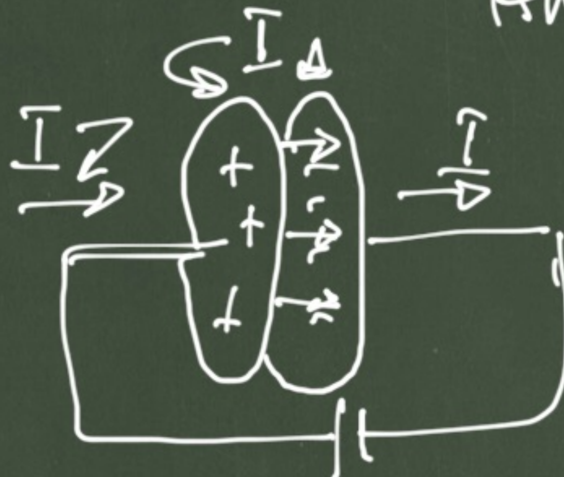
$$\oint_{C'} \bar{B}\cdot d\bar{s} = \mu_0 I$$

AMPERE



$$Q = CV = \frac{\varepsilon_0 A}{h} Eh$$

$$q = \varepsilon_0 A E$$

$$I = \frac{dq}{dt} = \varepsilon_0 A \frac{dE}{dt} = \varepsilon_0 \frac{d\Phi_E}{dt}$$

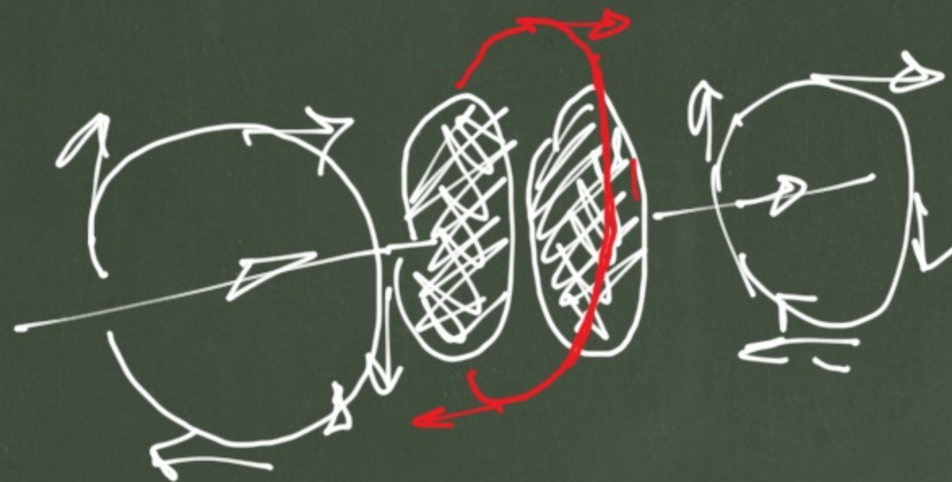
$$= I_d$$

displacement curr.

I conduz. $\quad E(t) \quad$ I cond

$$I_d = \varepsilon_0 \frac{d\Phi_E}{dt}$$

$I \quad | \quad I_d \quad | \quad I$



$$\oint \vec{B} \cdot d\vec{s} = \mu_0 (I + I_d)$$

$$= \mu_0 I + \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt}$$

 $r = 0.04 = a$

$$E = V/h$$

$$V = V_m\left(1 - e^{-t/RC}\right)$$

$$\oint_C B \cdot ds = \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt}$$

$$2\pi r B = \mu_0 \varepsilon_0 \pi a^2 \frac{dE}{dt}$$

$$B = \frac{\mu_0 \varepsilon_0 \pi a^2}{2\pi r\, h\, RC} e^{-t/RC}$$

$$E = E_0 + t^2$$

RLC $\quad R=1,\ C=21\,nF \quad L=13\,mH$

$I_0 = 5\,A \quad$ RIS: $\omega = \omega_{LC}$

$$\omega_{LC} = \frac{1}{\sqrt{13 \cdot 21\ 10^{-9}\, 10^{-3}}} \qquad \doteq \frac{1}{\sqrt{LC}}$$

$$= 0.06\,10^{-6} = 60\ kHz$$

$Z = R \qquad 0 = \phi \rightarrow \cos\phi$

$V_R = I_0 R \qquad V_L = V_C$

$V_L = X_L I_0$

$V_C = X_C I_0$

$$\oint_S \bar{E}\cdot d\bar{A} = \frac{Q}{\varepsilon_0}$$ GAUSS $$\mathrm{div}\,\bar{E} = \frac{\rho}{\varepsilon_0}$$

$$\oint_S \bar{B}\cdot d\bar{A} = \emptyset$$ "CABRERA" $$\mathrm{div}\,\bar{B} = \emptyset$$

$$\oint_C \bar{E}\cdot d\bar{s} = -\frac{d\Phi_B}{dt}$$ FARADAY $$\mathrm{rot}\,\vec{E} = -\frac{\partial \bar{B}}{\partial t}$$

$$\oint_c \bar{B}\cdot d\bar{s} = \mu_0\left(I + \varepsilon_0 \frac{d\Phi_E}{dt}\right)$$ AMPERE $$\mathrm{rot}\,\bar{B} = \mu_0\vec{J} + \mu_0\varepsilon_0\frac{\partial E}{\partial t}$$

$\mathrm{div}\,\vec{E} = 0$ $\qquad$ $\oint \vec{E} \cdot d\vec{A} = 0$

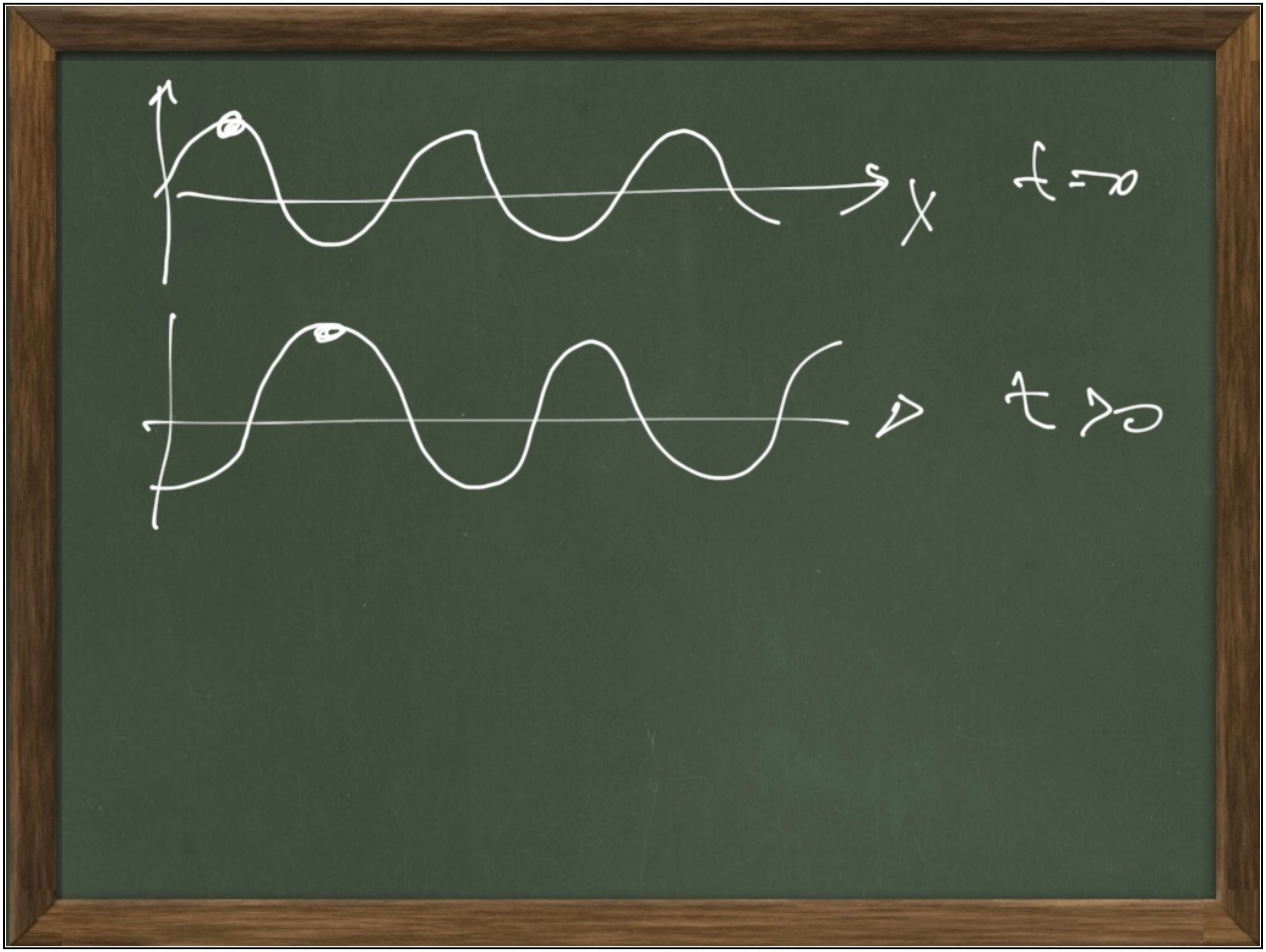
$\mathrm{div}\,\vec{B} = 0$ $\qquad$ $\oint \vec{B} \cdot d\vec{A} = 0$

$\mathrm{rot}\,\vec{E} = -\dfrac{\partial \vec{B}}{\partial t}$ $\qquad$ $\oint \vec{E} \cdot d\vec{s} = -\dfrac{d\Phi_B}{dt}$

$\mathrm{rot}\,\vec{B} = \mu_0 \varepsilon_0 \dfrac{\partial \vec{E}}{\partial t}$ $\qquad$ $\oint \vec{B} \cdot d\vec{s} = \mu_0 \varepsilon_0 \dfrac{d\Phi_E}{dt}$

Maxw senza sorgenti

sol. Maxw $\Longleftrightarrow$ sol. eq. d'onda


x
t = 0
t > 0

$$y = y_0 \cos(kx - \omega t) \qquad kx \equiv \bar{k} \cdot \bar{r}$$

$$x = 0 \qquad y_0 \cos \omega t$$

$$\cos(\omega(t + T)) = \cos(\omega t + 2\pi)$$

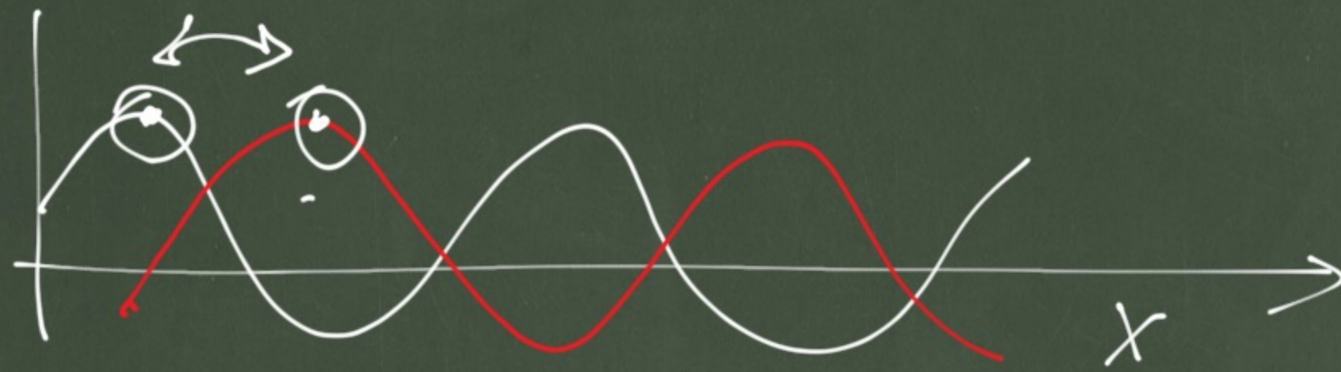
$$t = 0 \quad y = y_0 \cos(kx)$$

$$\omega T = 2\pi$$

$$T = \frac{2\pi}{\omega}$$

$$\cos(k(x + \lambda)) = \cos(kx + 2\pi)$$

$$k\lambda = 2\pi \qquad \lambda = \frac{2\pi}{k} \qquad k = \frac{2\pi}{\lambda}$$



$$y = y_0 \cos(kx - \omega t)$$

$$kx - \omega t = \text{cost}$$

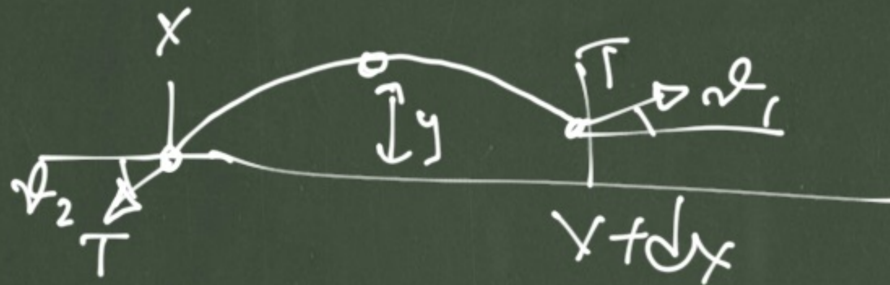
$$\left(\frac{d}{dt}\right) \qquad k\frac{dx}{dt} - \omega = 0$$

$$y(x - vt)$$

$$\boxed{v = \frac{\omega}{k}}$$

velocità

$$v = \frac{2\pi}{T}\frac{\lambda}{2\pi} = \frac{\lambda}{T} = \lambda f$$



$$F_1 \sim T(\sin\vartheta_1 - \sin\vartheta_2)$$

$$\operatorname{tg}\vartheta \sim \sin\vartheta$$

$$\vartheta \sim 0$$

$$F_1 \sim T(\operatorname{tg}\vartheta_1 - \operatorname{tg}\vartheta_2) = T\left(\left.\frac{dy}{dx}\right|_{x+dx} - \left.\frac{dy}{dx}\right|_{x}\right)$$

$$= T\,\frac{d^2y}{dx^2}\,\cancel{dx}$$

$$= ma = \mu\,\cancel{dx}\,\frac{\partial^2 y}{\partial t^2}$$

$$\mu\,dx = m$$

$$\boxed{\frac{\partial^2 y}{\partial x^2} - \frac{\mu}{T}\frac{\partial^2 y}{\partial t^2} = 0}$$

$$\boxed{y_{xx} - \frac{1}{v^2}\,y_{tt} = 0}$$

$$y(x,t) \overset{def}{=} y(x-vt) \qquad y = G \qquad z = x - vt$$

$$G(z)$$

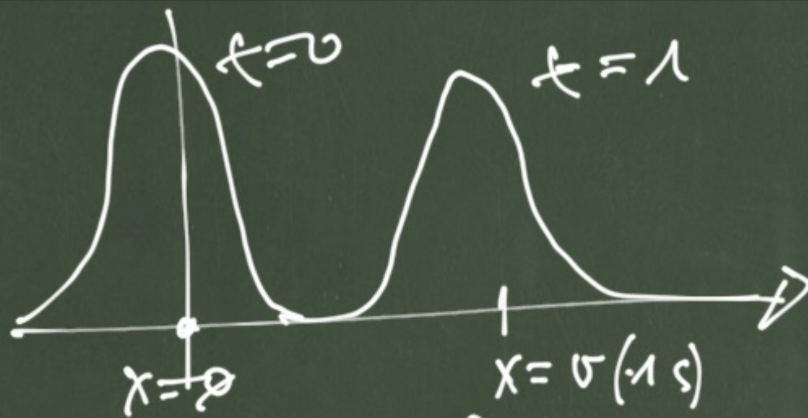
$$\frac{\partial y}{\partial x} = \frac{\partial G}{\partial z}\frac{\partial z}{\partial x} = \boxed{\frac{\partial G}{\partial z}}$$

$$\frac{\partial^2 y}{\partial x^2} = \frac{\partial^2 G}{\partial z^2}$$

$$\frac{\partial y}{\partial t} = \frac{\partial G}{\partial z}\frac{\partial z}{\partial t} = (-v)\frac{\partial G}{\partial z}$$

$$\frac{1}{v^2}\frac{\partial^2 y}{\partial t^2} = \frac{\partial^2 G}{\partial z^2} \qquad \frac{\partial^2 y}{\partial t^2} = \frac{\partial^2 G}{\partial z}(-v)^2$$

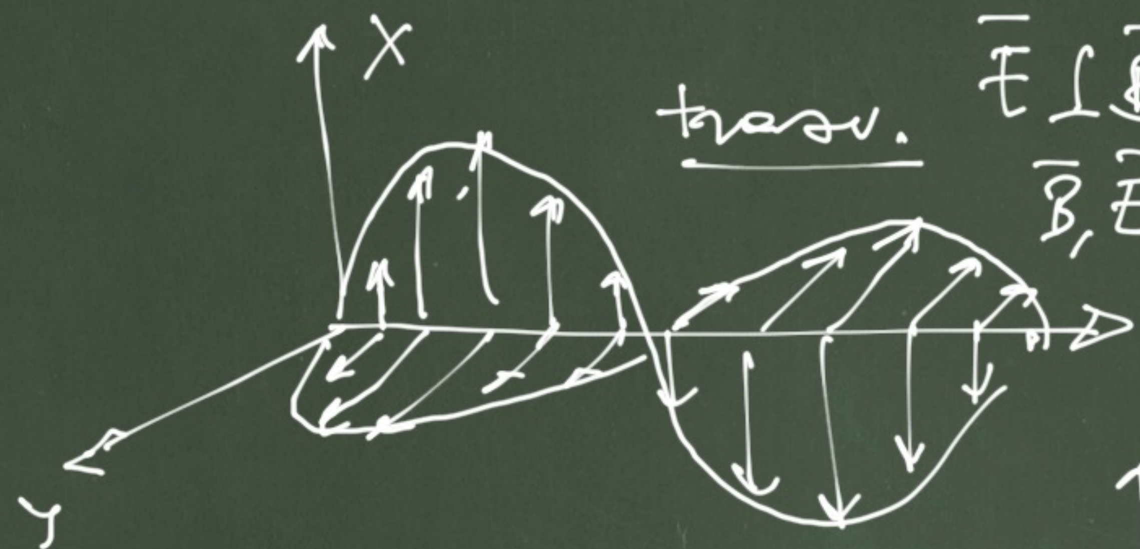
$$Y = A\, y(x-vt) + B\, y(x+vt)$$



$$e^{-\frac{(x-vt)^2}{x_0^2}}$$

$$\vec{E} = \hat{x}\, E_0 \cos(kz - \omega t) = \hat{x}\, E_x$$

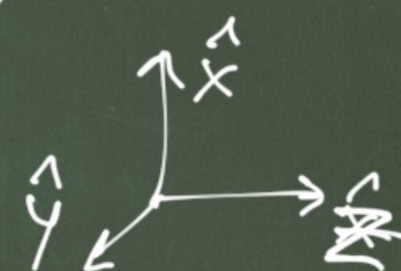
$$\bar{B} = \hat{y}\, B_0 \cos(kz - \omega t) = \hat{y}\, B_y$$

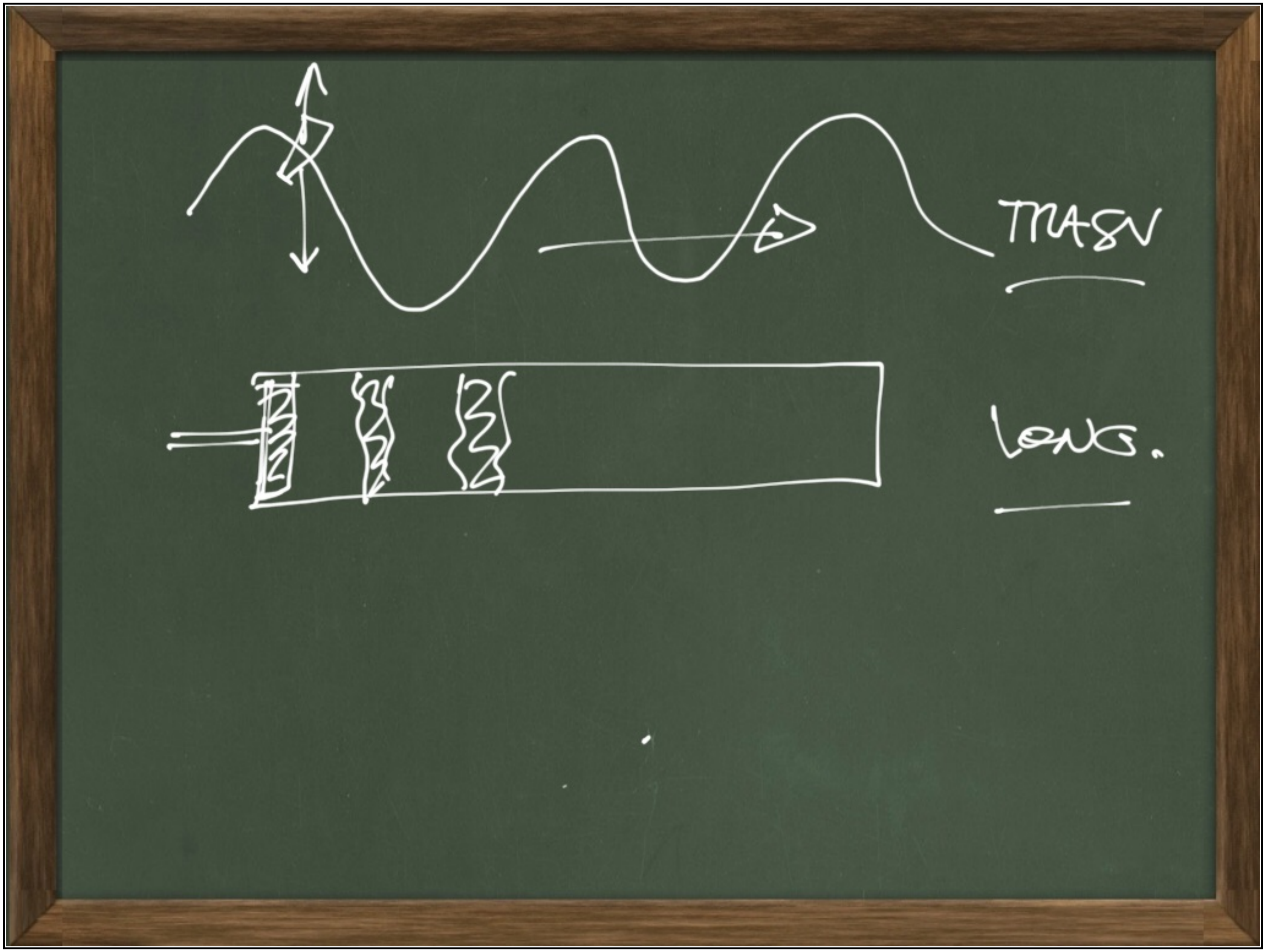


<u>trasv.</u>

$\bar{E} \perp \bar{B}$

$\bar{B}, \bar{E} \perp \hat{k}$




TRASV
LONG.

Eq. "della divergenza" (flussi)

$$\mathrm{div}\,\bar{E} = \emptyset = \mathrm{div}\,\bar{B} =$$

$$\stackrel{!}{=} \frac{\partial E_x}{\partial x} + \dots = \emptyset \stackrel{!}{=} \dots + \frac{\partial B_y}{\partial y} + \dots$$

$$\frac{\partial}{\partial x} E_x = \frac{\partial}{\partial x} E_0 \cos(kz - \omega t) = \emptyset$$

$$\frac{\partial}{\partial y} B_y = \dots = \emptyset$$

IV eq. III eq

$$\begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \partial_x & \partial_y & \partial_z \\ E_x & E_y & E_z \end{vmatrix} = \hat{x}\left(\partial_y E_z - \partial_z E_y\right) + \hat{y}\left(\partial_x E_z - \partial_z E_x\right)$$

$$+\hat{z}\left(\partial_x E_z - \partial_z E_x\right)$$

$$\vec{\nabla} \times \bar{E}$$

$$\mathrm{rot}\,\vec{E} = -\frac{\partial \vec{B}}{\partial t} = -\hat{y} B_0 \omega \sin(kz - \omega t)$$

$$\shortparallel$$

$$= \hat{y}\left(-\frac{\partial E_x}{\partial z}\right) = -\hat{y} k E_0 \sin(\dots)$$

$$B_0 \frac{\omega}{k} = E_0 \qquad \frac{\omega}{k} \equiv c$$

$$* \qquad \boxed{B_0 c = E_0}$$

$$\mathrm{rot}\,\bar{B} = \mu_0 \varepsilon_0 \frac{\partial \bar{E}}{\partial t} = \mu_0 \varepsilon_0 E_0 \hat{x} \left(\omega \cancel{\sin(kz-\omega t)} \right)$$

$$= -\hat{x} \frac{\partial B_y}{\partial z} =$$

$$= \hat{x}\, k B_0 \cancel{\sin(kz-\omega t)}$$

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$$

$$1 \quad \cancel{B_0} = \mu_0 \varepsilon_0 E_0 \frac{\omega}{k}$$

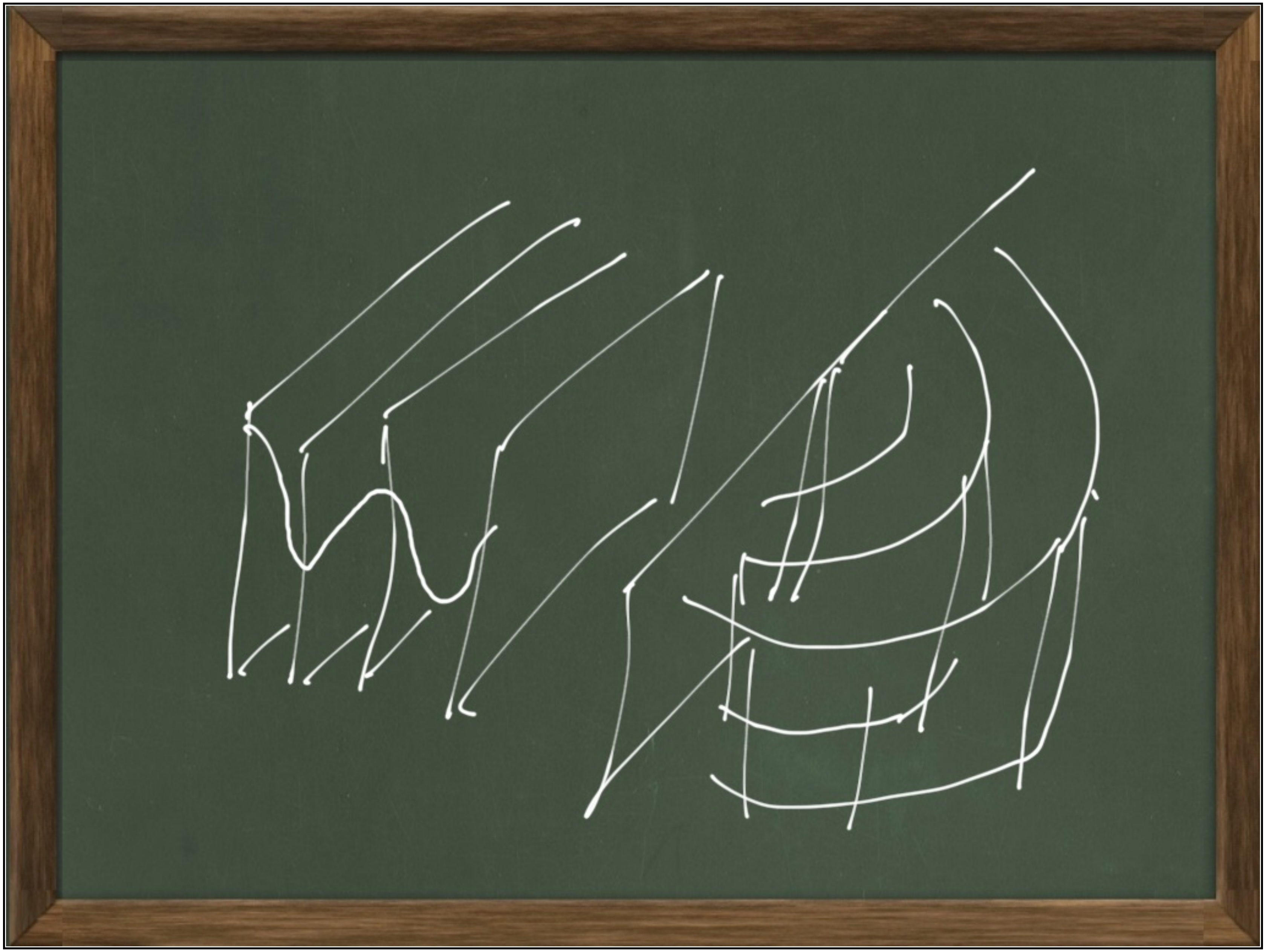
$$= \mu_0 \varepsilon_0 E_0\, c$$

$$= \mu_0 \varepsilon_0 \cancel{B_0}\, c^2$$

$$\boxed{c^2 = \frac{1}{\mu_0 \varepsilon_0}}$$

$$\boxed{E_0 = B_0\, c}$$

$$\boxed{c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}}$$



$$\mathrm{div}\, E = \rho / \varepsilon_0$$

$$\mathrm{rot}\left(\mathrm{rot}\,\bar{E}\right) = \mathrm{rot}\left(-\frac{\partial \bar{B}}{\partial t}\right) =$$

$$\cancel{\mathrm{grad}\,\mathrm{div}\,\bar{E}} - \mathrm{div}\,\mathrm{grad}\,\bar{E} = -\frac{\partial}{\partial t}\left(\mathrm{rot}\,\bar{B}\right) = -\frac{\partial}{\partial t}\left(\cancel{\mu_0 \vec{J}} + \mu_0 \varepsilon_0 \frac{\partial \bar{E}}{\partial t}\right)$$

$$= -\frac{\partial^2 \bar{E}}{\partial t^2}\mu_0 \varepsilon_0$$

$$\bar{\nabla} \cdot \bar{A} = \left(\hat{x}\frac{\partial}{\partial x} + \dots\right)\left(\hat{x} A_x + \dots\right)$$

$$\frac{\partial A_x}{\partial x} + \dots$$

$$-\vec{\nabla}\cdot\vec{\nabla}\,\vec{E} = -\left(\hat{x}\frac{\partial}{\partial x} + \hat{y}\frac{\partial}{\partial y} \dots\right)\left(\hat{x}\frac{\partial}{\partial x} + \hat{y}\frac{\partial}{\partial y} \dots\right)\vec{E}$$

$$= -\frac{\partial^2}{\partial x^2}E_x + \dots$$

$$= -\nabla^2\vec{E}$$

$$= -\Delta\vec{E}$$

$$\nabla^2 \bar{E} = \mu_0 \varepsilon_0 \frac{\partial^2 E}{\partial t}$$

$$\nabla^2 \bar{E} = \frac{1}{c^2} \frac{\partial^2 E}{\partial t}$$

$$\boxed{\frac{\partial^2 E}{\partial x^2} = \frac{1}{c^2} \frac{\partial^2 E}{\partial t^2}}$$

REIFICARE

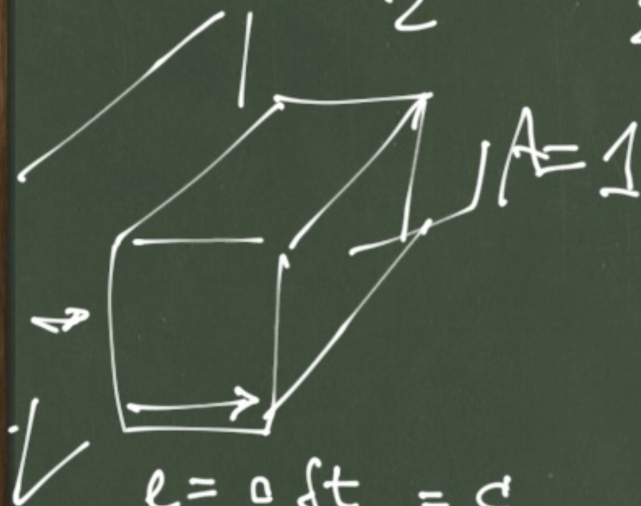
~~Galileo~~

x

$\cancel{x' = x + vt}$

Lorentz

$$u_E = \frac{\varepsilon_0 E^2}{2} = \frac{E^2}{2\mu_0 c^2} = \frac{B^2}{2\mu_0} = u_B$$



$l = c\,\delta t = c$

$\delta t = 1$

$$u = \varepsilon_0 E^2 = \varepsilon_0 E B c$$

$$S = u c = \varepsilon_0 E B c^2 = \frac{EB}{\mu_0} \quad \frac{J}{m^3} \cdot 1m^2 \cdot 1\frac{m}{s} \cdot 1s$$

$$\frac{EB}{\mu_0} \overset{\text{dim}}{=} \frac{V}{m}\frac{T}{\mu_0} = \frac{V}{m}\frac{A\cancel{T}}{\cancel{T}m} = \frac{W}{m^2}$$

$\frac{\text{potenza}}{\text{area}}$

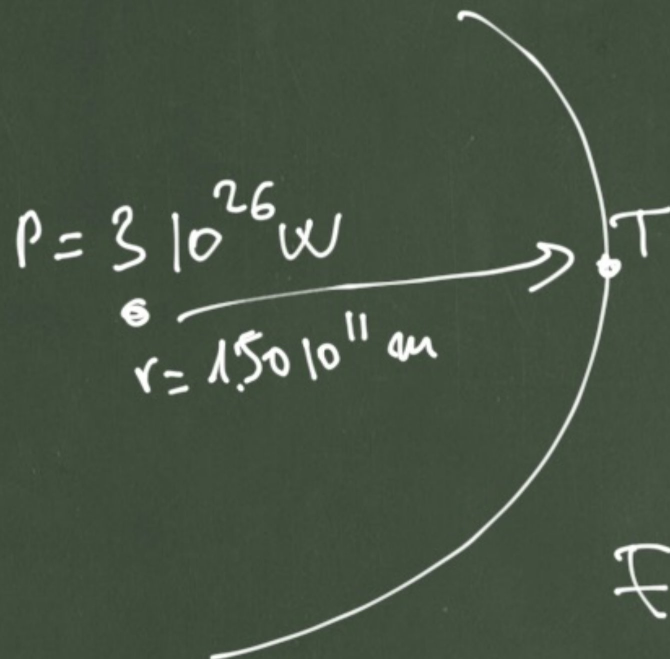
$$\bar{S} = \frac{\vec{E} \times \bar{B}}{\mu_0}$$ Poynting

$$\boxed{\langle |\bar{S}| \rangle = \frac{E_0 B_0}{2\mu_0} \equiv I \equiv S}$$

$$I = \frac{E_0}{2\mu_0 c} = \frac{\varepsilon_0 E_0^2 c}{2}$$

$$E_0 = 100 \, \frac{V}{m}$$

$$S = 13 \, \frac{W}{m^2}$$



$$\frac{P}{4\pi r^2} = \frac{3 \cdot 10^{26}}{36 \; 10^{22}} = 0.1 \; 10^{4} = 10^{3} = 1 \, \frac{\mathrm{kW}}{\mathrm{m}^2}$$

$E_0, \; \omega$ –

$$\lambda = \frac{2\pi}{k}$$

$$\omega / k = c$$

$$\omega = c k$$

$$\frac{P}{A} = \frac{Fv}{A} = pv$$

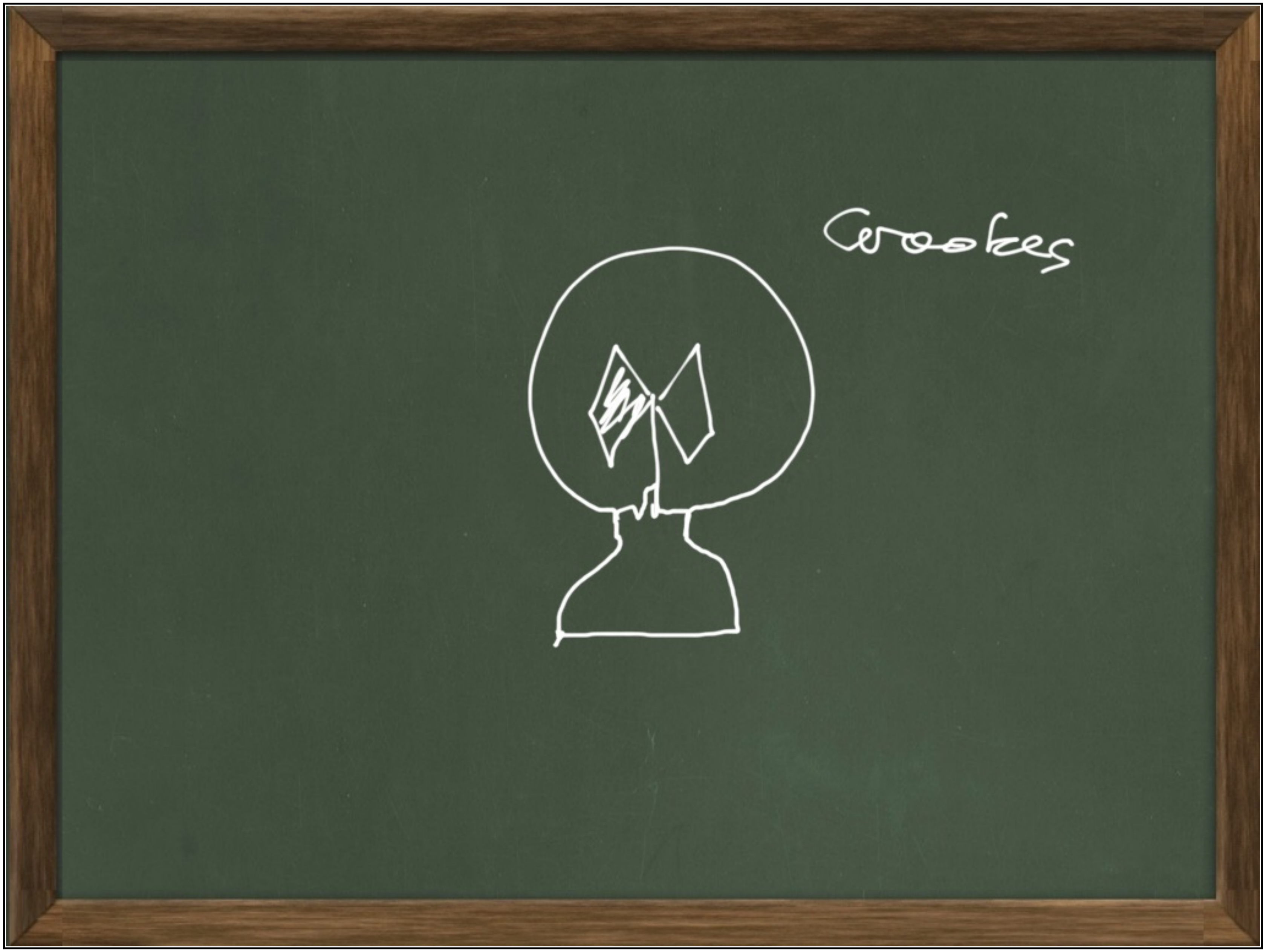
$$S = \frac{P}{A} = pc \qquad p = \alpha \frac{S}{c}$$

$\alpha = 1, 2$

abs., refl.

$$p = \frac{S}{c}, \quad 2\frac{S}{c}$$

abs. refl.


Crookes