LECTURE 20

QUESTIONS

ToC

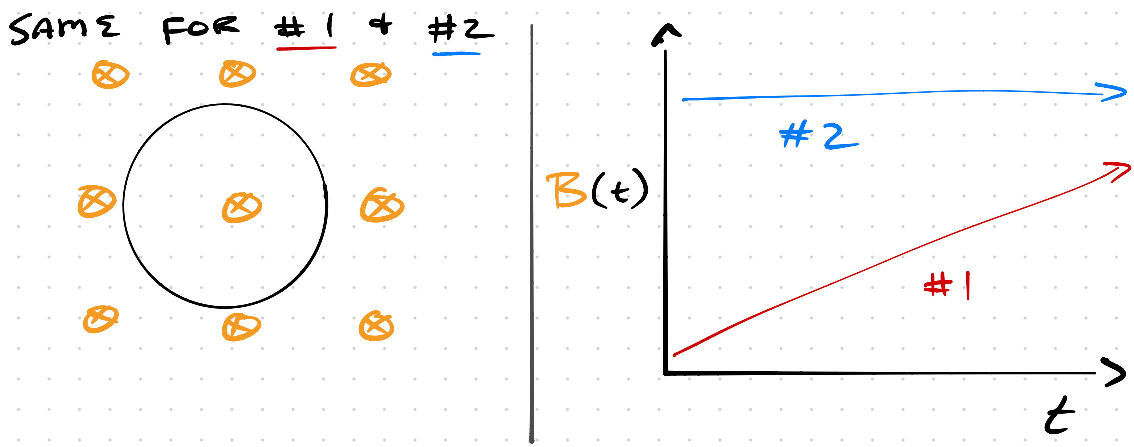
QUESTIONS | PAGE

ANSWERS

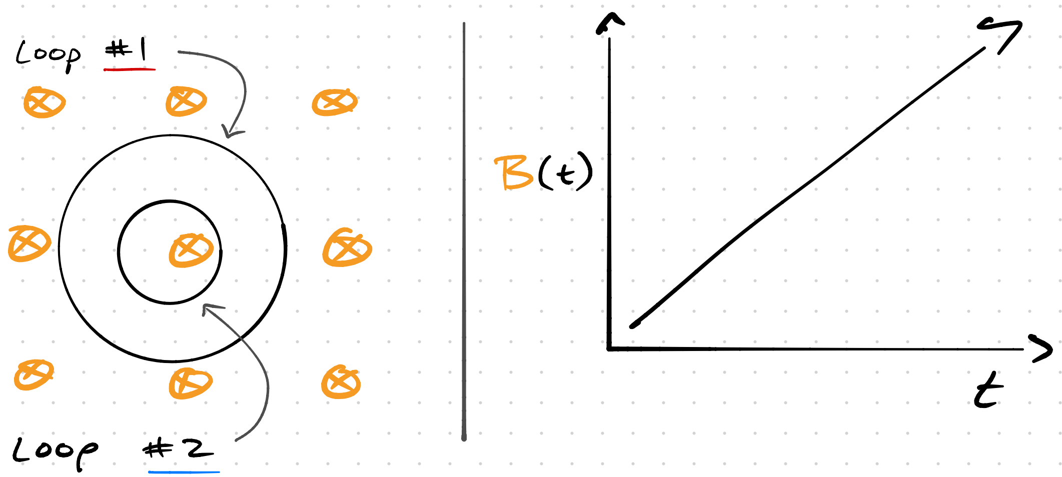
Q1 FARADAY'S LAW

In the following, pick which of the two cases (#1 or #2) has the larger induced emf. Assume in all case the magnetic field is spatially uniform, though possibly changing with time.

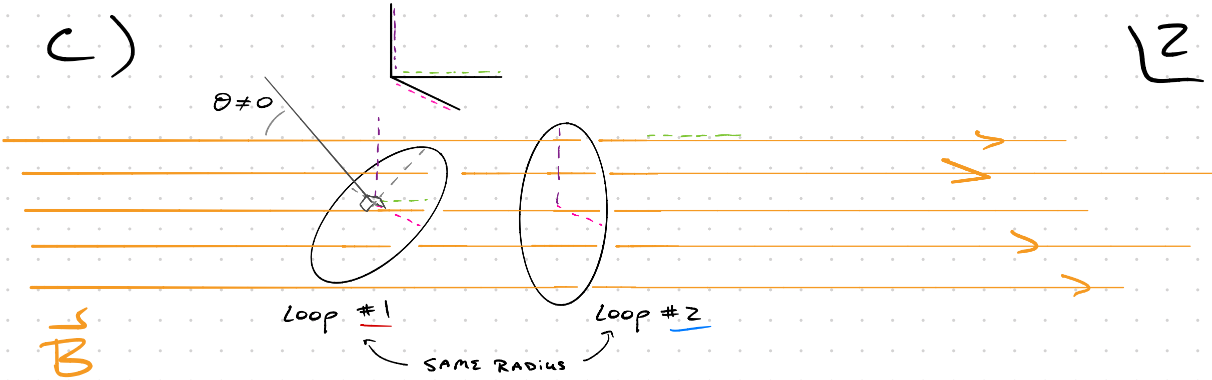
(a)

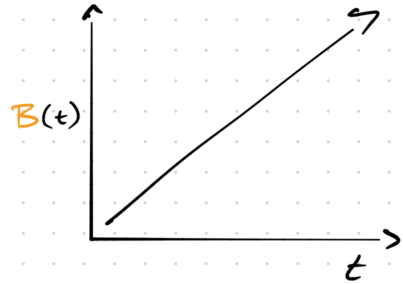


(b)

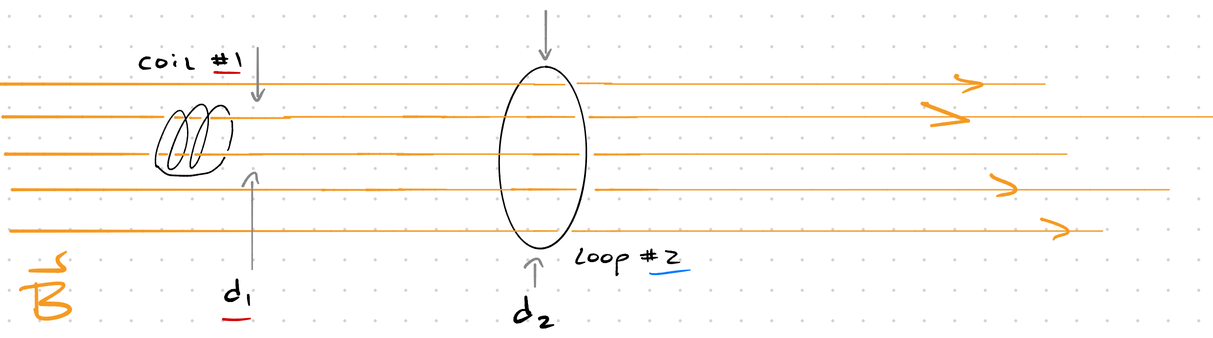


c)

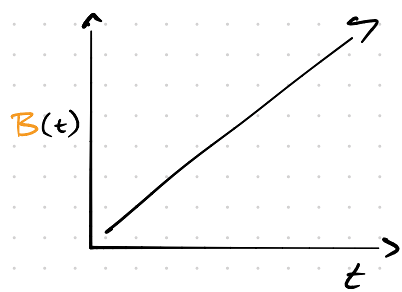




d)



$$d_2 = 2d_1$$

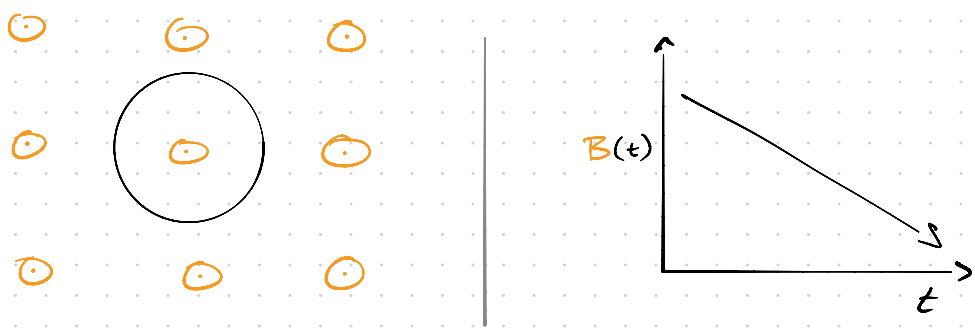


Q2) LENS' LAW

On each of the following diagrams, draw the direction of induced current and the induced magnetic field. Assume all magnetic fields are spatially uniform.

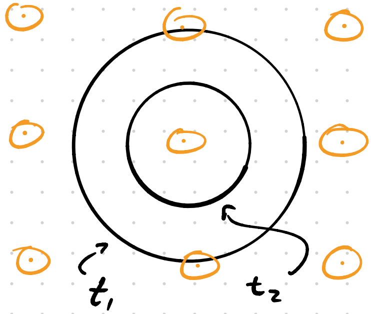
a)

b)

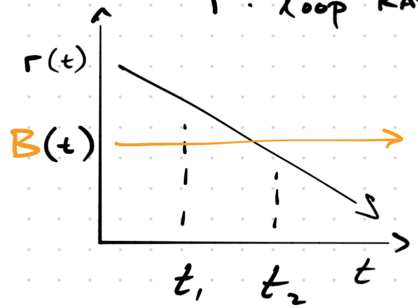


c)

Loop shrinking



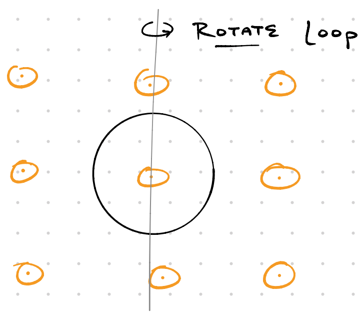
r : loop Radius

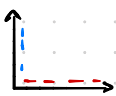


$\vec{B}$ constant in Time

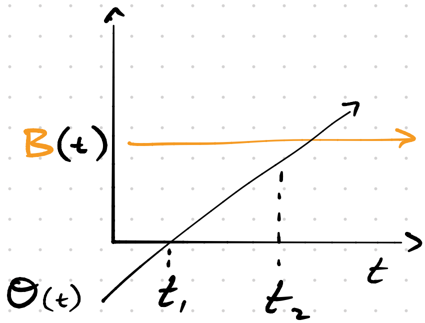
d)

Top View:

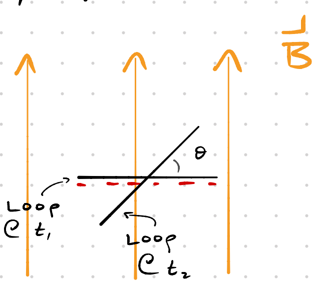




$\vec{B}$ constant in Time



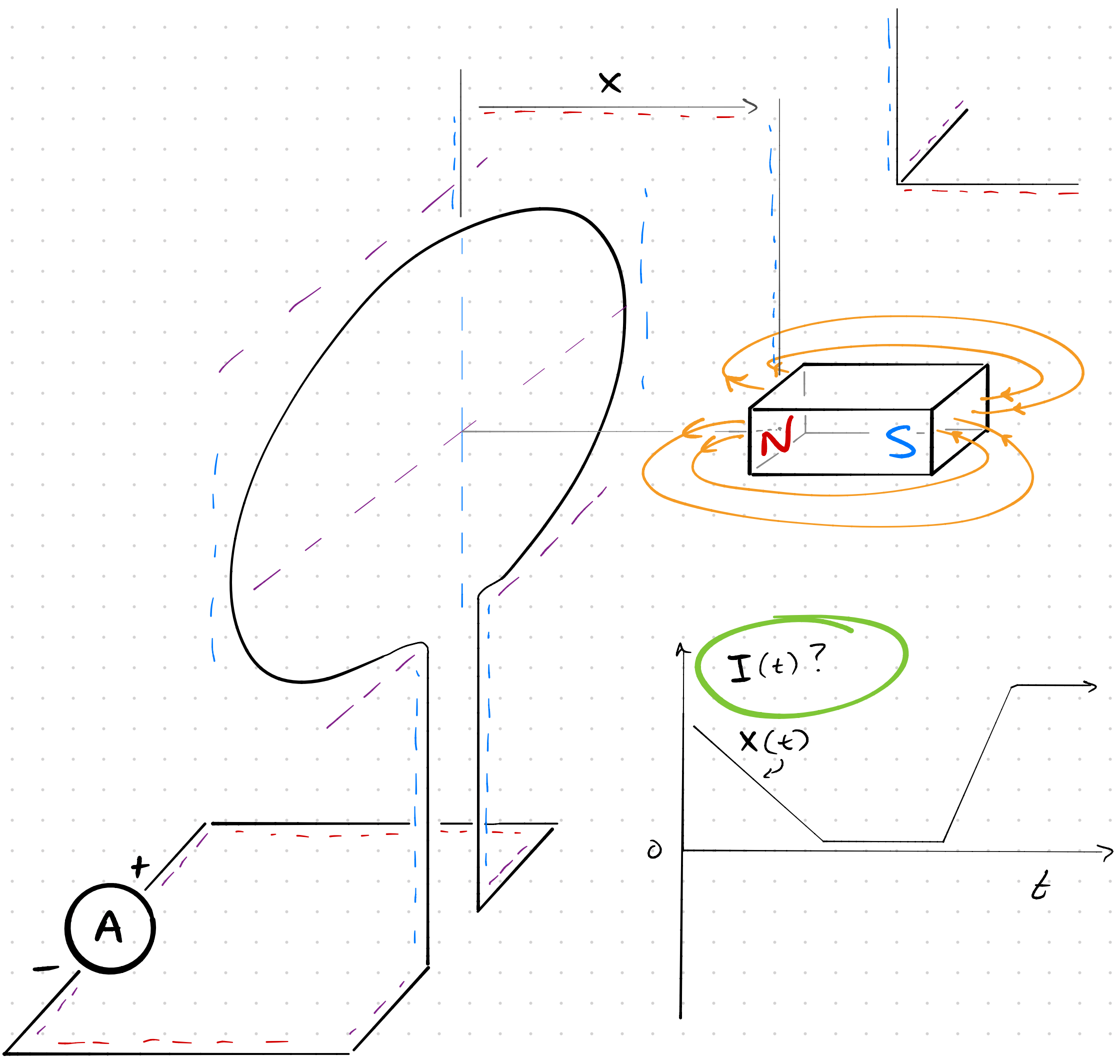
Profile View:



Q3)

NO CALCULATIONS!

A bar magnet is moved towards and away from a wire loop, as shown. Plot (roughly) the measured current $I(t)$ as a function of time given the bar magnet trajectory $X(t)$.



ANSWERS

Q1

a) Although the magnetic field in case #2 is larger, it is constant in time so there will be no emf.

b) The area of the loop is larger for loop #1. Since the field is uniform, this means the flux is larger for #1, and thus also the time rate of change of flux.

c) Because loop #1 is tilted so that it is no longer perpendicular to the magnetic field, it subtends fewer magnetic field lines than loop #2*. The flux through loop #1 is thus smaller (they have the same radius), and so also the time rate of change of flux.

* Mathematically: $\Phi \propto \cos\theta$

d)

\# of loops ("turns")

17

$$\text{EMF} = N \frac{\Delta \Phi}{\Delta t}$$

$$\Phi \propto A \propto r^2$$

loop area — loop radius

$\longrightarrow \text{EMF} \propto N r^2$

$N_1 = 3$

$N_2 = 1$

$r_2 = 2 r_1$

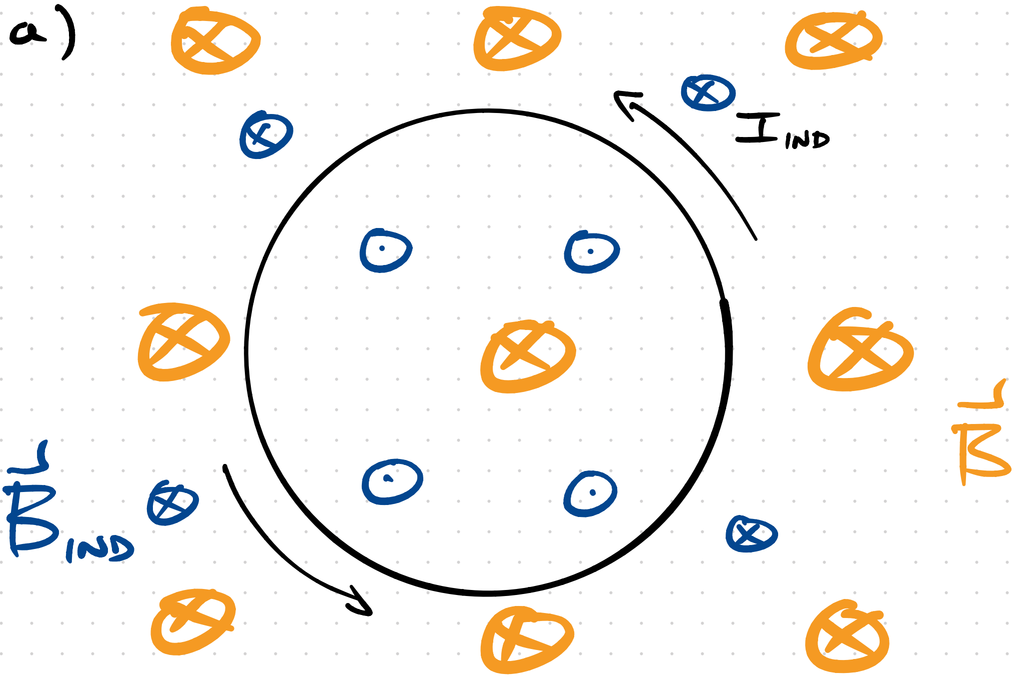
$$\longrightarrow \frac{\text{EMF}_1}{\text{EMF}_2} = \frac{3}{2^2} = \frac{3}{4}$$

$\longrightarrow \text{EMF}_2 > \text{EMF}_1$

ANSWERS

Q2

a)



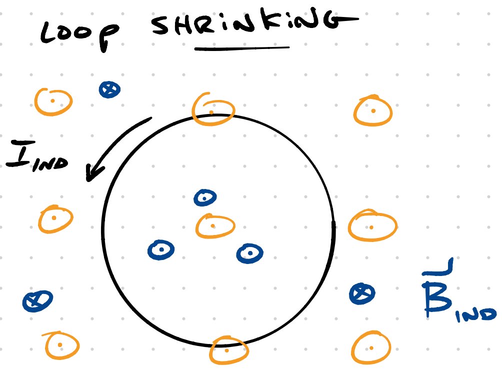
Because the flux into the page is increasing, the induced current will flow in the direction that generates an induced field that points out of the page when inside the loop.

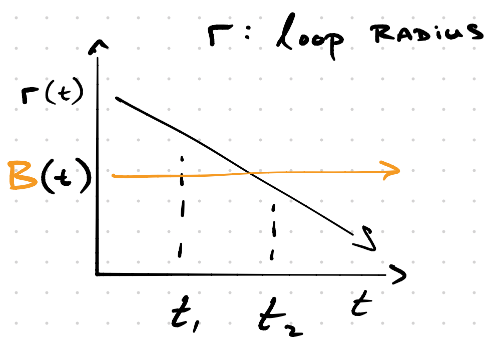
b)

Now the flux out of the page is decreasing, so the induced current will generate a field which acts to increase the flux out of the page. This is the same result as part a).

c)

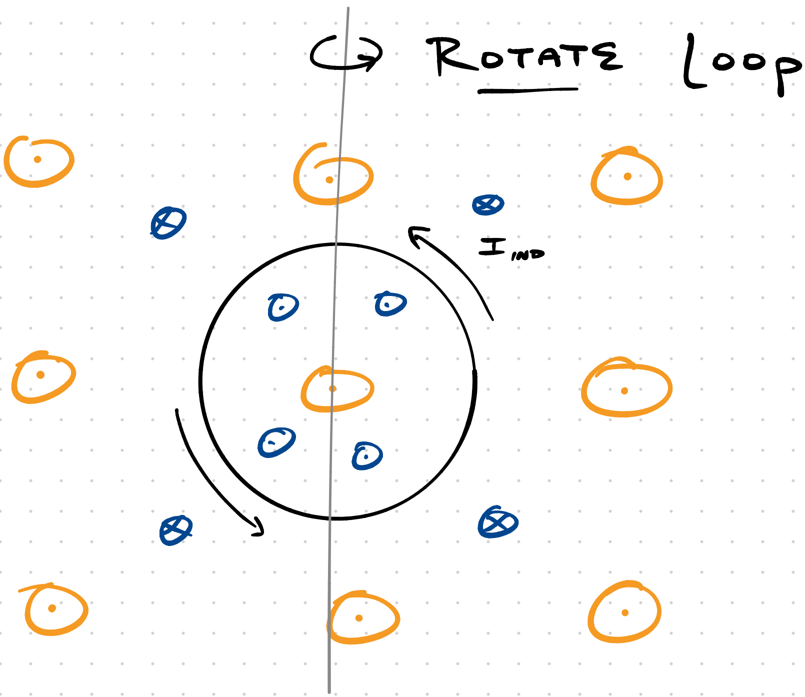
Since the area of the loop is decreasing and the magnetic field is constant and pointing out of the page, the flux out of the page is decreasing. The induced current thus will generate a field which increases the flux out of the page:





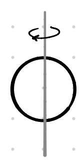
d)

As the loop rotates away from being perpendicular to the magnetic field, it will intercept less of the outwards magnetic flux. The induced current will then flow in the direction which induces a field that increases the outwards flux:



FOLLOW UP: WHAT IF WE HAD ROTATED LOOP IN OPPOSITE DIRECTION?

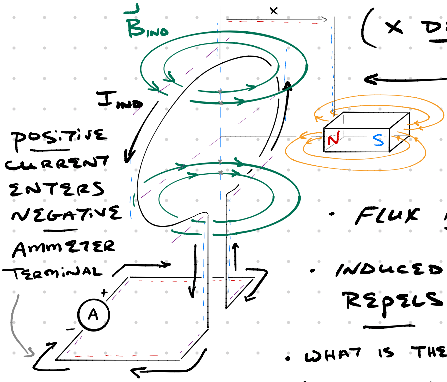
i.e.:



Q3)

BAR MAGNET MOVES TOWARDS LOOP:

(X DECREASING)



- FLUX INCREASING,
- INDUCED FIELD REPELS MAGNET!
- WHAT IS THE LOOP'S "BAR MAGNET EQUIVALENT"?

BAR MAGNET MOVES AWAY FROM LOOP (X INCREASING):

- FLUX DECREASING
- INDUCED FIELD ATTRACTS BAR MAGNET!
- EXERCISE FOR YOU:
  - ADAPT DIAGRAM TO THE LEFT FOR THIS CASE (X INCREASING). CONVINCE YOURSELF AMMETER NOW MEASURES POSITIVE CURRENT.