LENZ'S LAW:

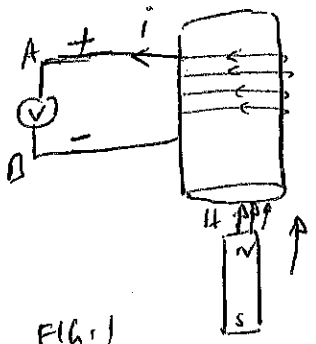


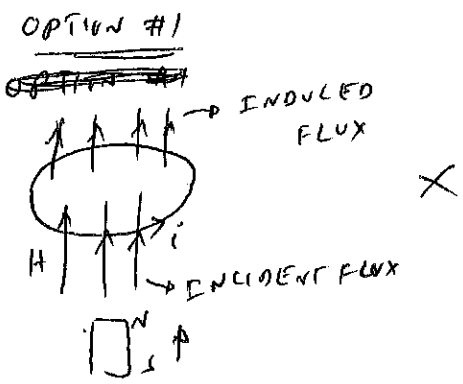
FIG. 1

FARADAY'S LAW IS EXPRESSED AS

$$emf = -\frac{d\Psi_m}{dt}$$

THE -VE SIGN SHOWS THAT THE FLUX (DUE TO AMPERE'S LAW) PRODUCED BY THE INDUCED VOLTAGE OPPOSES THE INCIDENT FLUX. THIS BEHAVIOR IS DESCRIBED BY LENZ'S LAW WHICH STATES THAT "THE POLARITY OF THE INDUCED EMF IS SUCH THAT IT PRODUCES CURRENT THAT LEADS TO MAGNETIC FLUX (AMPERE'S LAW) WHICH OPPOSES THE INCIDENT FLUX DUE TO THE BAR MAGNET".

FOR EXAMPLE, IF THE BAR MAGNET IS MOVING UPWARDS, THERE ARE TWO OPTIONS FOR THE CURRENT FLOW (i.e. emf polarity). THE FOLLOWING FIGURE SHOWS THE TWO POSSIBLE CURRENT DIRECTIONS IN A COIL:



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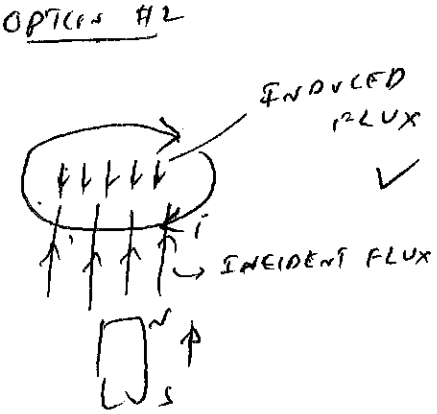

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FIG. 2

WITH OPTION #1, THE CURRENT IS IN CLOCKWISE DIRECTION & THE RESULTING FLUX (BY AMPERE'S LAW) IS IN THE SAME DIRECTION AS THE INCIDENT FLUX DUE TO THE BAR MAGNET. THESE TWO FLUXES REINFORCE EACH OTHER & HENCE, THE INDUCED EMF WOULD INCREASE RESULTING IN LARGE CURRENT. THIS POSITIVE FEEDBACK IMPLIES A VERY LARGE EMF & CURRENT IN AN EXTERNAL CIRCUIT, WHICH VIOLATES THE ENERGY CONSERVATION PRINCIPLE.

WITH OPTION #2, THE CURRENT IS IN COUNTERCLOCKWISE DIRECTION & RESULTING FLUX OPPOSES THE INCIDENT FLUX. THIS IS CONSISTENT WITH LENZ'S LAW. THE IRON CORE WITH COPPER WINDING ACTS AS A SOURCE OF EMF WITH ITS POLARITY AS SHOWN IN FIG. 1.

NOTE THAT WHILE APPLYING LENZ'S LAW, THE DIRECTION OF INDUCED FLUX WITHIN THE CORE (NOT OUTSIDE THE CORE) SHOULD BE OPPOSITE OF THE INCIDENT FLUX. USING THE RIGHT HAND RULE, IT MAY BE NOTED THAT THE DIRECTION OF INDUCED FLUX OUTSIDE THE CORE IS THE SAME AS THAT OF THAT OF INCIDENT FLUX. THE REASON FOR

THIS BEHAVIOR IS THAT THE SYSTEM OPPOSES THE MOVEMENT OF THE BAR MAGNET & HENCE, IT TRIES TO DECREASE THE FLUX IN THE REGION WHERE THERE IS MOTION OF THE MAGNET.

LENZ'S LAW IS NOTHING BUT NEWTON'S 3rd LAW APPLIED TO AN ELECTROMAGNETIC SYSTEM. NEWTON'S 3rd LAW STATES THAT "FOR EVERY ACTION, THERE IS EQUAL & OPPOSITE REACTION". IF YOU PUSH AN OBJECT WITH A FORCE F, THE OBJECT PUSHES YOU BACK WITH AN EQUAL FORCE IN MAGNITUDE, BUT OPPOSITE IN DIRECTION. IN THE CASE OF COPPER WINDING, IT OPPOSES THE MOTION OF THE BAR MAGNET BY PRODUCING A CURRENT THAT OPPOSES THE INCIDENT FLUX.

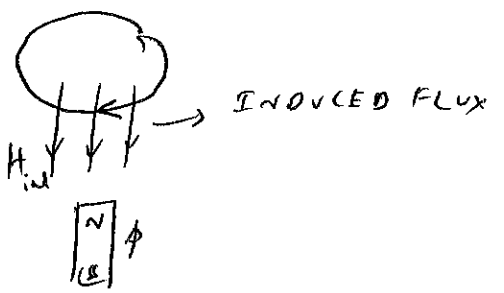

FIG. 3

IF YOU ARE PUSHING THE MAGNET UPWARDS INTO THE IRON CORE, THE FIELD ~~WHICH~~ EXERTS A FORCE ON THE MAGNET IN A DOWNWARD DIRECTION. RECALL THAT THE MAGNETIC FIELD INTENSITY $\vec{H}$ IS THE FORCE PER UNIT +VE MAGNETIC CHARGE & ITS DIRECTION IS THE SAME AS THE DIRECTION ALONG WHICH A ~~NORTH~~ TEST NORTH POLE WOULD MOVE. (SEE FIG. 4).

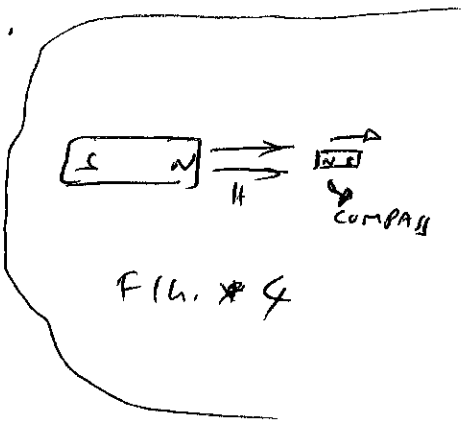

FIG. 4

IN FIG. 3, THE INDUCED MAGNETIC FIELD H_{ind} PUSHES THE BAR MAGNET DOWNWARDS. IN OTHER WORDS, WORK NEEDS TO BE DONE (AGAINST THIS OPPOSITION) TO PUSH THE MAGNET INTO THE IRON CORE & THIS IS HOW THE MECHANICAL ENERGY IS CONVERTED INTO ELECTRICAL ENERGY.