Electromagnetic induction

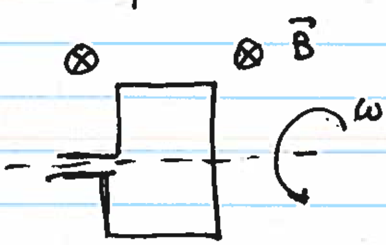
An emf is induced in a loop of wire by changing the magnetic flux through the loop

Magnitude from Faraday law: $\mathcal{E} = -\frac{d\Phi_B}{dt}$

Direction from Lenz law:
the induced current is in the direction that produces magnetic field opposing the change of magnetic flux

This is a source of most of our power plants!

AC generator: wire loop rotating in a permanent magnet

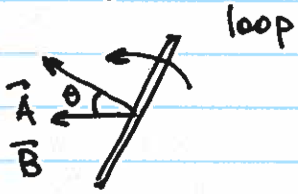


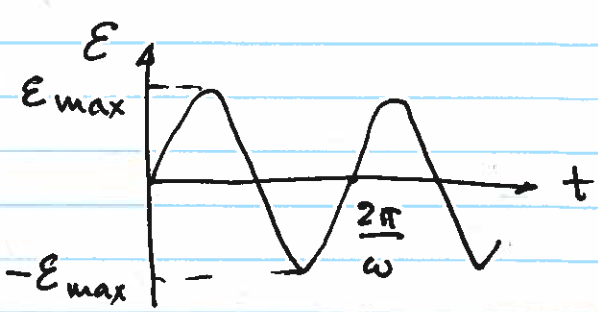
if ω is the rotation rate
$\theta = \omega \cdot t$

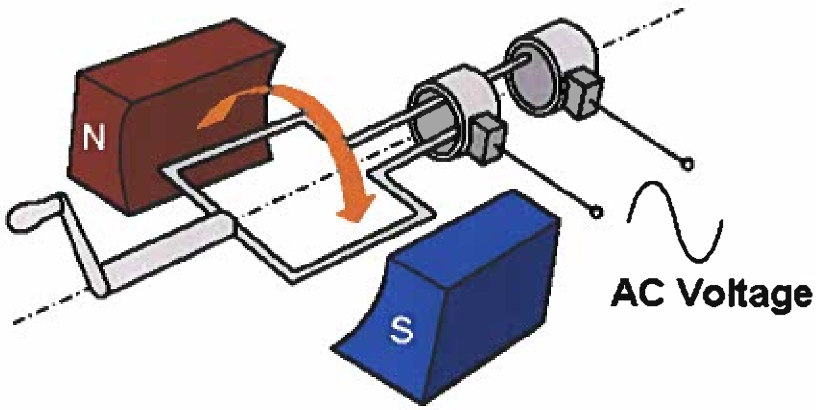
$\Phi_B = B \cdot A \cdot \cos\theta = B \cdot A \cos \omega t$

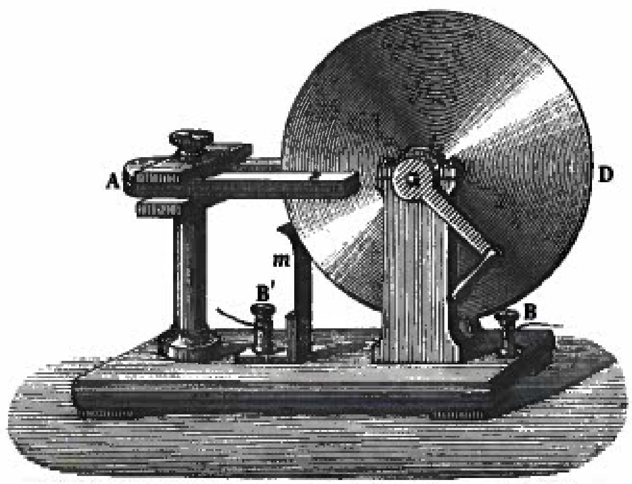
$\mathcal{E} = -\frac{d\Phi_B}{dt} = \underbrace{BA\omega}_{\text{max instantaneous EMF}} \sin \omega t$

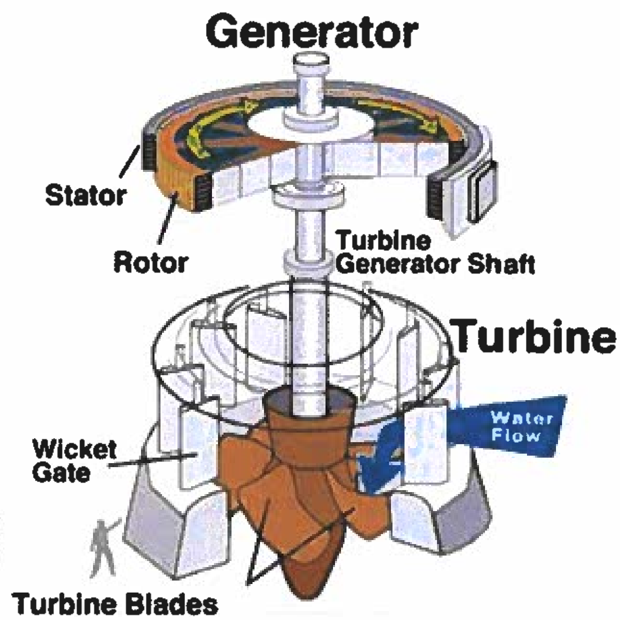
side view



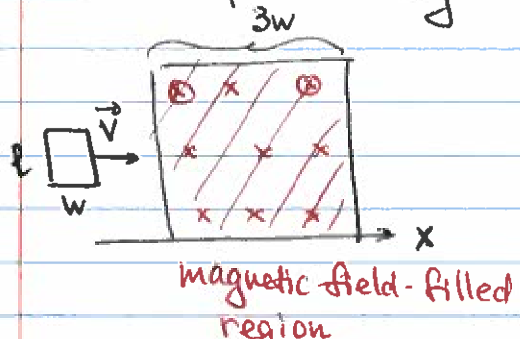



N
S
AC Voltage

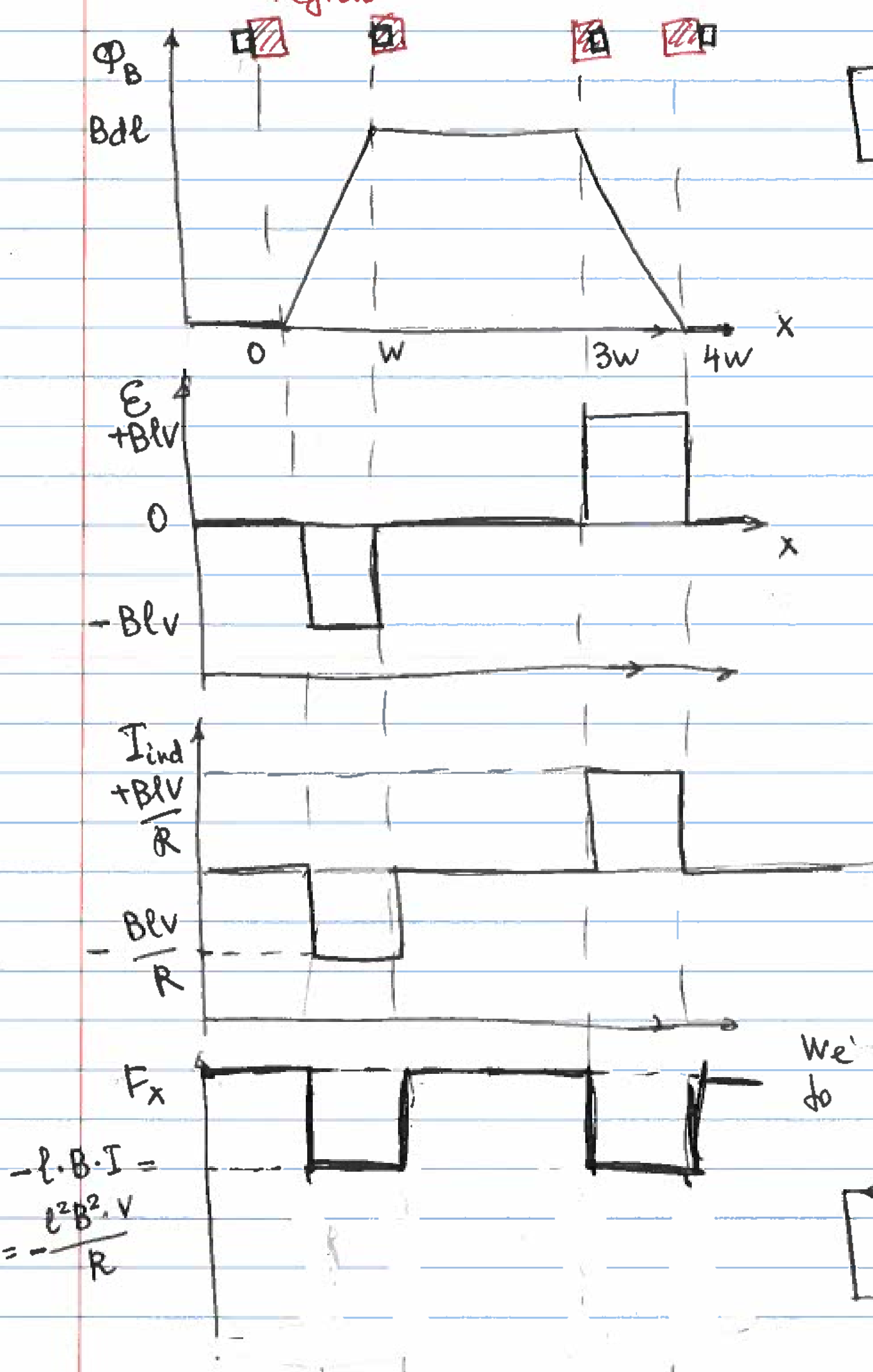

A
D
m
B'
B

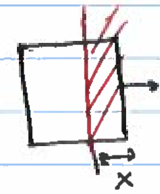

Generator
Stator
Rotor
Turbine Generator Shaft
Turbine
Water Flow
Wicket Gate
Turbine Blades

A loop moving through a magnetic field



A ractangular loop moving with constant speed $\vec{V}$ throu a region of constant magnetic field B.





$\Phi = B\ell \cdot x$
for $x < w$
$x = v \cdot t$

$$\mathcal{E}_{ind} = -\frac{d\Phi}{dt} =$$
$$= -B\ell \frac{dx}{dt} = \mp B\ell v$$

If R is the internal resistance of the loop

$$I = \frac{\mathcal{E}}{R} = \pm \frac{B\ell v}{R}$$

Energy lost to heat: $P = I^2 R$ electric power

We must apply force to maintain constant speed