High-Speed Electronics in Practice

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MM5. Forces and Moments in Magnetic Field

FORCES AND MOMENTS IN MAGNETIC FIELD

Targets:

1. Read “Transducere” (Page 1-26) (before or after the lecture)

2. Be able to calculate with electrodynamic motor and generator as well as rotating coil (lecture)

3. Finish the exercise (after the lecture)

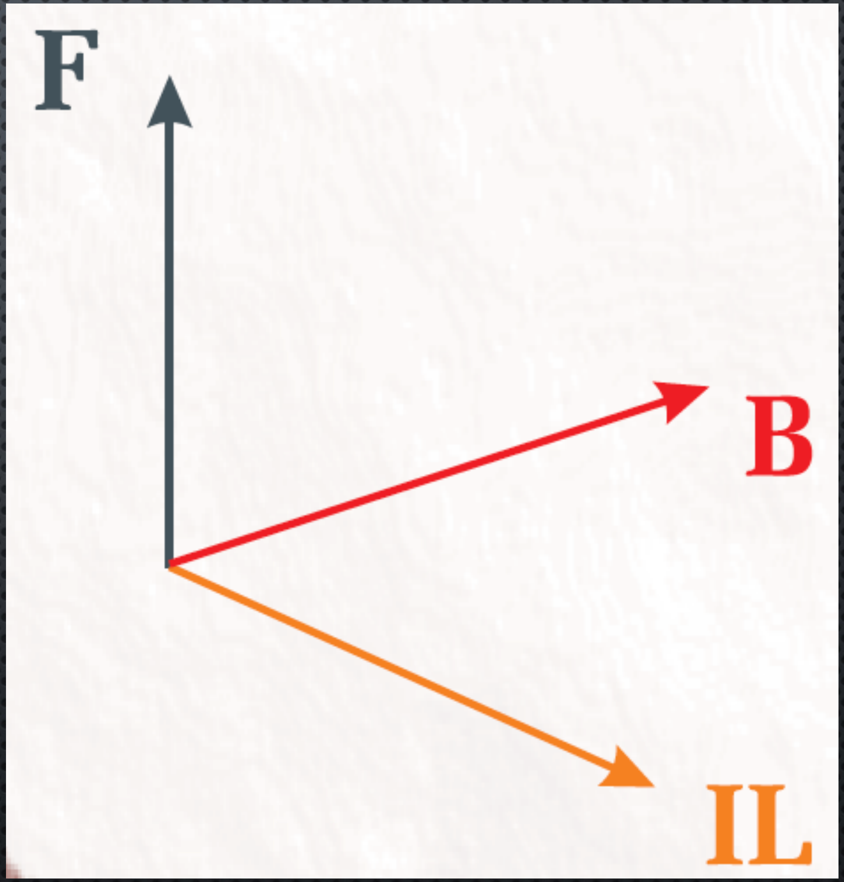
Electrodynamic Principle

Laplaces lov:

$$\overline{F} = \overline{IL} \times \overline{B} \quad [N]$$

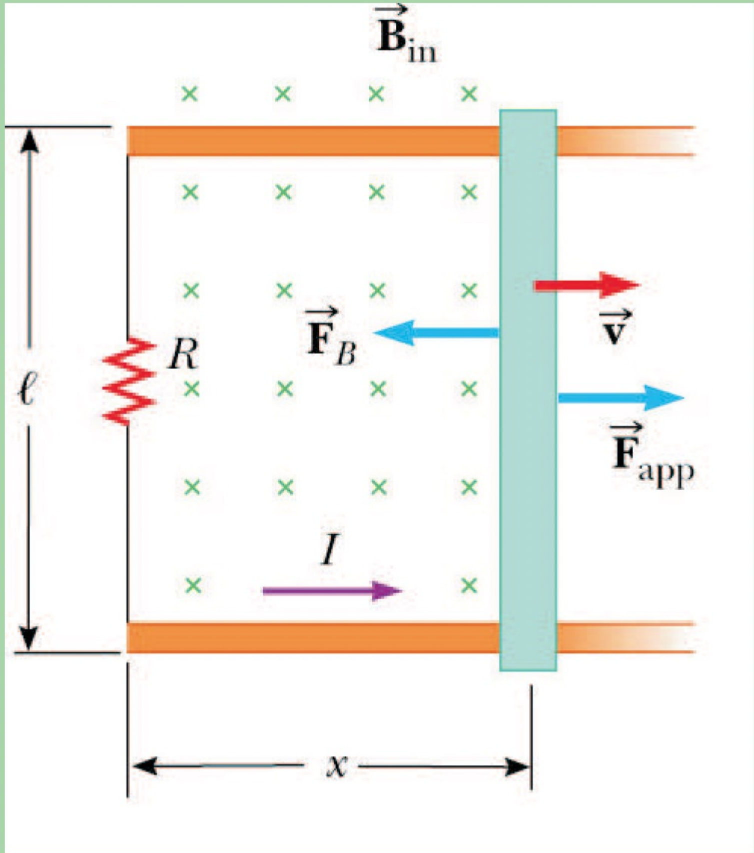
Def. af magnetfelt:

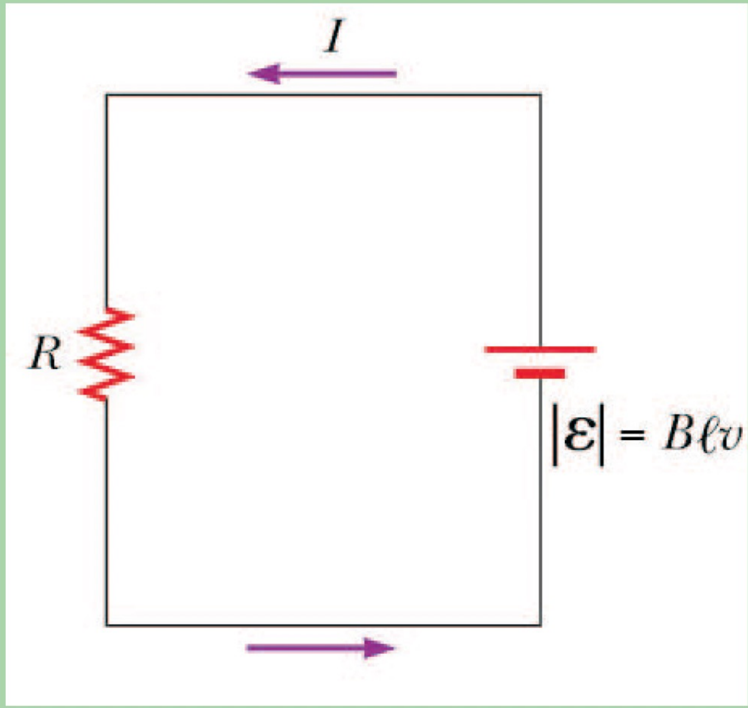
$$\overline{B} = \frac{|\overline{F}|}{|\overline{IL}|} \cdot \frac{(\overline{F} \times \overline{IL})}{|\overline{F} \times \overline{IL}|} \quad \left[\frac{Wb}{m^2}\right]$$



Blackboard (1) (2)

Lenz's Law





Lenz's Law

Different formulas and expressions

$$\boxed{\mathcal{V} = -\frac{d\Phi}{dt} \qquad \text{(V)}} \qquad (7\text{-}6)$$

Equation (7–6) states that ***the electromotive force induced in a stationary closed circuit is equal to the negative rate of increase of the magnetic flux linking the circuit***. This is a statement of ***Faraday's law of electromagnetic induction***. A time-rate of change of magnetic flux induces an electric field according to Eq. (7–3), even in the absence of a physical closed circuit. The negative sign in Eq. (7–6) is an assertion that the induced emf will cause a current to flow in the closed loop in such a direction as to oppose the change in the linking magnetic flux. This assertion is known as ***Lenz's law***. The emf induced in a stationary loop caused by a time-varying magnetic field is a ***transformer emf***.

Lenz's Law

Different formulas and expressions

the differential form of Faraday's law.

$$\text{curl}\ \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

The negative sign in Faraday's law indicates, as can be easily demonstrated, that the direction of the induced emf is such as to tend to oppose the change that produces it. Thus if we attempt to increase the flux through a circuit, the induced emf tends to cause currents in such a direction as to decrease the flux. If we attempt to thrust one pole of a magnet into a coil, the currents caused by the induced emf set up a magnetic field which tends to repel the pole. All these phenomena are covered by Lenz's law, which may be stated as:

In case of a change in a magnetic system, that thing happens which tends to oppose the change.

It is clear that this accounts for the direction of the current and the direction of the force in the examples given above. The utility of Lenz's law should not be underestimated. In many cases it represents the quickest if not the only way of obtaining information about electromagnetic reactions. Even if other methods are available, it affords a valuable check.

Lenz's Law

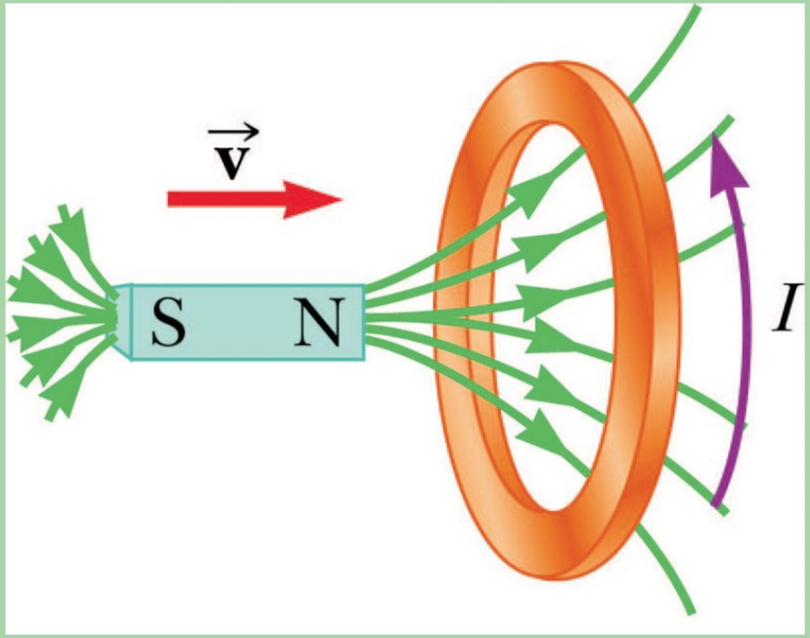
Different formulas and expressions

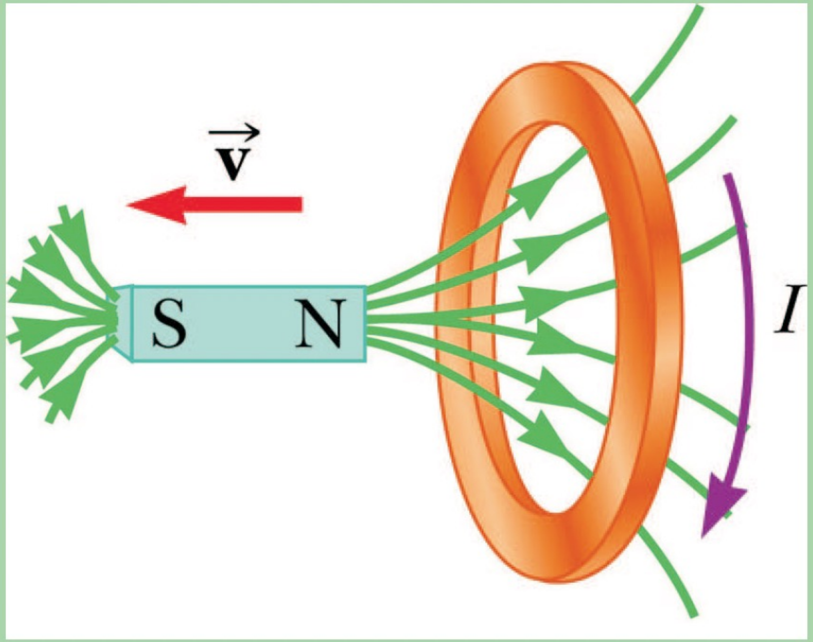
Nature abhors a change in flux.

The induced current will flow in such a direction that the flux *it* produces tends to cancel the change. (As the front end of the magnet in Ex. 7.5 enters the ring, the flux increases, so the current in the ring must generate a field to the *right*—it therefore flows *clockwise*.) Notice that it is the *change* in flux, not the flux itself, that nature abhors (when the tail end of the magnet exits the ring, the flux *drops*, so the induced current flows *counterclockwise*, in an effort to restore it). Faraday induction is a kind of "inertial" phenomenon: A conducting loop "likes" to maintain a constant flux through it; if you try to *change* the flux, the loop responds by sending a current around in such a direction as to frustrate your efforts. (It doesn't *succeed* completely; the flux produced by the induced current is typically only a tiny fraction of the original. All Lenz's law tells you is the *direction* of the flow.)

Lenz's Law

Example: Determine the current direction

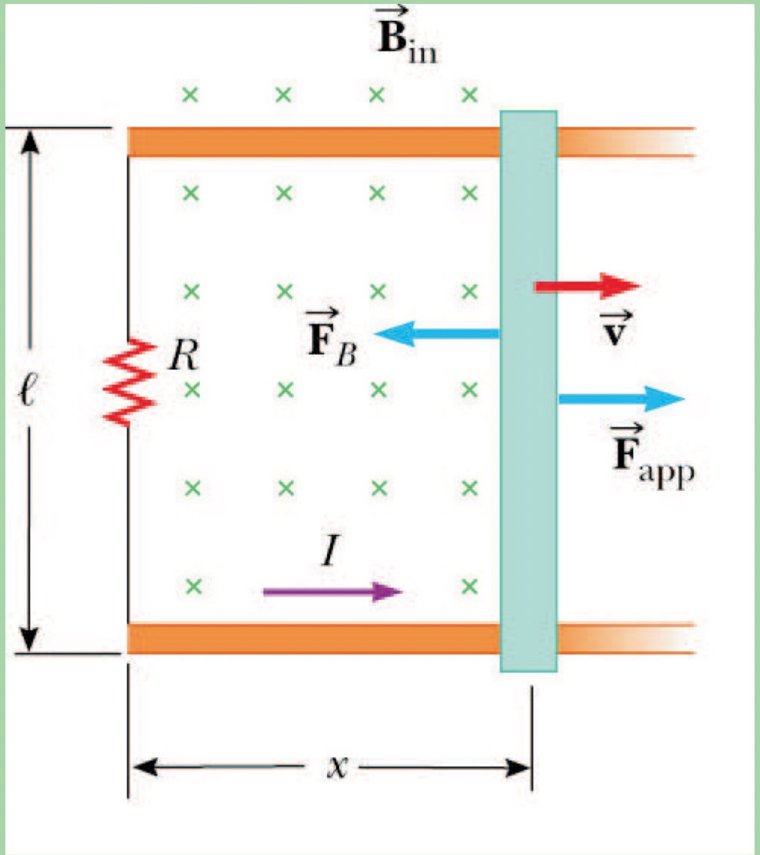


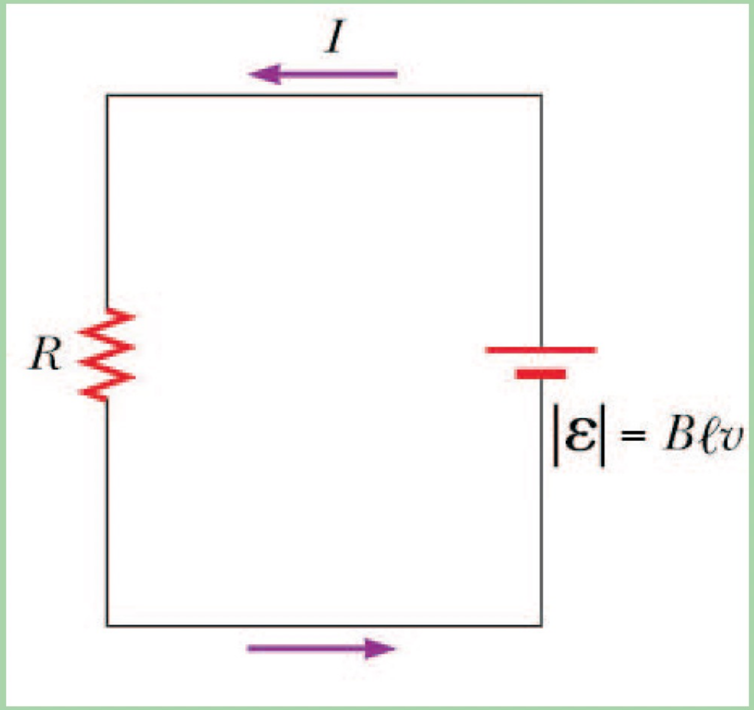


Right-hand regulation

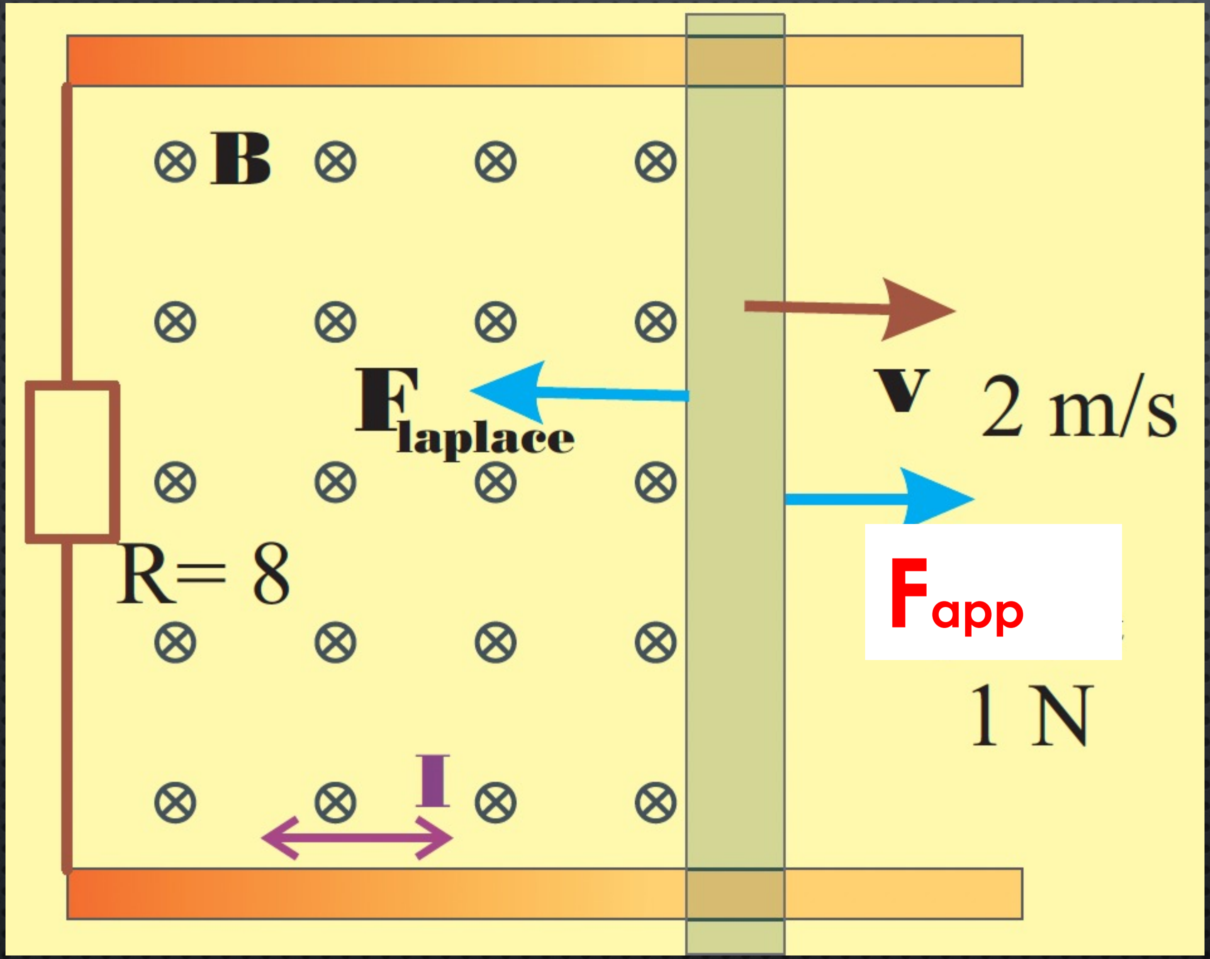
Lenz's Law

Try to determine the current direction by flux or B field change?





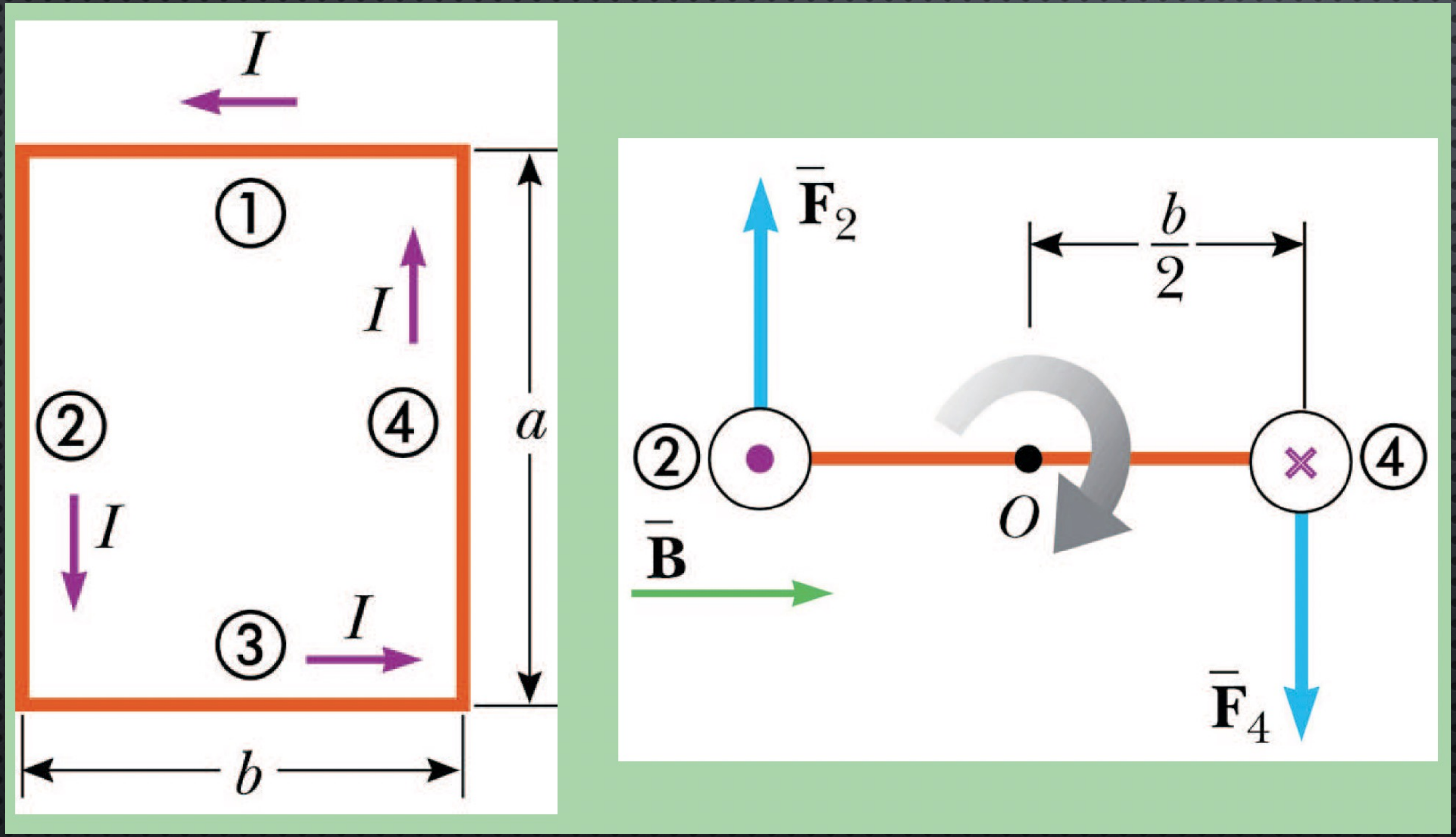
Exercise 1

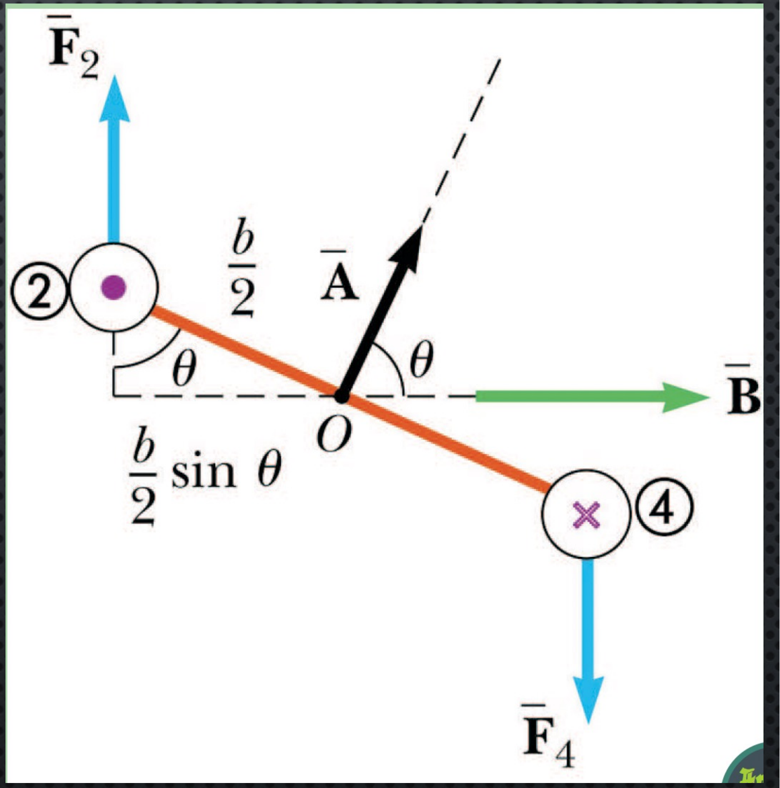


a. What is the power delivered to R?
b. What mechanical power is supplied to the circuit?
c. Which way does the current flow?

Blackboard (3)

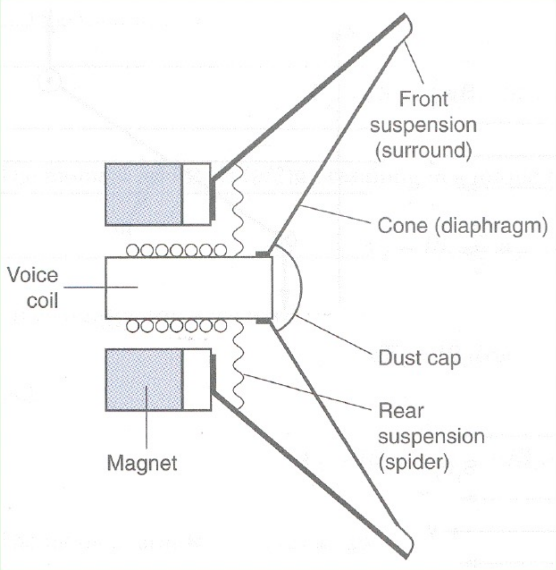
Moments in Magnetic Field

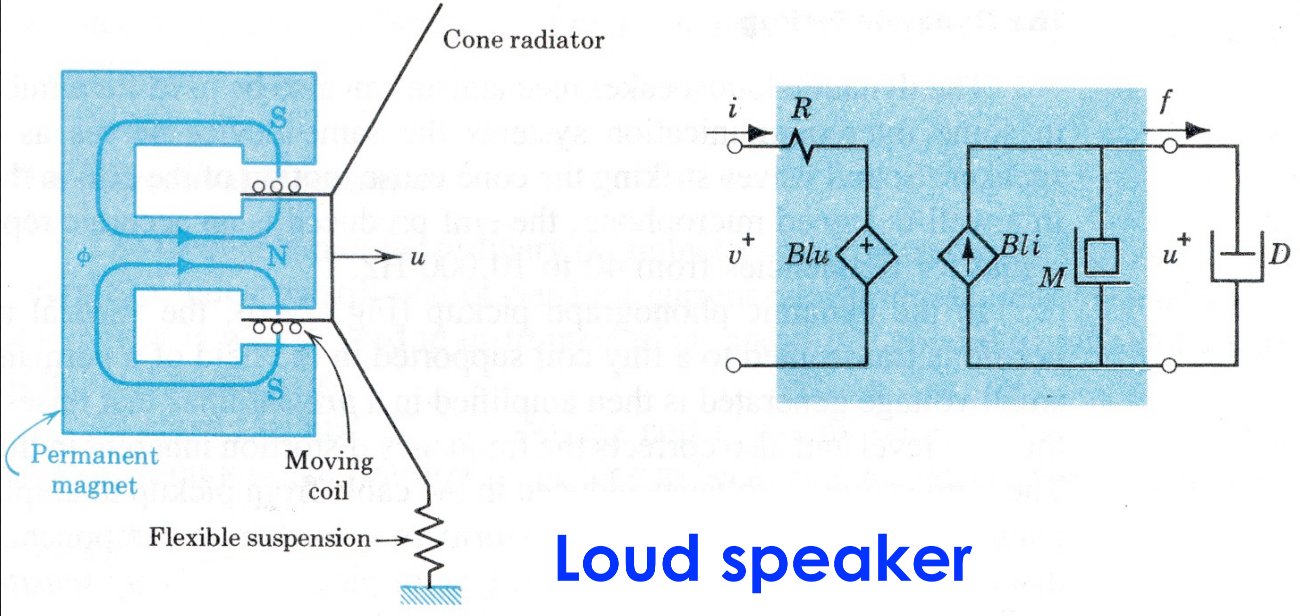




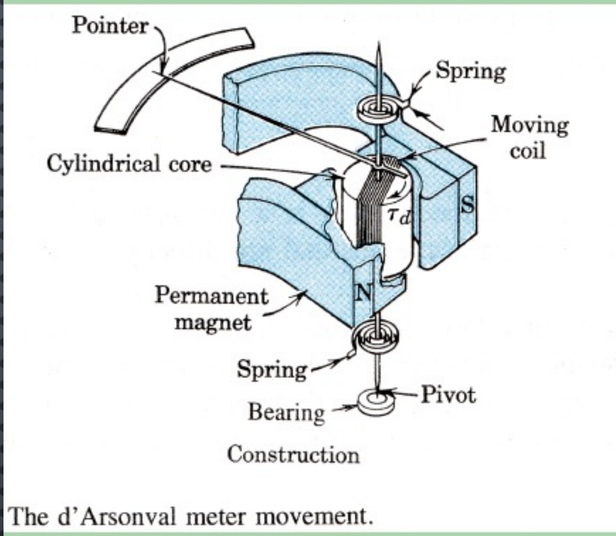
Blackboard (4)(5)

Applications

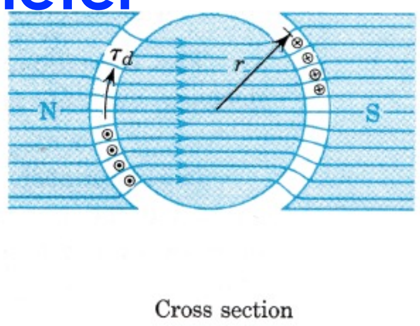




Loud speaker

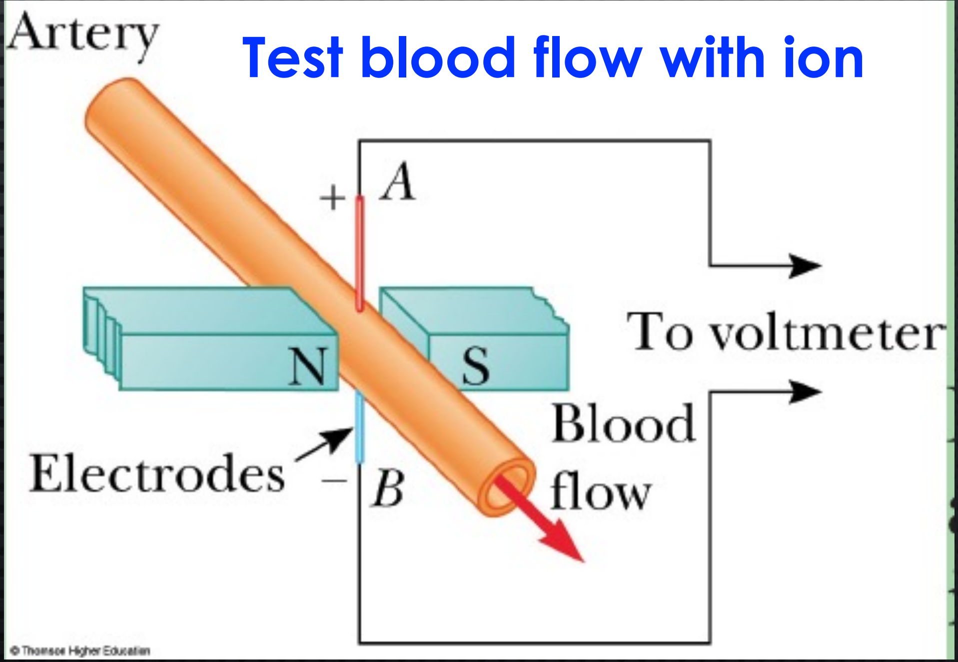


Turning coil meter



Cross section

The d'Arsonval meter movement.



Test blood flow with ion