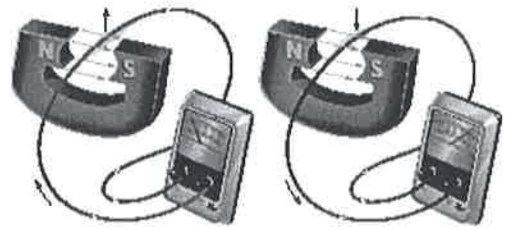
Electromagnetic Induction

Why will moving a wire through a magnetic field induce a potential difference and a current in the wire? Moving a wire through a magnetic field generates a magnetic force on the electrons in the wire and causes them to flow through the wire.

emf (electromotive force): potential difference or voltage

Not a FORCE!



Maximum emf (and current) is induced when . . .

Wire is ⊥ to magnetic field

Induced EMF:

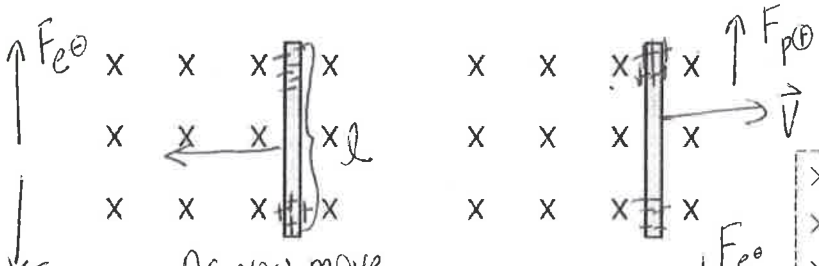
"ε" replaces "V"

$\varepsilon = \vec{B} \times \vec{l} \times \vec{v}$

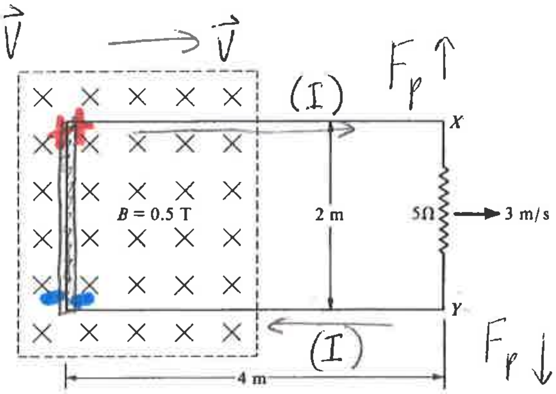
$\varepsilon = \frac{N}{C\frac{m}{s}} \times m \times \frac{m}{s} = \frac{Nm}{C}$

$V = \frac{N \cdot m}{C} = \frac{J}{C}$

Variable:	ε or V	$\vec{B}$	$\vec{l}$	$\vec{v}$
Quantity:	voltage	magnetic field	length	velocity
Units:	[V] or $\frac{J}{C}$	[T]	[m]	$[\frac{m}{s}]$
Type:	scalar	vector	vector	vector



As you move the rod, electrons get pushed.

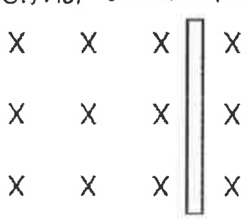


1. What is the potential difference induced in a 1.5 meter length of wire moving perpendicular to a 0.40T magnetic field at a speed of 2.1 m/s?

$\varepsilon = Bl\vec{v} = (0.4T)(1.5m)(2.1 m/s) = 1.3V$

2. In which direction should the wire be moved to induce the most potential difference?

either direction as long as $\vec{v} \perp \vec{B}$



3. A wire loop as shown is pulled to the right at a constant speed of 3 m/s.

a) Determine the induced potential difference between points X and Y.

$\varepsilon = Bl\vec{v} = (0.5T)(2m)(3 m/s) = 3V$

b) Determine the magnitude of the induced current.

$I = \frac{V}{R} = \frac{3V}{5\Omega} = 0.6A$

c) Which way will the current flow?

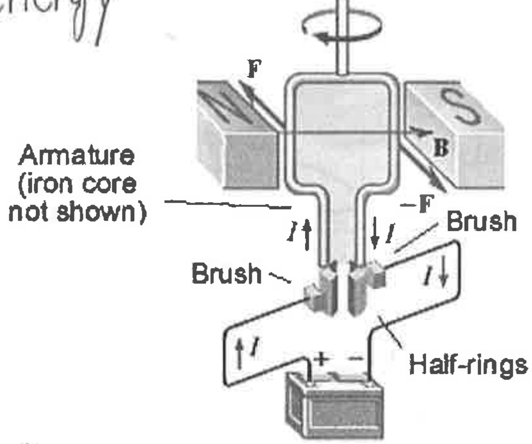
clockwise

electrical → mechanical energy = motors

mechanical → electrical energy = generators

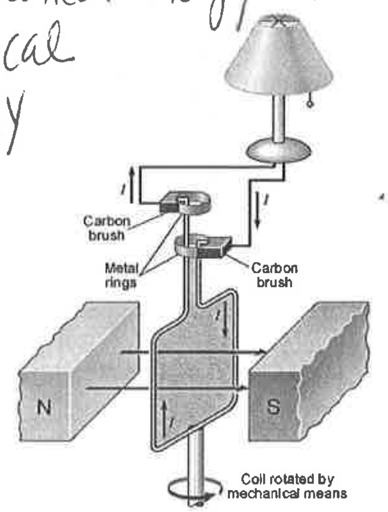
Motors and Generators

Motor: device that converts electrical energy into mechanical energy



Operating Principle: current in wire in a magnetic field produces a force on the wire + causes motor parts to move

Generator: device that converts mechanical energy into electrical energy



Operating Principle: moving a wire through a magnetic field induces a current

Why is household electricity AC instead of DC?

1) easier to generate

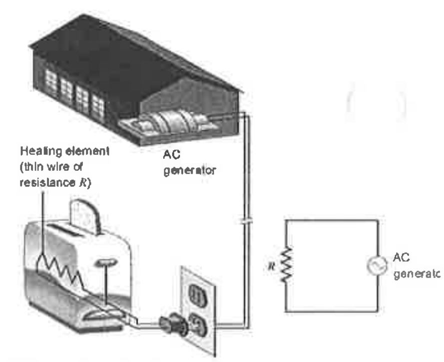
2) easier + more efficient to transport over long distances

Why is electricity sent at very high voltages in transmission lines?

$P = IV$

to transport power that current is reduced so that wires do not overheat + lose energy

$P = IV$



Household alternating current is produced by large AC generators at the power plant that use turbines to rotate coils of wire in magnetic fields.

For economic reasons, there is no ideal value of voltage for electrical transmission. Typical values are shown below.

1. AC power is generated at a power plant at 12,000 V and then stepped up to 240,000 V by step-up transformers.
2. The high-voltage, low-current power is sent via high-voltage transmission lines long distances.
3. In local neighborhoods, the voltage is stepped-down (and current is stepped-up) to 8000 V at substations.
4. This voltage is stepped-down even further at transformers on utility poles on residential streets.