Lecture 32 iq28

1. Motional emf is one special case of Faraday's law.

2. Dicussions on selected problems in Ch23.h1.

    - 001-006
    - 007 Ec can be directed direcrtly from Faraday's law independent of the presence of the wire loop.
    - 8-9 Total energy dissipated. P=IV, V=IR.
    - 10 Figures involve coils.
    - 12 Calcuation of the flux in a loop where B depends on x.
    - A problem which calculates E_{NC}

Announcement:

Re: Adjustment on present lesson plan

Our lectures are slightly behind our original lesson plan. The updated lesson plan is as follows.

- Postpone the due date of ch23.h2 from the coming Sunday to next Tuesday.
- Due dates of ch23.h3 and ch24.h1 will be on the Wednesday of the following week. (Using present lesson plan notation, it is "W")
- Ch24.h2, ch24.h3 on Su.
- Ch24 h4, ch24.h5 on W
- Ch25-h1 on Su

Midterm3 will now cover the exam materials only through ch23-h2.Notice that the inductance and the LR circuit are covered in ch23-h2. They will be included in the exam. On the other hand problems which involve LC circuits only appear in ch23-h3. They will not be included in this exam.

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Motional emf is a special case of Faraday's Law

General form of Faraday's law –

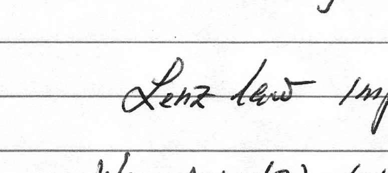
$$\mathcal{E} = \int_{path} E \cdot dl = -\frac{d\phi_{path}}{dt}$$

The path is the Faradian loop here.

$$RHS = -\frac{dBA}{dt} = -\frac{dB}{dt}A - B\frac{dA}{dt}. \quad (1)$$

Check: Moving rod along two // railing setup gives emf = vBl which can be derived based on Faraday's Law.

From motional emf: $\mathcal{E} = \frac{qvBl}{q} = vBl$ (2)



Lower end has higher potential
$\mathcal{E}$ in CW. (2)'

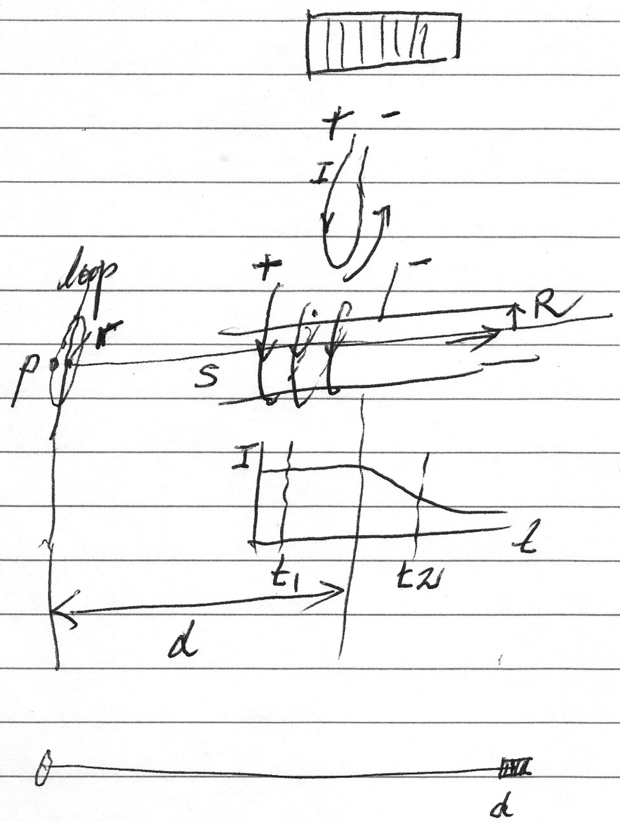
From RHS of F.L., i.e. eq(1), $\left|-\frac{BdA}{dt}\right| = \left|\frac{Bd\,lx}{dt}\right| = Bl\frac{dx}{dt}$
$= Blv.$
(3)

Lenz law implies B_{in} is $\otimes$, or E_{in} CW. (3')

We see (2) + (2') agree with (3) + (3'). Or motional emf is a special case of Faraday's Law.

One can show in the case of current loop from both consideration one finds
$\mathcal{E} = \mathcal{E}_{max} \sin \omega t$, where for N turn coils,
$\mathcal{E}_{max} = NvBl$

001-007



1) Find Φ define by the loop

$$\Phi_{loop}^{sol} = B_{loop}\pi r^2$$

$$B = B_{loop}^{solenoid} = \frac{\mu_0}{4\pi}\frac{2\mu^{sol}}{d^3}$$

$$\mu^{sol} = N\mu^{ring} = NIA = NI\pi R^2$$

$$\Phi_{loop}^{sol} = \text{const } I$$ mutual inductance

$$L = \text{const} = \frac{\Phi}{I} = \left(\frac{\mu_0}{4\pi}\right)\left(\frac{2N\pi R^2}{d^3}\right)\pi r^2$$

2) What is E_{in} at P when $I = \text{const}$?

choices $|E_{in}| = 0$, or > 0.

3) At t_2 as $I\downarrow$, find $\langle E_{in}\rangle$. Curly pattern is generated.

choices: $\langle E_{ind}\rangle = \uparrow$ or $\downarrow$

4) find $\left|\frac{\Delta\Phi}{\Delta t}\right|$. $\left|\frac{\Delta\Phi}{\Delta t}\right| = \left|\frac{\Delta LI}{\Delta t}\right| = L\frac{\Delta I}{\Delta t}$,

5) $|emf|_{in\ loop} = \left|\frac{\Delta\Phi}{\Delta t}\right|$.

6) Find $|E_{ind}|$

$2\pi r E_{ind} = \left|\frac{\Delta\Phi}{\Delta t}\right|$, $|E_{ind}| = \frac{1}{2\pi r}\left|\frac{\Delta\Phi}{\Delta t}\right|$

7) $|E_{ind}|$ with wire loop removed.

8-9

Remove the ring for $B=B_1$ region

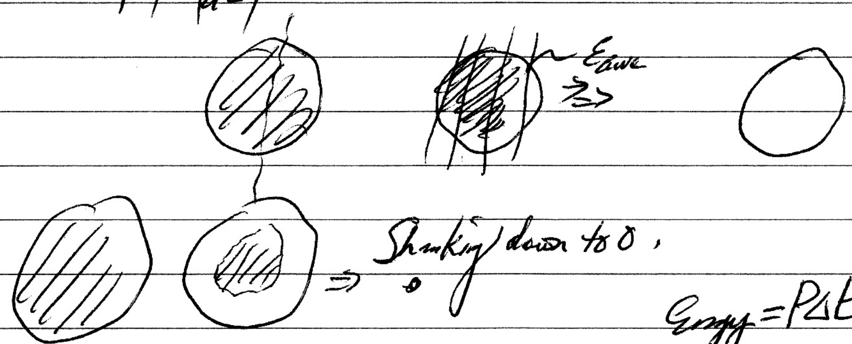
to other region where $B=0$ in t_1 sec. Assume ring resistance is R.

Find: Ave $\mathcal{E}$, Energy consumed,

$$\text{Ave } \mathcal{E} = \frac{(B_1 A - 0A)}{t_1 - 0} = \frac{\overset{\text{Tesla}}{B_1} \overset{m^2}{A}}{\underset{\text{sec}}{t_1}} = \frac{B_1 A}{t_1} \text{ volts},$$

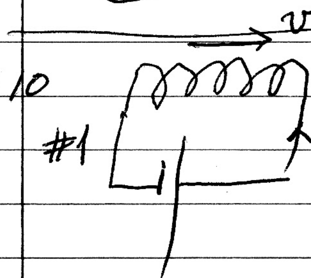
$$\text{Energy consumed} = P\Delta t = I\mathcal{E}\,\Delta t = \frac{\mathcal{E}^2}{R}\Delta t,$$

$|\mathcal{E}| = \left|\frac{d\Phi}{dt}\right|$ Assume same $\mathcal{E}$ throughout t-interval



$$\text{Energy} = P\Delta t = \frac{\mathcal{E}_{AVG}^2}{R}\Delta t,$$

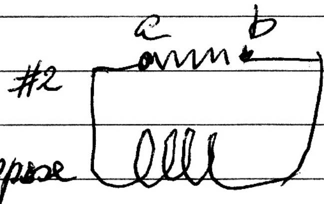
10



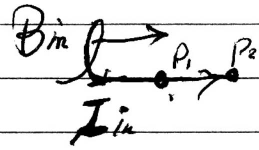
→ North

$\rightarrow B_2^1$: Determine $\langle B_{in} \rangle$ at right coil #2 due to motion of #1

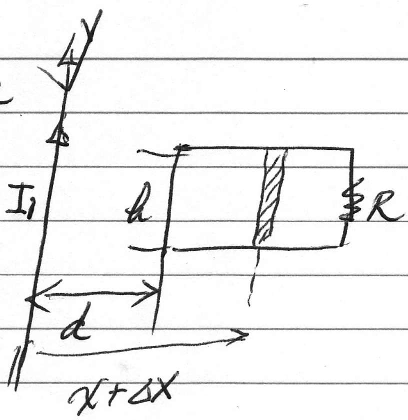
$\therefore \langle B_{in} \rangle \longleftrightarrow ?$



Suppose



Q12



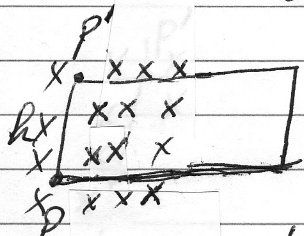
If I_1 is decreasing, find direction of emf ind. in the loop
choice: CW or ccW.

Find |emf|. Hint: $|emf| = \left|\frac{d\phi}{dt}\right|$

$$= \frac{d}{dt}\iint dx\,dy\, B = \frac{d}{dt}\, h \int dx \frac{\mu_0}{2\pi x} I_1$$

$$= \frac{h\mu_0}{2\pi}\frac{dI_1}{dt}\int_d^{d+W}\frac{dx}{x}$$

Q14



Determin the direction of the force on the segment AB as B is decreasing.

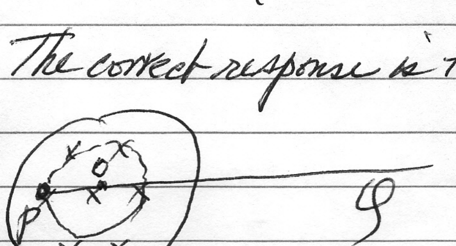
Hint: The force on PP' is given by

$$F^{B_{in}}_{I_{in}h} = I_{in}\, h \times B_{in}.$$

First determine the direction of B_{in}
(should it be into or out).

The correct response is to keep flux within the loop constant

Q16



Hint: To find $\vec{E}_{NC}$ at P
first write down Faraday's Law
for the Faradian loop: circular loops thru P, centered at C