JOINT INSTITUTE
交大密西根学院

Recitation Class 7

(Examples)

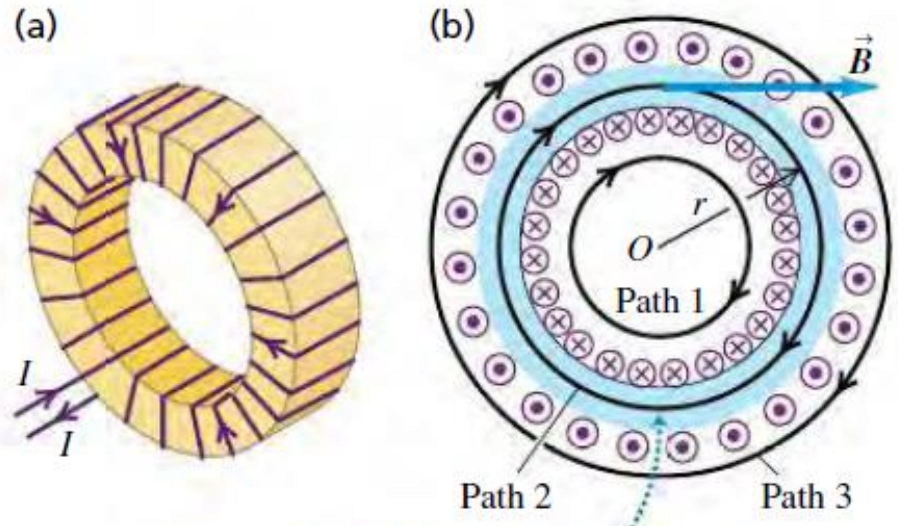
Teaching Assistant
Xie Jinglei

1

Ampere's Law

Solenoid

28.25 (a) A toroidal solenoid. For clarity, only a few turns of the winding are shown. (b) Integration paths (black circles) used to compute the magnetic field $\vec{B}$ set up by the current (shown as dots and crosses).



The magnetic field is confined almost entirely to the space enclosed by the windings (in blue).

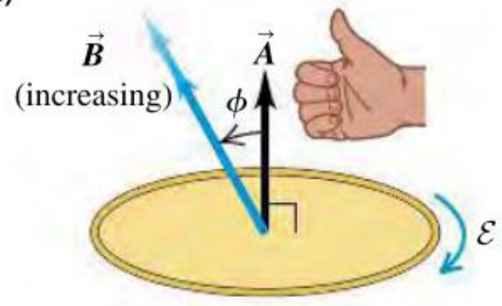
Figure 28.25a shows a doughnut-shaped **toroidal solenoid,** tightly wound with N turns of wire carrying a current I. (In a practical solenoid the turns would be much more closely spaced than they are in the figure.) Find the magnetic field at all points.

2

Induction

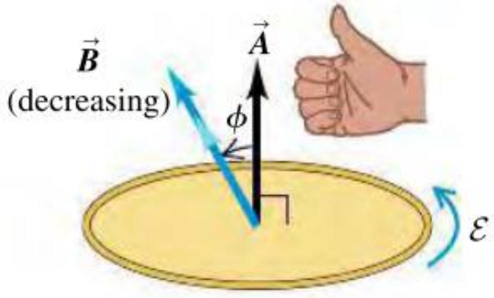
Direction

(a)



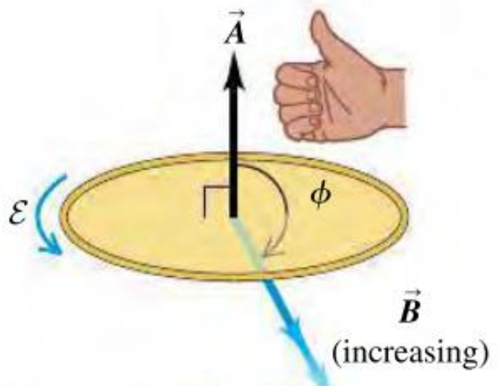
- Flux is positive ($\Phi_B > 0$) ...
- ... and becoming more positive ($d\Phi_B/dt > 0$).
- Induced emf is negative ($\mathcal{E} < 0$).

(b)



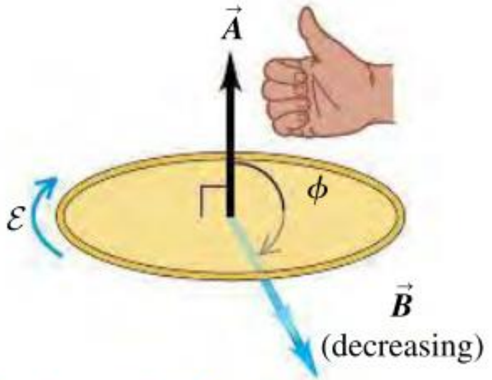
- Flux is positive ($\Phi_B > 0$) ...
- ... and becoming less positive ($d\Phi_B/dt < 0$).
- Induced emf is positive ($\mathcal{E} > 0$).

(c)



- Flux is negative ($\Phi_B < 0$) ...
- ... and becoming more negative ($d\Phi_B/dt < 0$).
- Induced emf is positive ($\mathcal{E} > 0$).

(d)

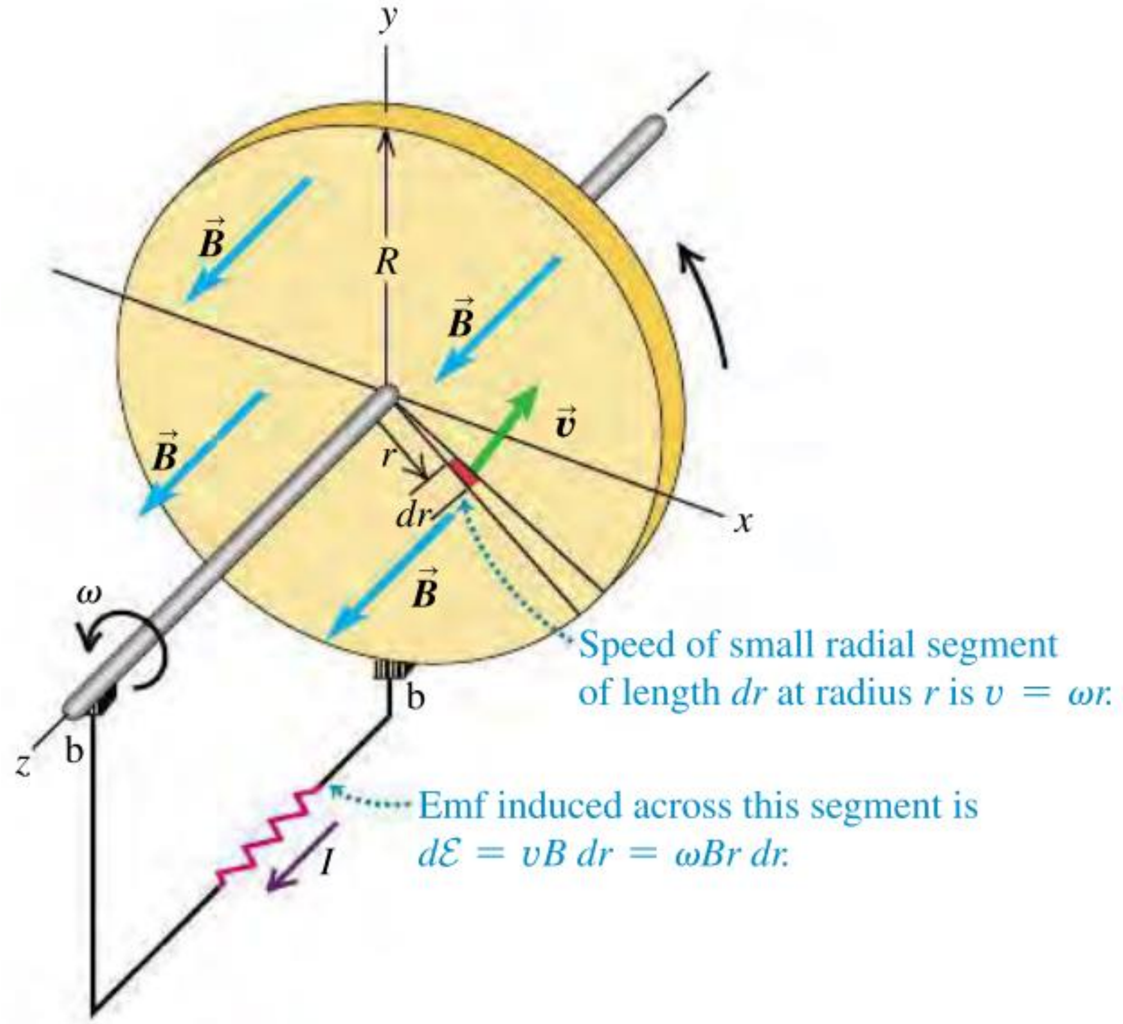


- Flux is negative ($\Phi_B < 0$) ...
- ... and becoming less negative ($d\Phi_B/dt > 0$).
- Induced emf is negative ($\mathcal{E} < 0$).

Lenz's Law

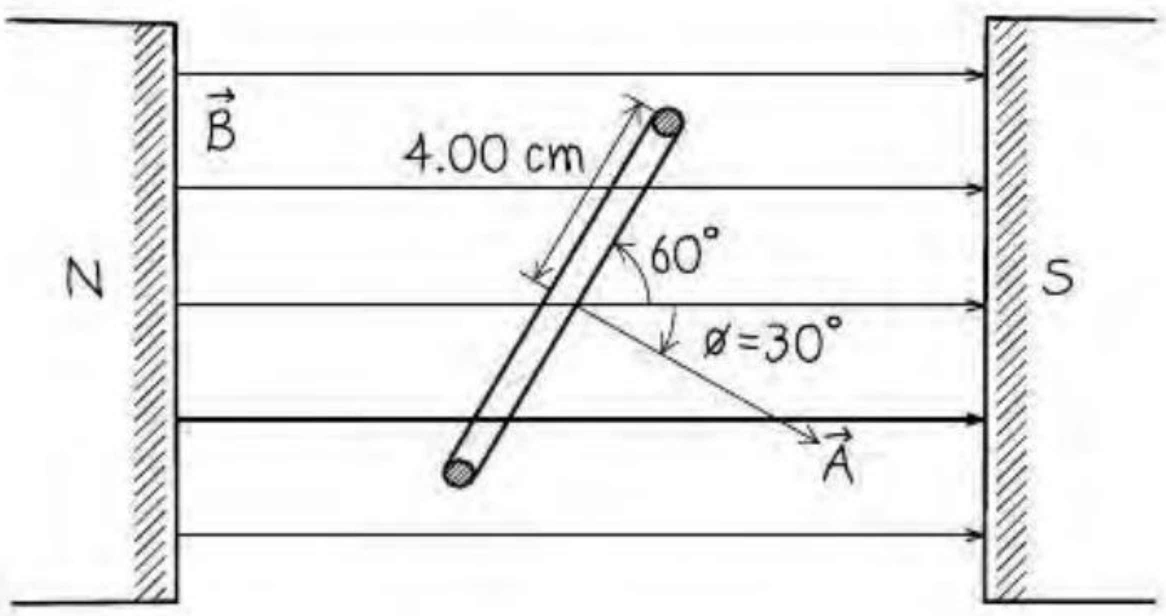
The direction of any magnetic induction effect
is such as to oppose the cause of the effect.

Faraday's disk

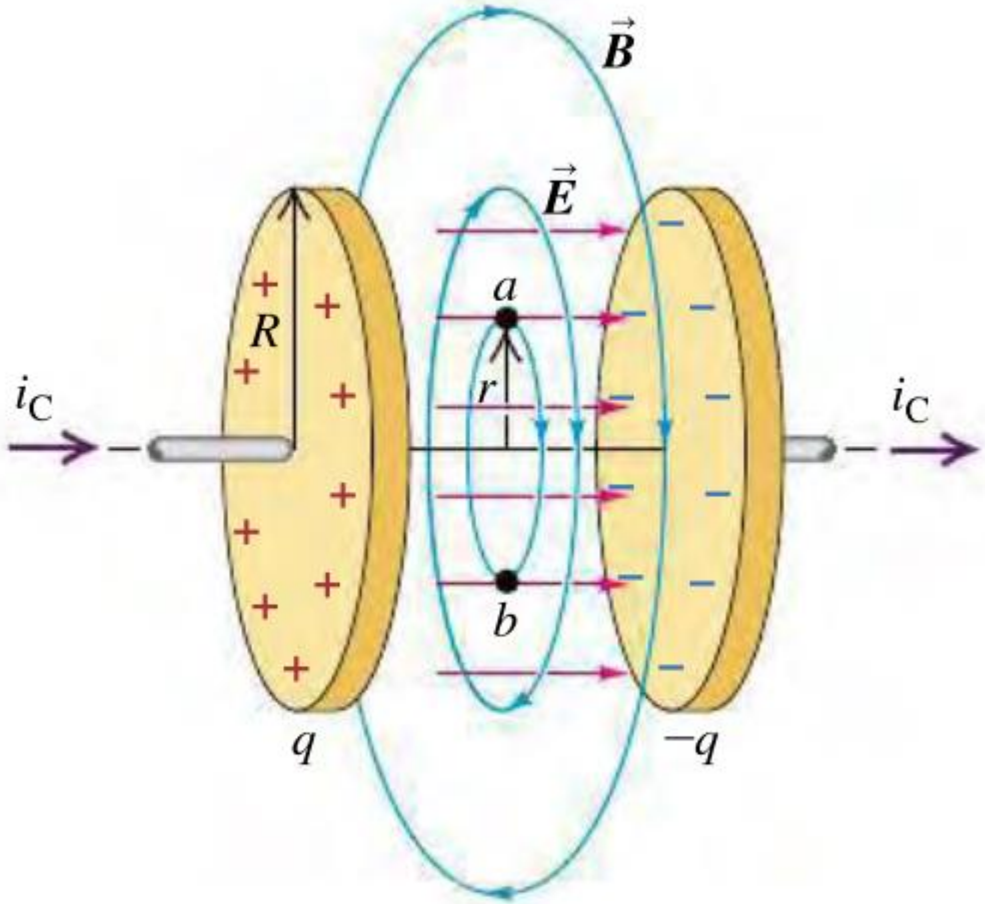


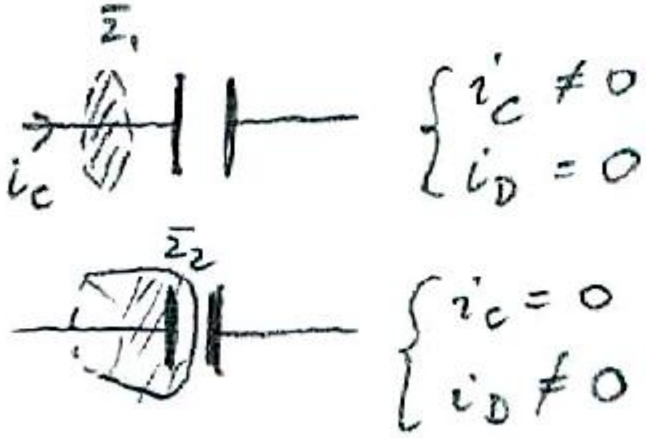
Example

A 500-loop circular wire coil with radius 4.00 cm is placed between the poles of a large electromagnet. The magnetic field is uniform and makes an angle of 60° with the plane of the coil; it decreases at 0.200 T/s. What are the magnitude and direction of the induced emf?



Displacement Current





Maxwell’s Equations

Gauss’s law for $\vec{E}$:

$$\overbrace{\oint \vec{E} \cdot d\vec{A}}^{\text{Flux of electric field through a closed surface}} = \frac{Q_{\text{encl}}}{\epsilon_0} \tag{29.18}$$

Charge enclosed by surface (Q_{encl})

Electric constant (ϵ_0)

Gauss’s law for $\vec{B}$:

$$\overbrace{\oint \vec{B} \cdot d\vec{A}}^{\text{Flux of magnetic field through any closed surface ...}} = 0 \tag{29.19}$$

... equals zero.

Faraday’s law for a stationary integration path:

$$\overbrace{\oint \vec{E} \cdot d\vec{l}}^{\text{Line integral of electric field around path}} = \underbrace{-\frac{d\Phi_B}{dt}}_{\text{Negative of the time rate of change of magnetic flux through path}} \tag{29.20}$$

Maxwell's Equations

Ampere's law for a stationary integration path:

$$\overbrace{\oint \vec{B}\cdot d\vec{l}}^{\text{Line integral of magnetic field around path}} = \underbrace{\mu_0}_{\text{Magnetic constant}}\Bigg(\underbrace{i_C}_{\text{Conduction current through path}} + \underbrace{\overbrace{\epsilon_0}^{\text{Electric constant}}\overbrace{\frac{d\Phi_E}{dt}}^{\text{Time rate of change of electric flux through path}}}_{\text{Displacement current through path}}\Bigg)_{\text{encl}} \qquad (29.21)$$

Example

29.65 • **CALC** The long, straight wire shown in Fig. P29.65a carries constant current I. A metal bar with length L is moving at constant velocity $\vec{v}$, as shown in the figure. Point a is a distance d from the wire. (a) Calculate the emf induced in the bar. (b) Which point, a or b, is at higher potential? (c) If the bar is replaced by a rectangular wire loop of resistance R (Fig. P29.65b), what is the magnitude of the current induced in the loop?

Figure **P29.65**