Lecture36 iq32

Maxwell equations and 1D plane EM waves

1. LC and LRC circuits: The amped envelop
2. Maxwell equations:
    a. Gauss law
    b. Gauss law for magnetism: No magnetic monopole
    c. Ampere-Maxwell law
        i. Piercing through a plane film
        ii. Piercing through 3D film which includes E-flux in the gap
        iii. Partial piercing
3. Ch24.h1: 15-16. 1D plane EW aves.
    a. Switch on the current sheet at t=0.
    b. B-flux passing through the front window 12341 and Faraday's law
    c. E-flux passing through the top area 12561 and Ampere-Maxwell's law
    d. v^2=1/(esp0 x mu0)
    e. Measurement of esp0 and mu0 in static experiments.

Reflection: Faraday law and Ampere-Maxwell's law enable the propagation of EM waves in vacuum.

Announcement:

Midterm 3, class average 71.

The lecture video in our homepage is now available for viewing. Keep in mind it is an experimental project. Your feedback is welcome.

Application of the LA position is now available. For those of you who do well in this course are encouraged to apply the LA job. LAs are playing an important part in helping students through their interaction with students. If you are interested in this job opportunity please contact Lisa Gentry*.

*Lisa's contact information: Undergraduate Coordinator, Department of Physics
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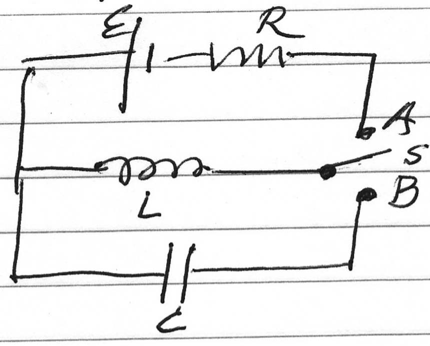
email address: ugaffairs@physics.utexas.edu

RLC circuit –

Typical set up to get LC oscillation started



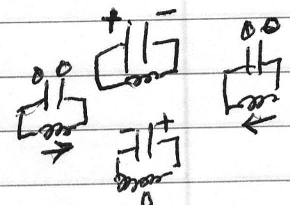
S at A to build up current.

S from A to B begin osc. max I in L

Lenz Rule continue current flux charging the plate.

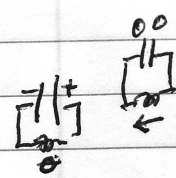
Typical Oscillator cycle: Fig 32.1a

$t=0 \rightarrow t=T/2$



Neutralize plate charge : CCW current

from $t=T/2 \rightarrow T$: CW current



Loop eqn: $\mathcal{E} - L\frac{dI}{dt} - \frac{q}{C} - IR = 0$

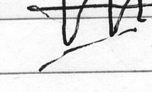
Power eqn: $I\mathcal{E} - \frac{d}{dt}\left(\frac{LI^2}{2} + \frac{q^2}{2C}\right) - I^2R = 0$

$U_{L\,max} = U_{C\,max} = U_L + U_C = \text{const}$

$\mathcal{E}=0,\ R=0,$ conservation of energy $\frac{d}{dt}(U_L + U_C) = P_L + P_C =$

$\mathcal{E}=0,\ R\neq 0$ $\quad \underbrace{P_L + P_C}_{\text{negative}} + I^2R = 0$

Damped envelope



Maxwell eqn —

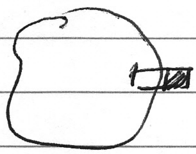
— Gauss Law

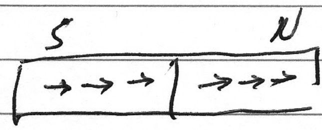
$$\oint E\cdot dA = \frac{Q}{\epsilon_0}$$

— Magnetic gauss Law

$$\oint B\cdot dA = 0$$ (no magnetic charge
magnetic charge exists in the form of dipole)

Can we have ?



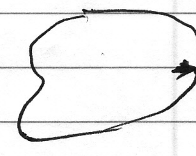


At microscopic level

Dipole orbital current loop

spin: μ_{spin}

Dipole present as fundamental unit

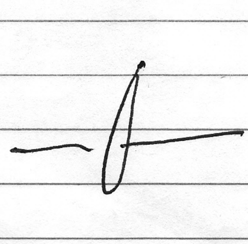


~~either~~ inside or outside

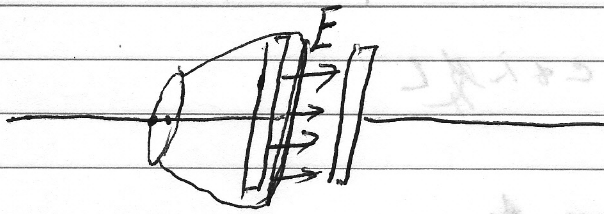
— Ampere's Law —

$$\int_{path} B\cdot dl = \mu_0 I$$

current piercing the surface where the rim of the surface = path



straight wire



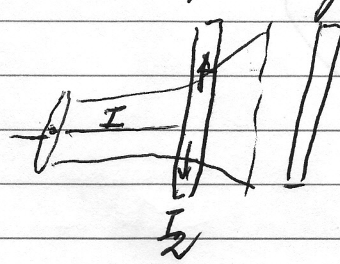
$E = \frac{Q/A}{\epsilon_0}$, $Q = \epsilon_0 E A$

Q on the plate, it generates E-flux

responsible for piercing the surface defined by the rim

$\frac{dQ}{dt} = \epsilon_0 \frac{d\Phi_E}{dt}$ (virtual current, displacement current

Partial piercing:



$$RHS = \mu_0 \left[I + \epsilon_0 \frac{d\Phi}{dt} \right]$$

partial piercing

$$I_2 + \epsilon_0 \frac{d\Phi_2}{dt}$$

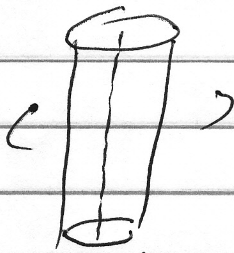
Difficult to understand.

How can em waves propagate in vacuum?

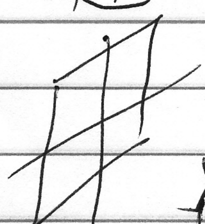
Why shouldn't it works in the same way as mechanical waves requires the presence of a medium?

How 1D plane waves propagate?

Drop a pebble in a pond → See circular wave front (adjacent pts with same phase)

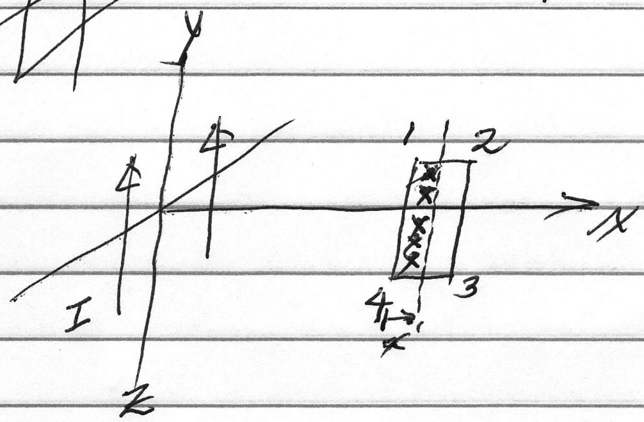


Cylindrical wave front

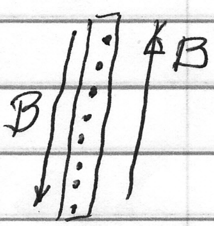


Sheet of current ⇒ 1d waves

plane waves.



Top view:



HW Ch24.41 $\quad Eh = Bhv$

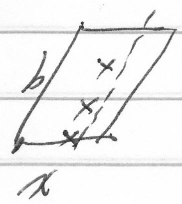
$$\frac{dBhx}{dt}$$

"Bin"

Einh

$\therefore E = Bv$

A-M: path



$$\oint B\cdot dl = \mu_0\left[\epsilon_0 \frac{d\phi_E}{dt}\right]$$

$$\frac{d}{dt}(Ebx) = Ebv$$

$$Bb = \mu_0\epsilon_0 E b v$$

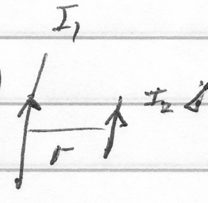
$$B = \mu_0\epsilon_0 v^2 B, \quad v = \frac{1}{\sqrt{\mu_0\epsilon_0}} \approx 3\times10^8\ m/s.$$

$$\frac{1}{\mu_0\epsilon_0} = \frac{4\pi}{\mu_0}\cdot\frac{1}{4\pi\epsilon_0} = 10^7\times 9\times10^9 = (3\times10^8)^2$$

All em waves in vac $\sim 3\times10^8\ m/s$

Measure μ_0:

$$F^{I_1}_{I_2\Delta} = (I_2\Delta)\left(\frac{\mu_0 I_1}{2\pi r}\right).$$



Meas ϵ_0: $F = \frac{qQ}{4\pi\epsilon_0 r^2}$.