Generators/Motors

"Airplanes are interesting toys but of no military value." Marechal Ferdinand Foch, Professor of Strategy, Ecole Superieure de Guerre.

Induced E-Fields

- A changing magnetic field induces an emf and current. Therefore an E-field must be created in the conductor as a result of the changing magnetic flux.
- Consider a loop of radius R in a B-field. Find the induced E-Field. See last slide
- Faraday's Law in general form:

$$\mathcal{E} = \oint E \cdot ds = -N \frac{d\Phi_B}{dt}$$

- The induced E-field is a nonconservative time-varying field that is generated by a changing B-field

Generators & Motors

- A generator converts mechanical → electrical energy
- A motor converts electrical → mechanical energy
- Suppose you have a loop of wire rotating in a B-field. Find the maximum induced emf.

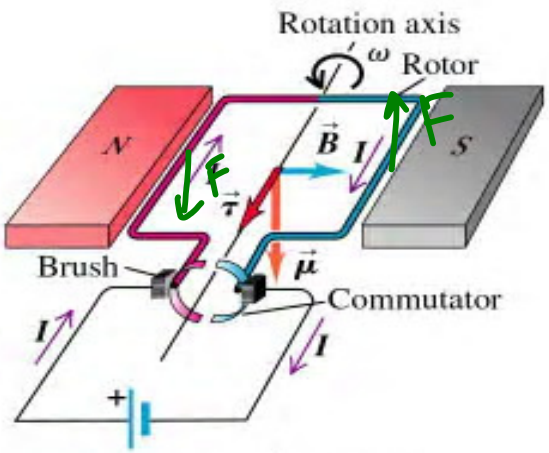
$$\mathcal{E} = -N\frac{d\Phi_B}{dt} = -NB\frac{d}{dt}(A\cos\omega t)$$

$$\mathcal{E} = +NBA\omega \sin\omega t$$

$$\boxed{\mathcal{E}_{MAX} = NBA\omega}$$

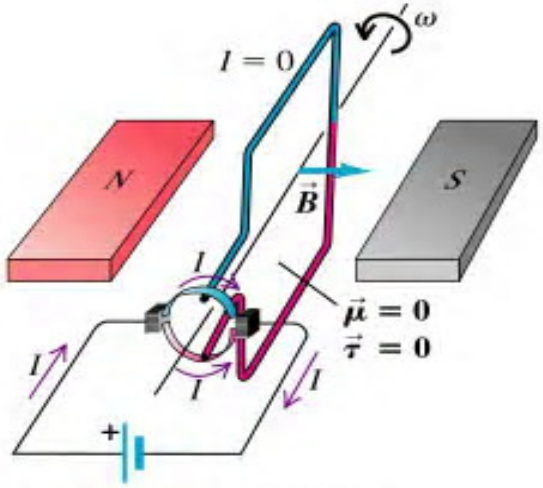
- Show diagrams of generators and motors.

DC Motor



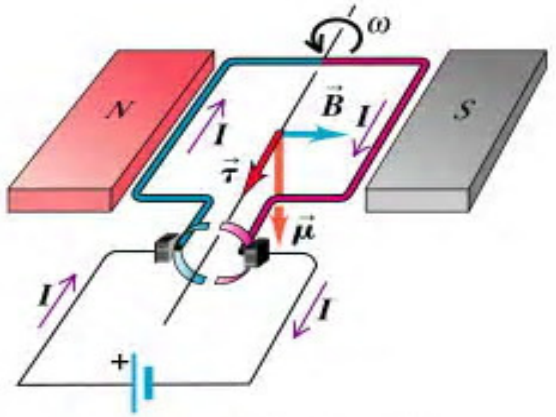
• Brushes are aligned with commutator segments
• Current flows into red-colored side of rotor and out of blue-colored side
• Magnetic torque causes rotor to spin counterclockwise

(a)



• Rotor has turned 90°
• Each brush is in contact with both commutator segments
• Current bypasses rotor altogether
• No magnetic torque on rotor

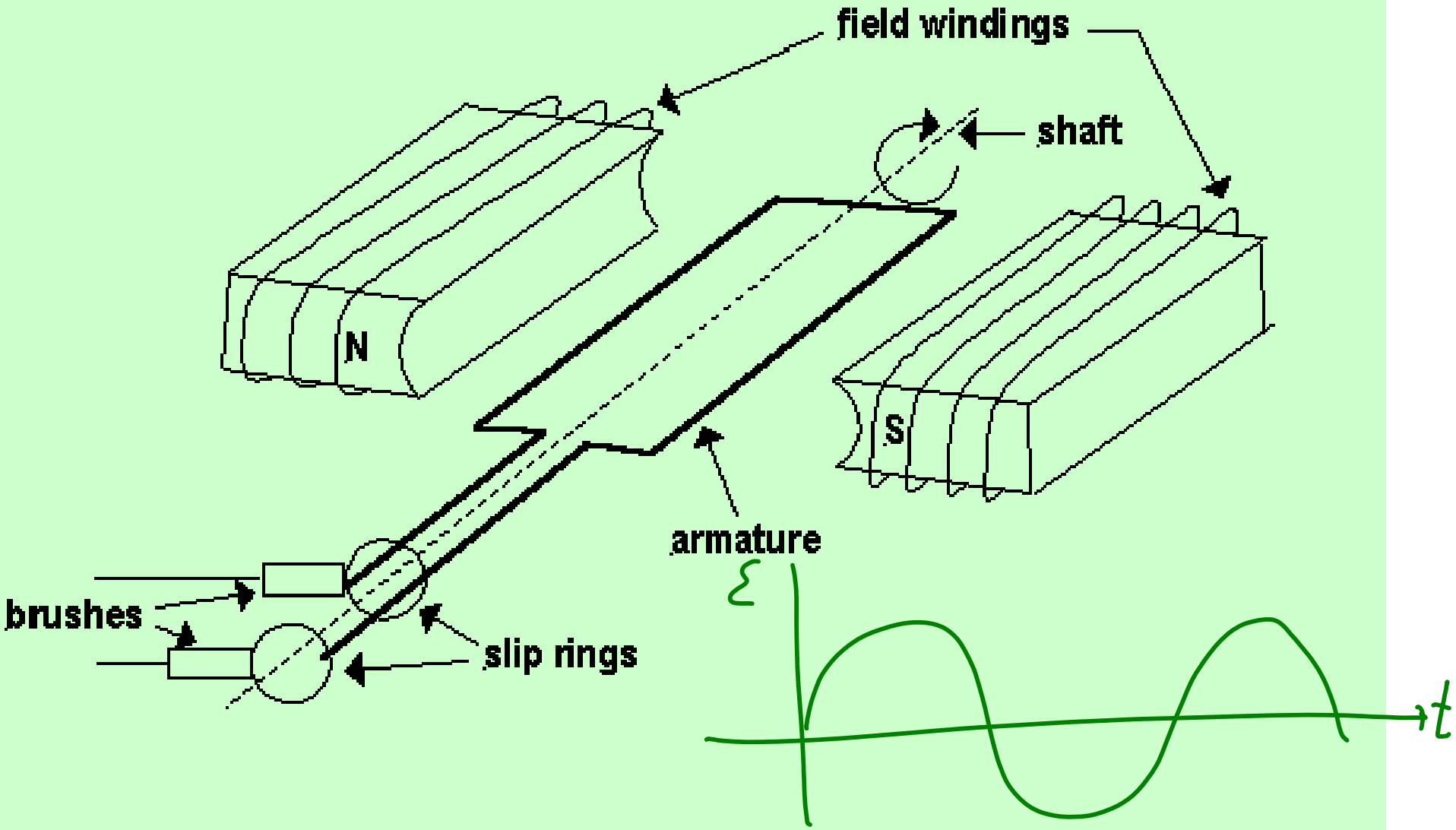
(b)



• Brushes are aligned with commutator segments
• Current flows into blue-colored side of rotor and out of red-colored side
• Magnetic torque again causes rotor to spin counterclockwise

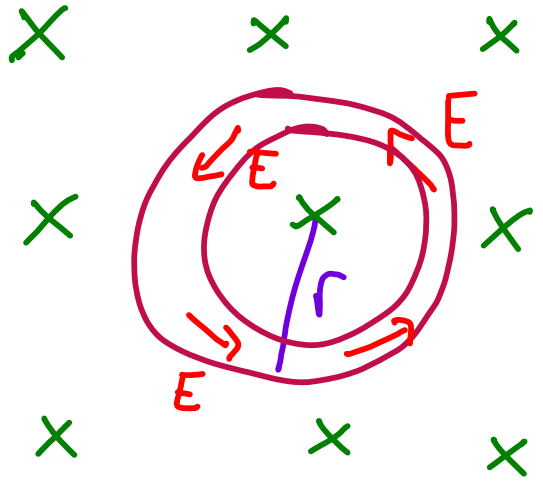
(c)

AC Generator



$\mathcal{E} = -\frac{d\Phi_B}{dt} \Rightarrow I$ in loop $\quad \frac{dB}{dt} > 0$

$\Rightarrow E$ tangent to loop



Work done by E-field

$W = F \cdot d = Eq(2\pi r)$

$|\Delta U| = W$

$q\mathcal{E} = qE(2\pi r)$ $\qquad \Delta V = \frac{\Delta U}{q}$

& $\mathcal{E} = -\frac{d}{dt}(\pi r^2 B) = -\pi r^2 \frac{dB}{dt}$

$-\pi r^2 \frac{dB}{dt} = E(2\pi r)$

$$\boxed{E = -\frac{r}{2}\frac{dB}{dt}}$$

if Conservative $\quad \oint E \cdot ds = 0$

b/c $\Delta V = -\int E \cdot ds$