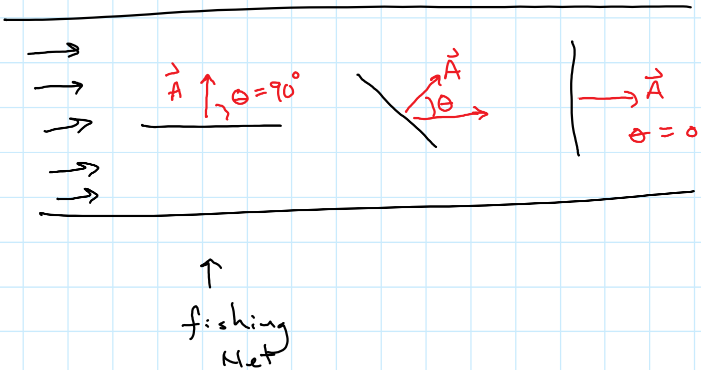
Phy 2B 2/18

Wednesday, February 18, 2015 10:03 AM

Ch 23 - Induction

Flux

River



Flux - amount of water that goes through the surface the surface defined by our fishing net

3 ways to change flux:

1) orientation

2) Area of Net

3) Turn up flow of water

Magnetic flux: the amount of magnetic field lines that pass through a surface defined by a loop of wire

$$\Phi = \vec{B} \cdot \vec{A}$$

$$= B A \cos\theta$$

Faraday's Law:

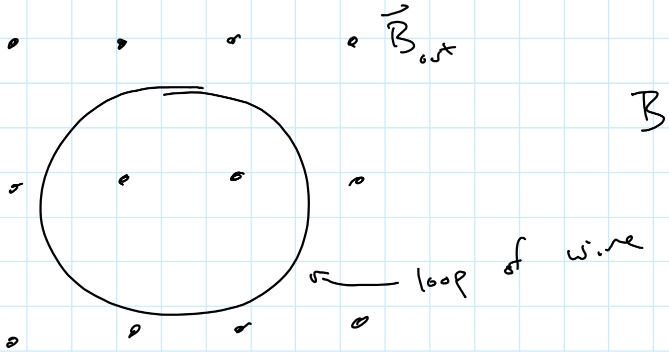
$$\mathcal{E} = -N \frac{\Delta \Phi}{\Delta t}$$

$$|\mathcal{E}| = N \left| \frac{\Delta \Phi}{\;} \right|$$

$$|\mathcal{E}| = N\left|\frac{\Delta\Phi}{\Delta t}\right|$$

Lenz's Law : an induced current always flows in a direction that opposes the change that caused it

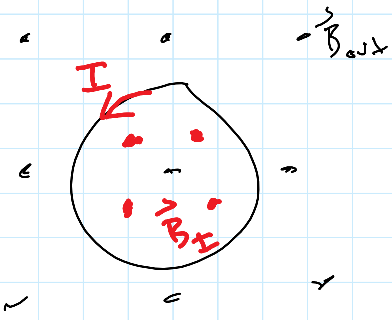
(conservation of energy)



B_{out} is increasing in time

we know current flows in loop → does it go cw or ccw ?

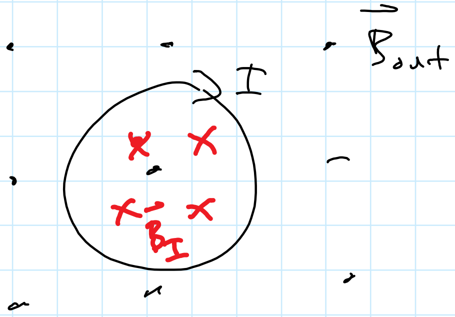
ccw



1) I starts to flow due to increasing B_{out}

2) I causes its own

cw



1) I flows due to an increase in B_{out}

2) I creates B

an increase in

2) I causes its own magnetic field, B_I
B_I would point out of page if I is CCW

3) B_I would cause more I to flow
which causes more B_I
⋮

Free energy

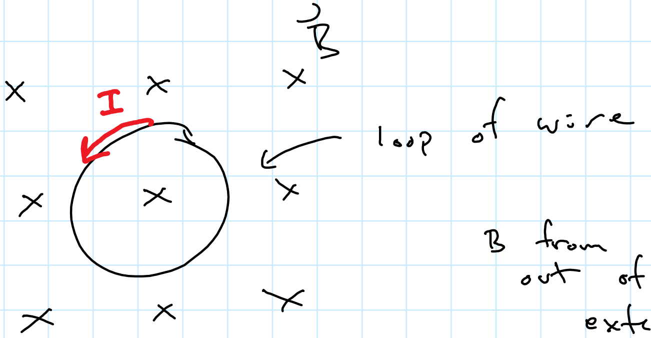
Violates Cons. of Energy

2) I creates B_I pointing into page

OK with Cons. of energy

Find direction of I (induced current)

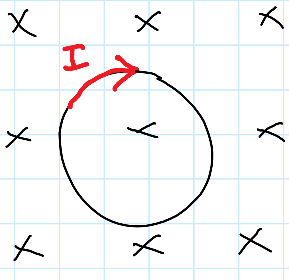
1)



B is increasing in time

B from the current must point out of page to oppose the increasing external B

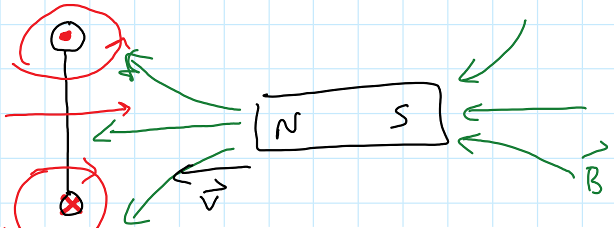
2)



B decreasing in time

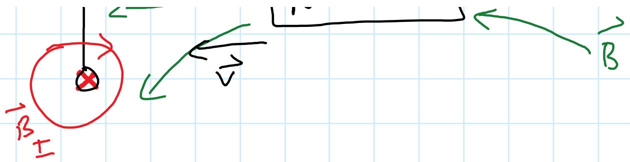
B from current must add to the external B to oppose the decrease

3)



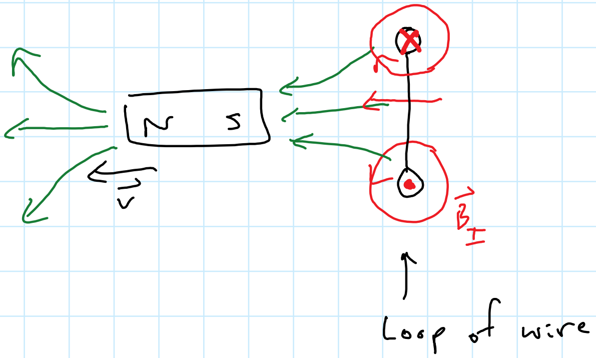
B increasing to the Left

So, I creates its own B pointing



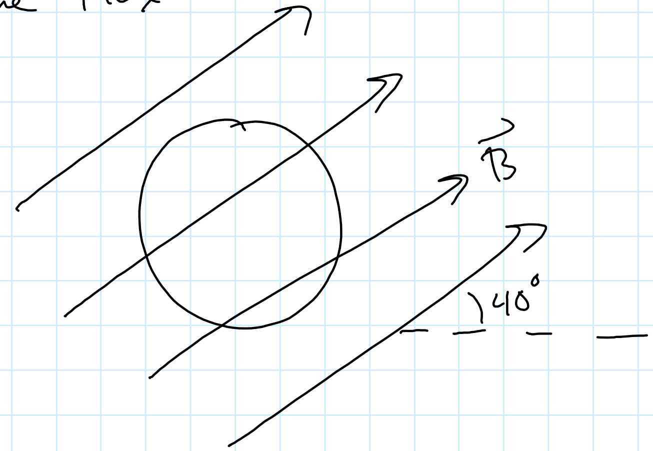
So, I creates its own B pointing to the Right

4)



Find the flux:

1)

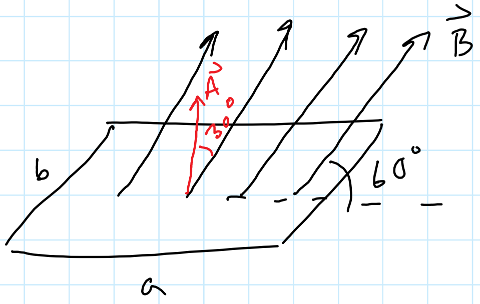


B and loop both in the plane of the page

radius = R

$\Phi = 0 = BA\cos 90^\circ$

2)

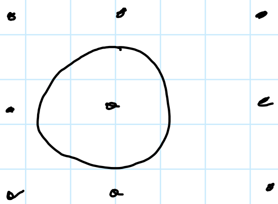


Loop is ⊥ to page

B is in plane of page

$\Phi = B(ab)\cos 30^\circ$

3)



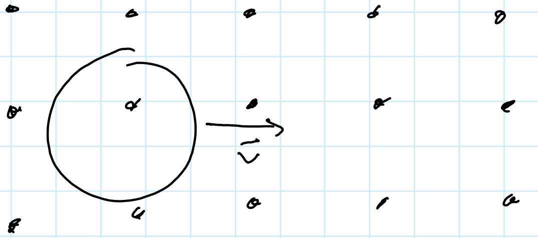
Loop in plane of page

B ⊥ to page

radius = R

$$\Phi = BA\cos 0^\circ = B(\pi R^2)$$

4)

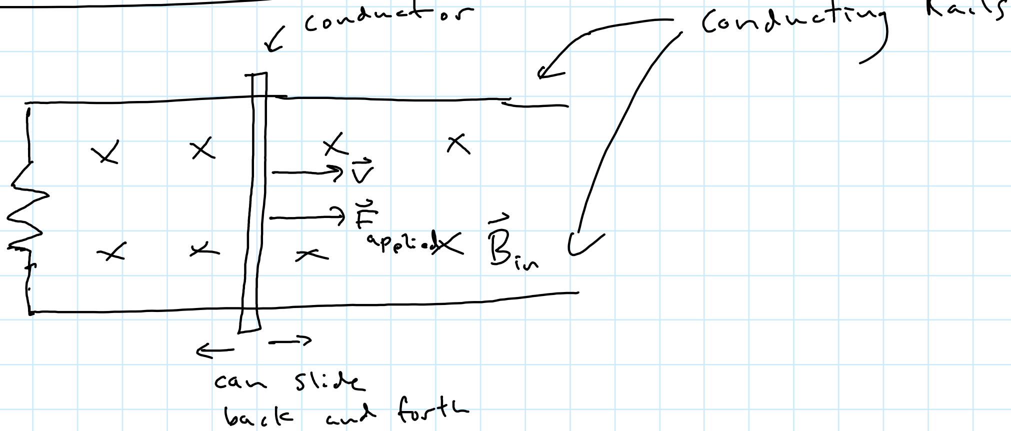


B ⊥ to page

Loop in plane of page

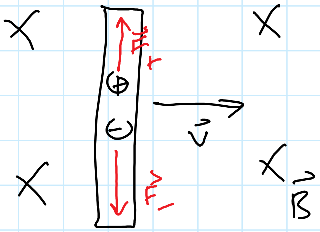
radius = R

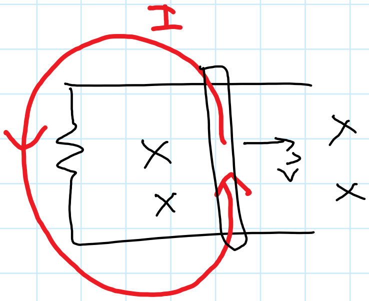
$$\Phi = BA\cos 0^\circ = B(\pi R^2)$$



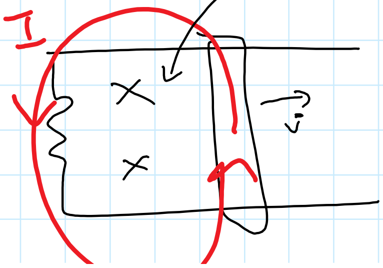
Push bar to Right:

1) Charges moving in a magnetic field:





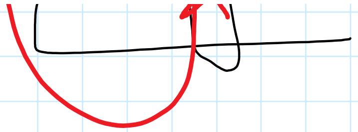
2) Lenz's Law: Area is increasing



Φ is into page

and increasing

So, B from induced current



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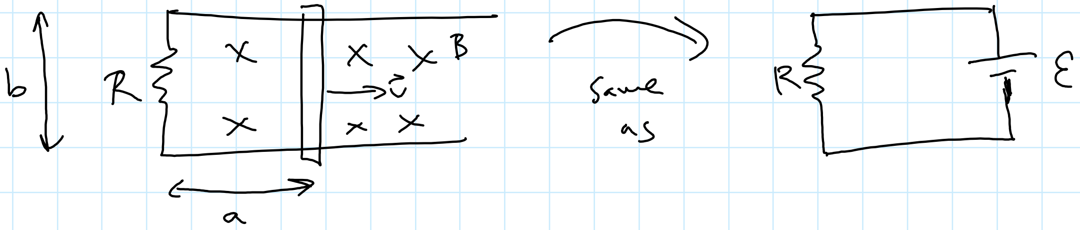
So, B from induced current must be out of page

3) Use Faraday's Law to quantify.



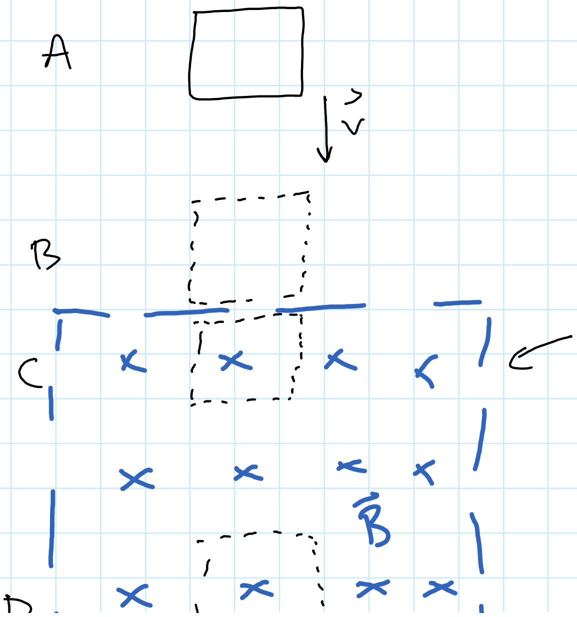
$$\mathcal{E} = N \frac{\Delta \Phi}{\Delta t}$$

$N = 1$

$\Phi = B(ab) \cos 0^\circ = B ab$

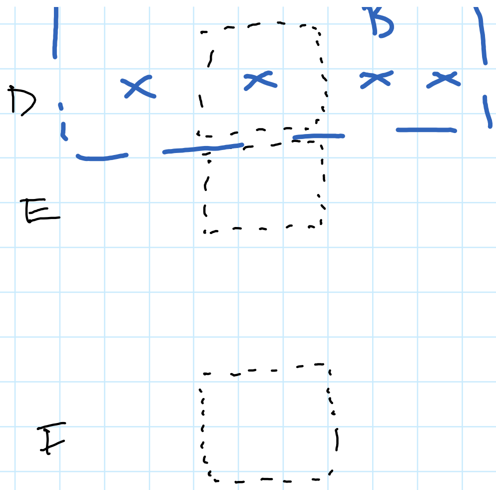
$$\mathcal{E} = \frac{\Delta(Bab)}{\Delta t} = B \frac{\Delta(ab)}{\Delta t} = B b \underbrace{\frac{\Delta a}{\Delta t}}_{\text{velocity}}$$

$$\mathcal{E} = B b \overset{\uparrow}{\underset{\text{velocity}}{v}}$$



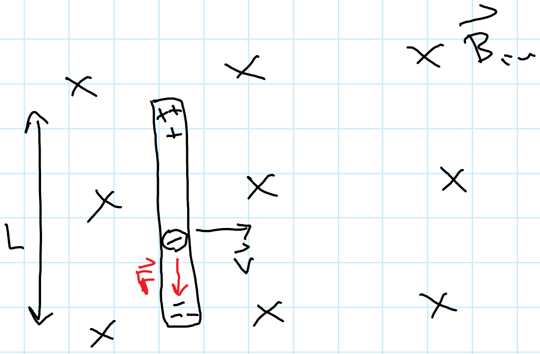
B is only in this region

	Direction of induced current in loop
A → B	No current
B → C	↶ CCW



B → C	↶ CCW
C → D	No current
D → E	↷ CW
E → F	No current

Motional Emf



$$\uparrow \vec{F}_E = qE = q\left(\frac{\Delta V}{L}\right)$$

$$\ominus$$

$$\downarrow \vec{F}_B = q\underset{\text{velocity}}{\underset{\uparrow}{v}}B$$

equal

$$F_E = F_B$$

$$\cancel{q}\,\frac{\Delta V}{L} = \cancel{q}\,vB$$

$$\underset{\substack{\text{Potential}\\\text{difference}\\\text{over length}\\\text{of rod}}}{\underset{\uparrow}{\Delta V}} = B\underset{\text{velocity}}{\underset{\uparrow}{v}}L$$

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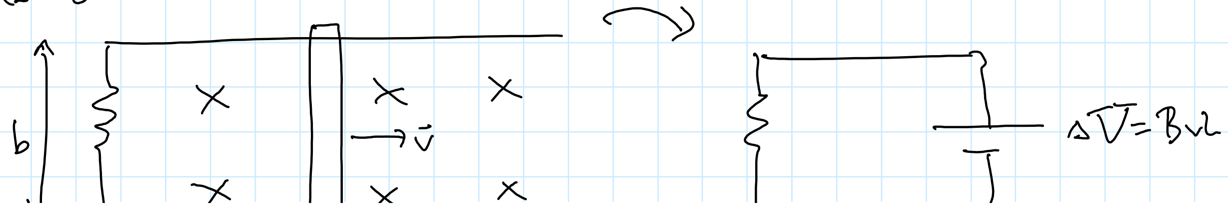
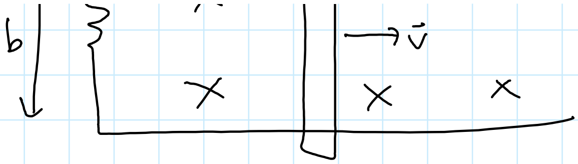
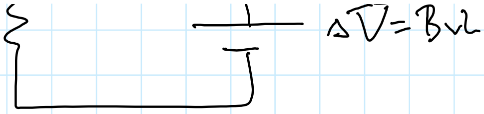
use motional Emf







$$\Delta V = BvL$$
$$= Bvb \quad \text{same}$$