

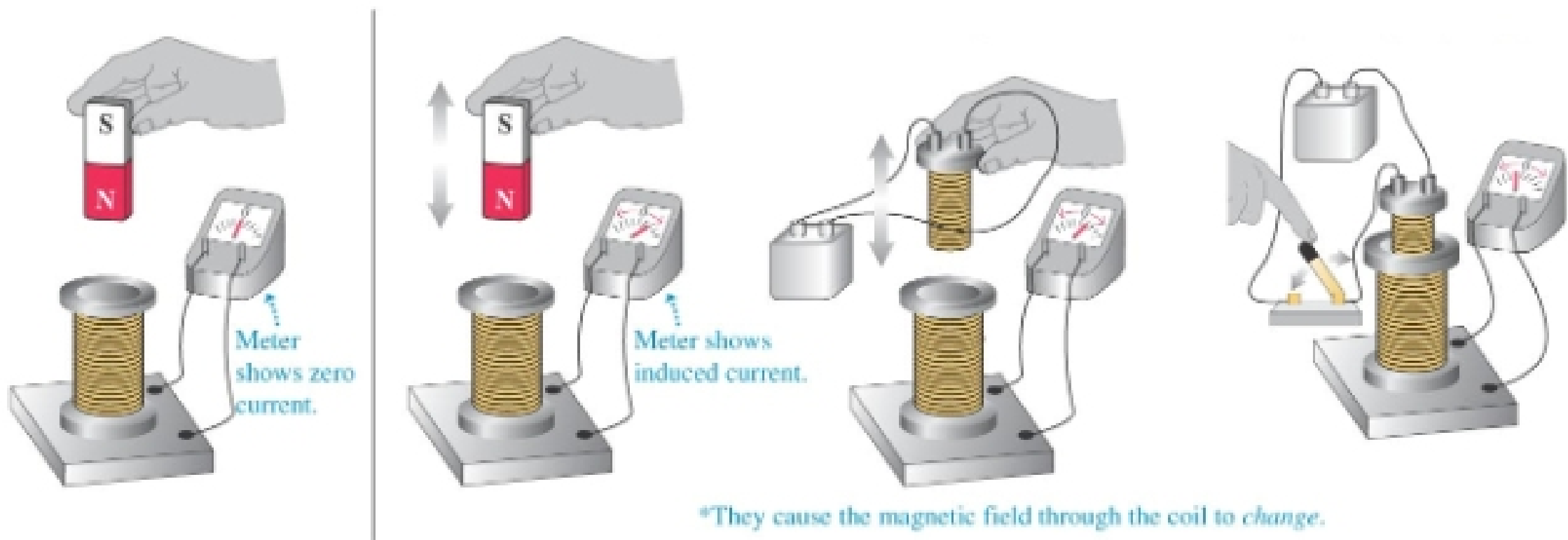
## Chapter 29 – Electromagnetic Induction

- Induction Experiments
- Faraday's Law
- Lenz's Law
- Motional Electromotive Force
- Induced Electric Fields
- Eddy Currents
- Displacement Current and Maxwell's Equations
- Superconductivity

- If the **magnetic flux** through a circuit changes, an emf and a current are induced.
- A time-varying magnetic field can act as source of electric field. **Maxwell**
- A time-varying electric field can act as source of magnetic field.

## 1. Induction Experiments (Faraday / Henry)

- An **induced current** (and **emf**) is generated when: (a) we move a magnet around a coil, (b) move a second coil toward/away another coil, (c) change the current in the second coil by opening/closing a switch.



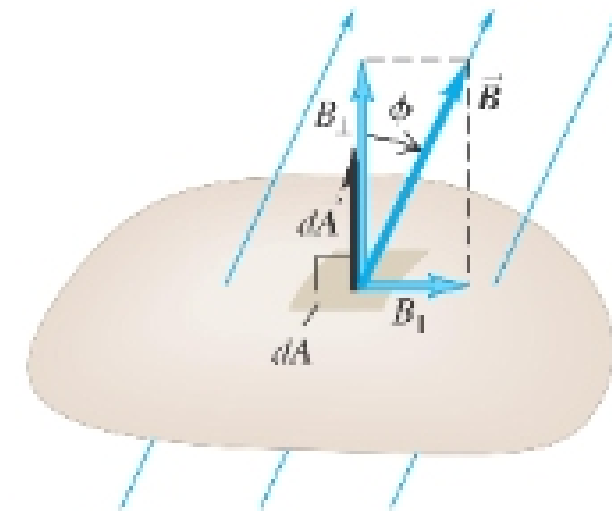
- Magnetically induced emfs are always the result of the action of non-electrostatic forces. The electric fields caused by those forces are  $\vec{E}_n$  (non-Coulomb, non conservative).

## 2. Faraday's Law

Magnetic flux:

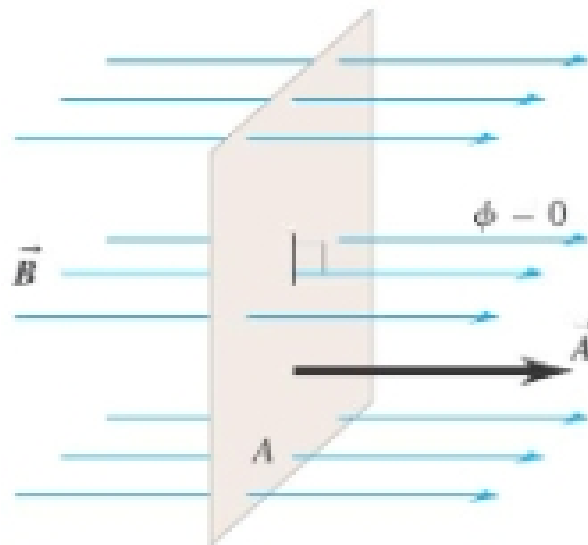
$$\Phi_B = \int \vec{B} \cdot d\vec{A} = \int B \cos \varphi \cdot dA$$

If  $\vec{B}$  is uniform over a flat area  $\vec{A}$ :  $\Phi_B = \vec{B} \cdot \vec{A} = B \cdot A \cdot \cos \varphi$



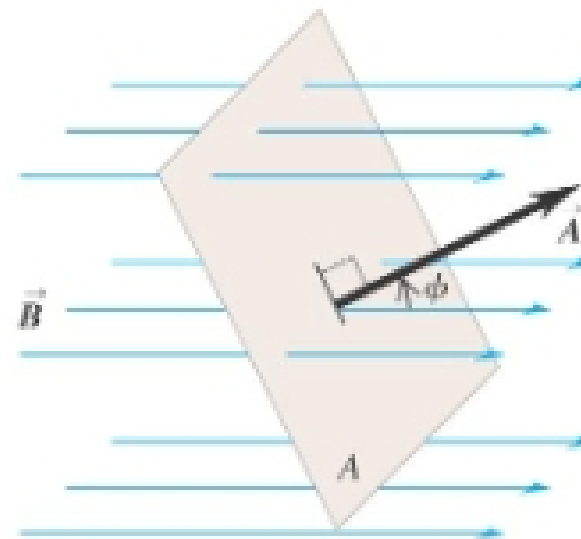
Surface is face-on to magnetic field:

- $\vec{B}$  and  $\vec{A}$  are parallel (the angle between  $\vec{B}$  and  $\vec{A}$  is  $\phi = 0$ ).
- The magnetic flux  $\Phi_B = \vec{B} \cdot \vec{A} = BA$ .



Surface is tilted from a face-on orientation by an angle  $\phi$ :

- The angle between  $\vec{B}$  and  $\vec{A}$  is  $\phi$ .
- The magnetic flux  $\Phi_B = \vec{B} \cdot \vec{A} = BA \cos \phi$ .



Surface is edge-on to magnetic field:

- $\vec{B}$  and  $\vec{A}$  are perpendicular (the angle between  $\vec{B}$  and  $\vec{A}$  is  $\phi = 90^\circ$ ).
- The magnetic flux  $\Phi_B = \vec{B} \cdot \vec{A} = BA \cos 90^\circ = 0$ .

