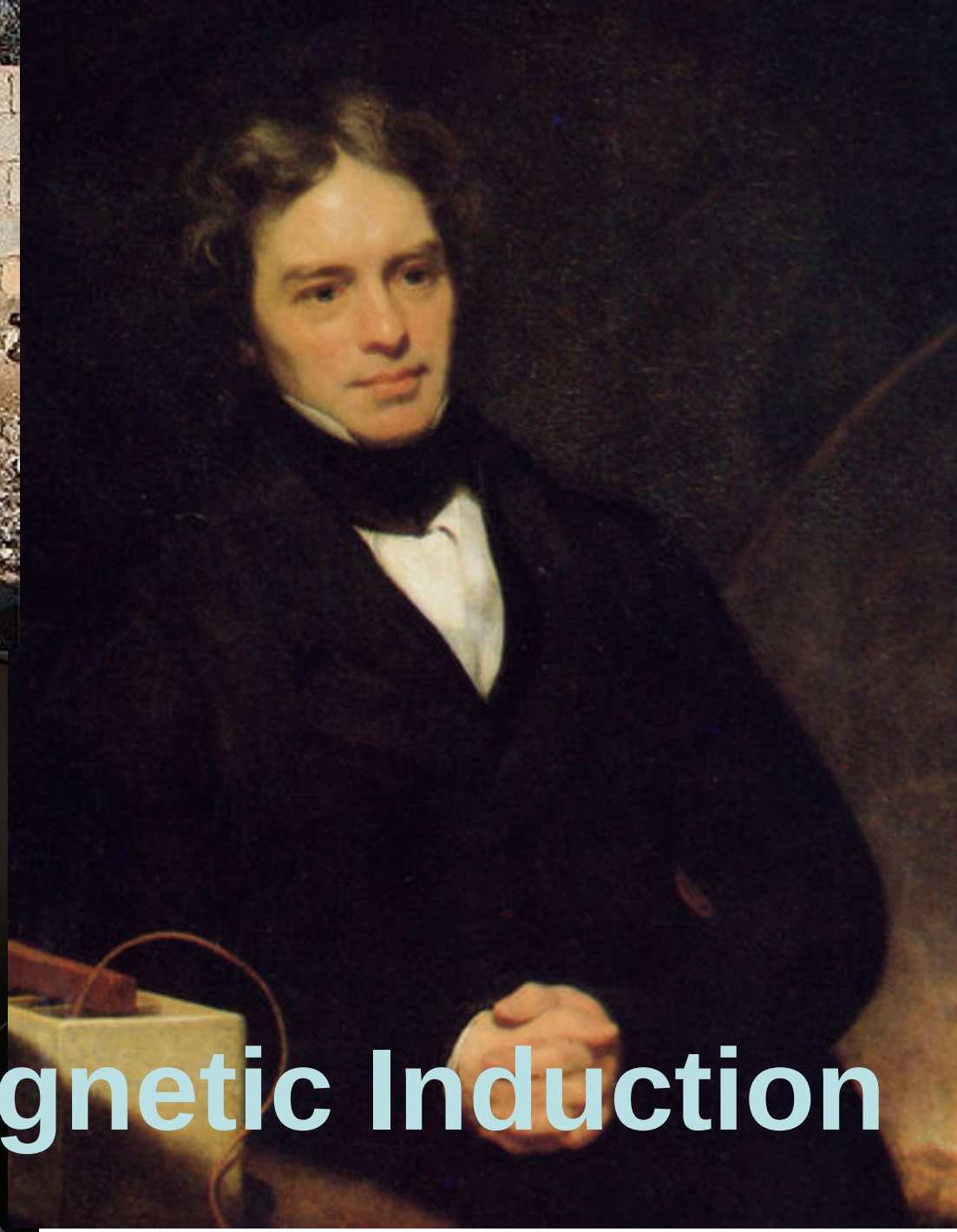


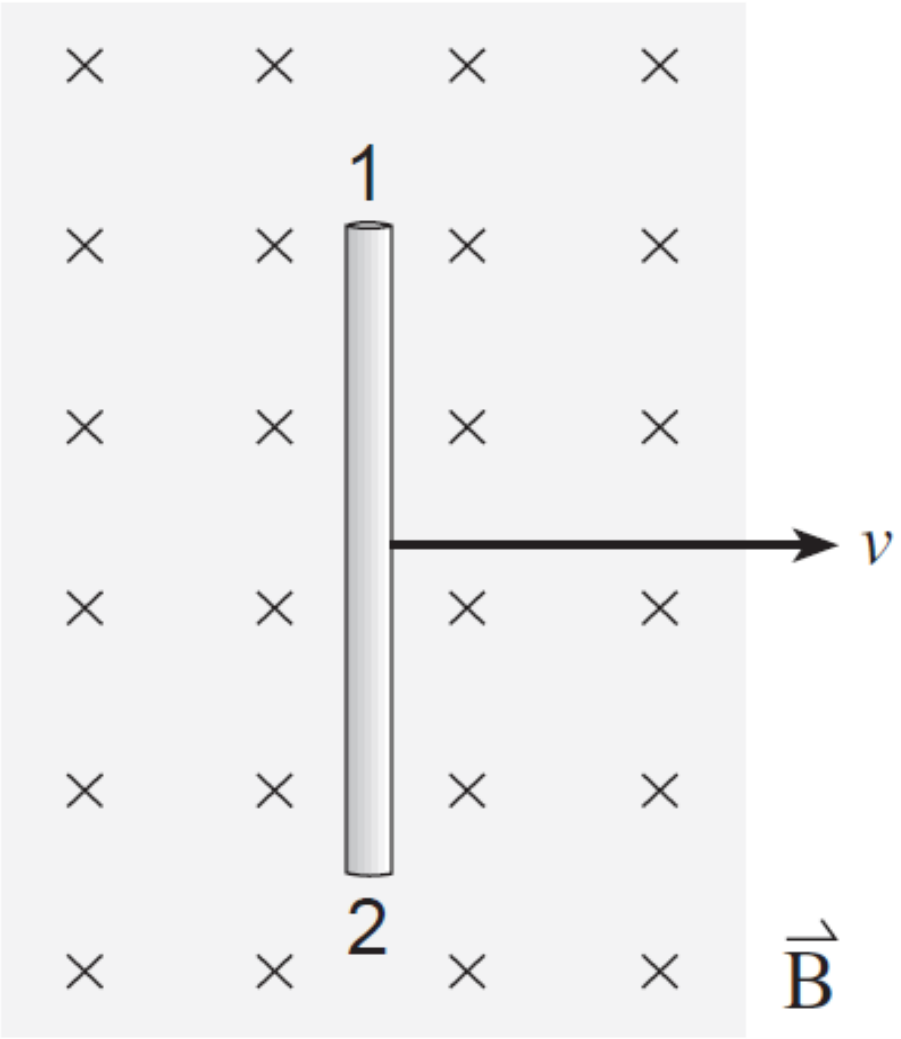
Electromagnetic Induction

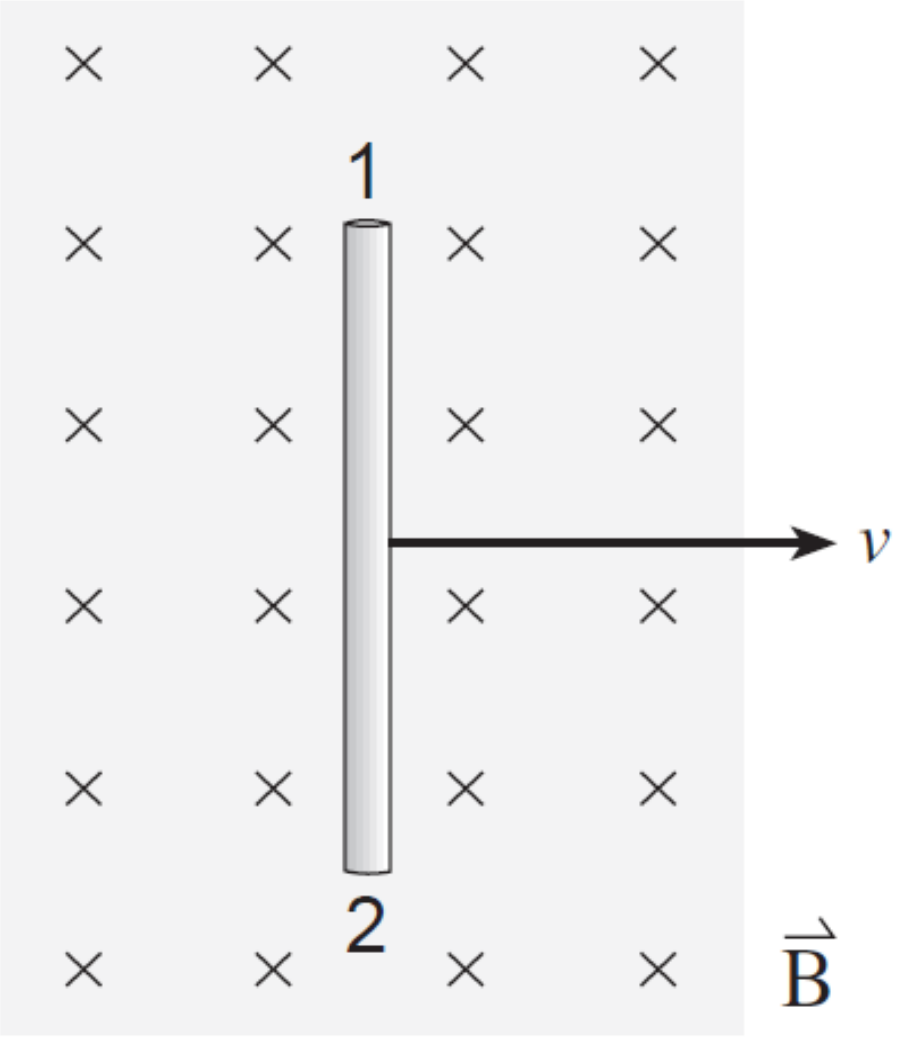
- Michael Faraday and Joseph Henry discovered that a magnetic field could cause an electric current to flow in a conductor moving in the field

- the magnetic field exerts a force on the electrons in the conductor, causing them to move

- allows physical work to be transformed into electrical energy

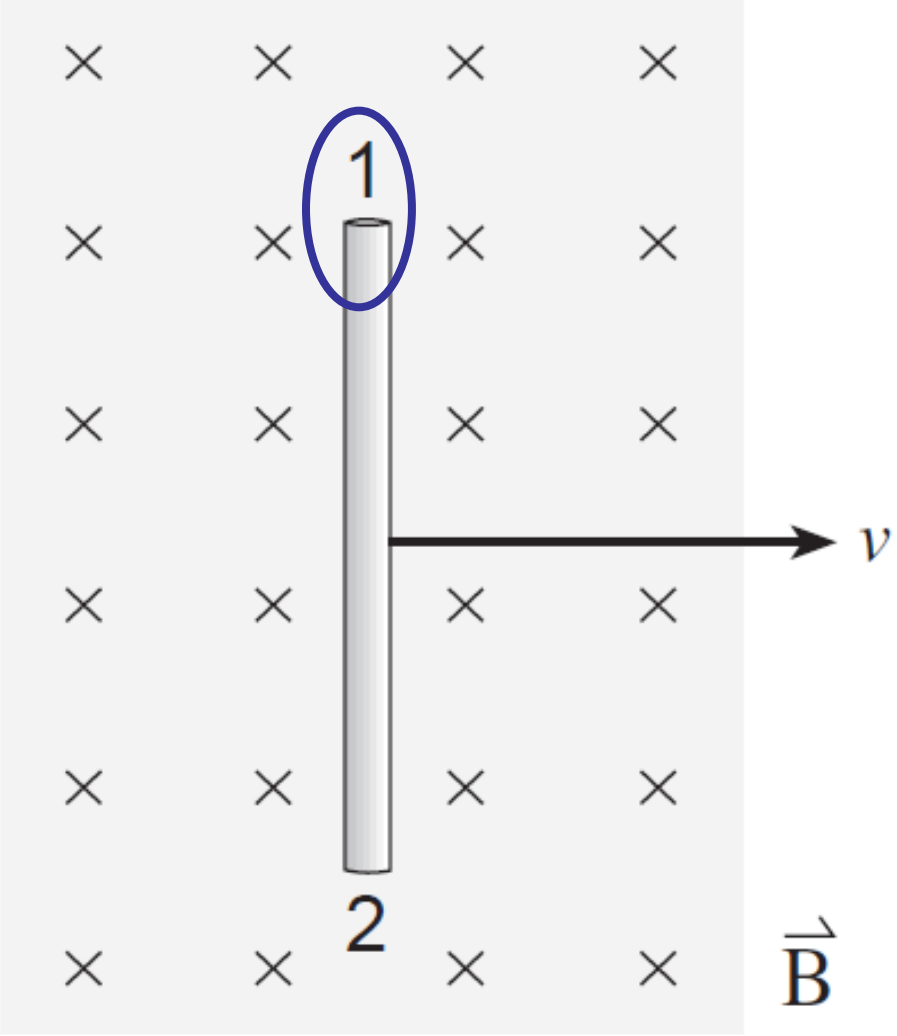
- Moving a conductor through a magnetic field will induce a potential difference across the conductor





- The magnetic field will exert a force on the free electrons in the conductor
- Electrons will be forced to 1 end of the conductor

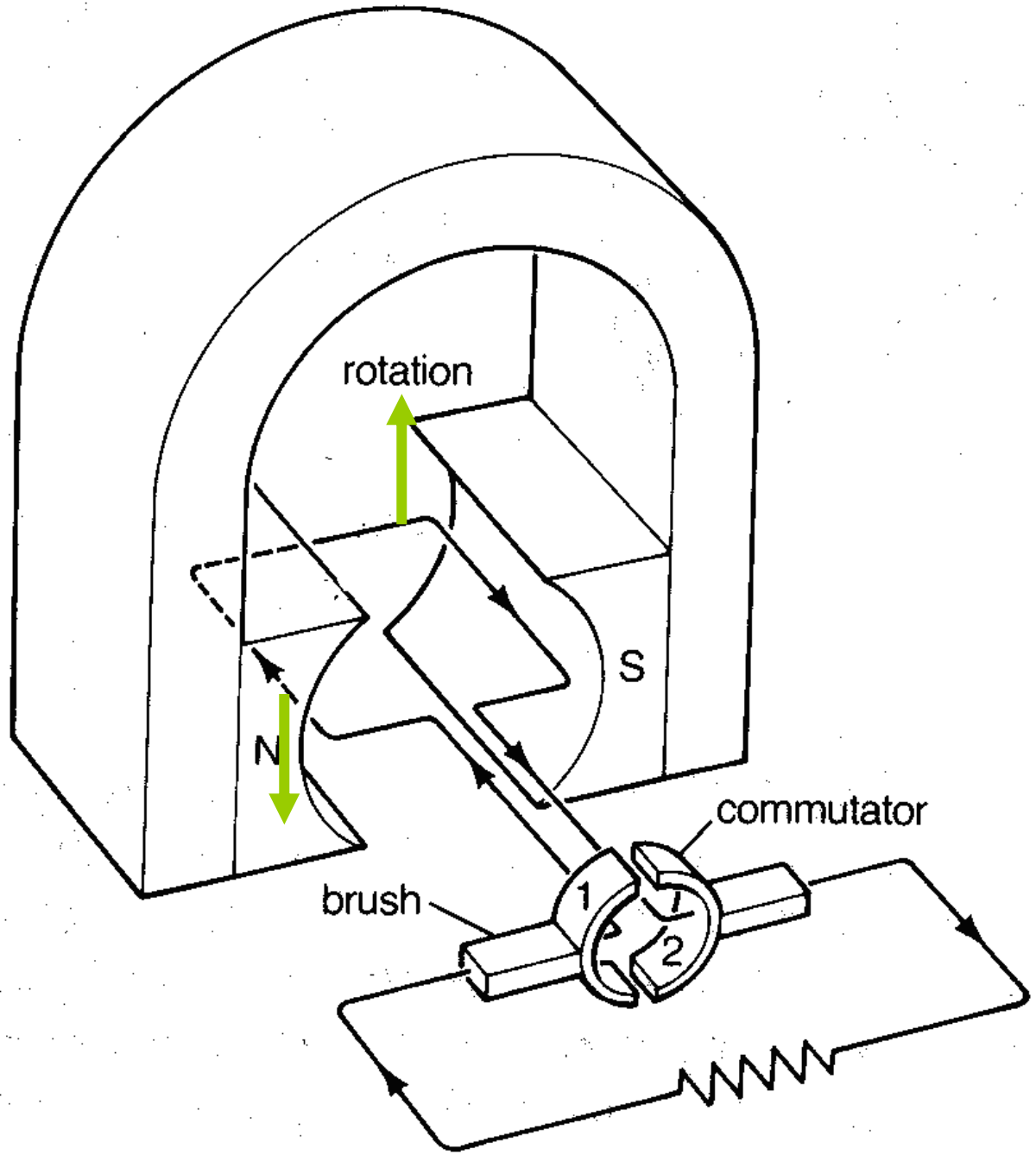
Example



- Which end of the conductor will be positive?
- Use the 3rd hand rule!
- The magnitude of the induced V depends on B, v and length of wire at $\perp$ to B

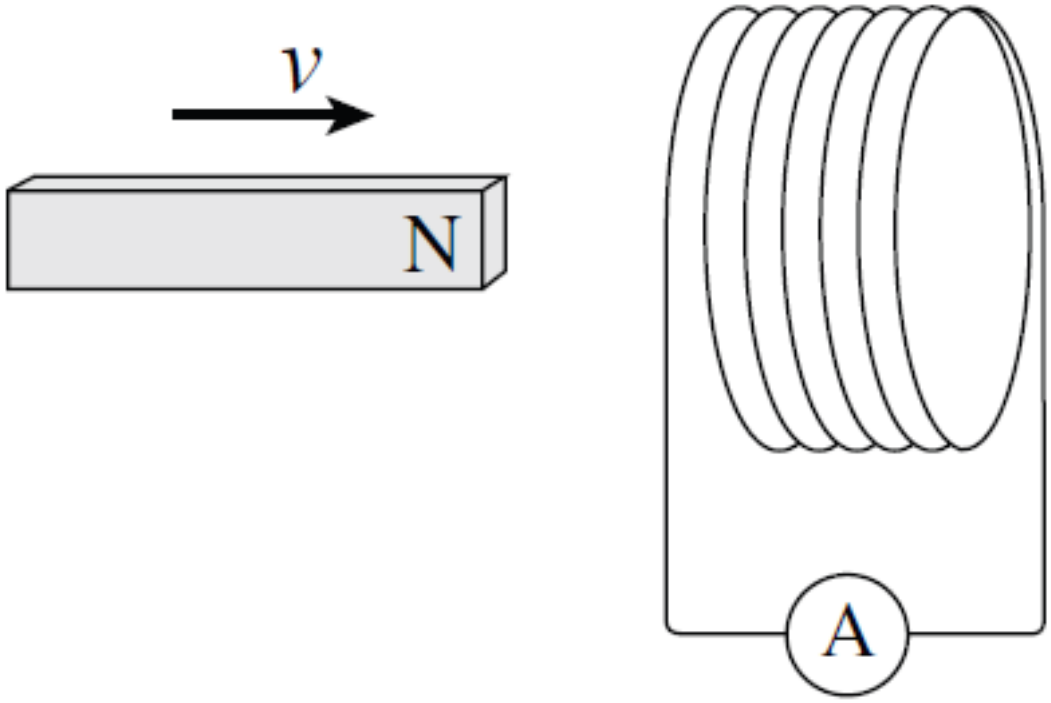
Generators

- If the ends of the conductor are connected, a current will flow


rotation
S
N
commutator
brush
1
2

- Induction will occur as long as there is relative motion between the conductor and the magnet

- Conductor can be at rest, magnet can move

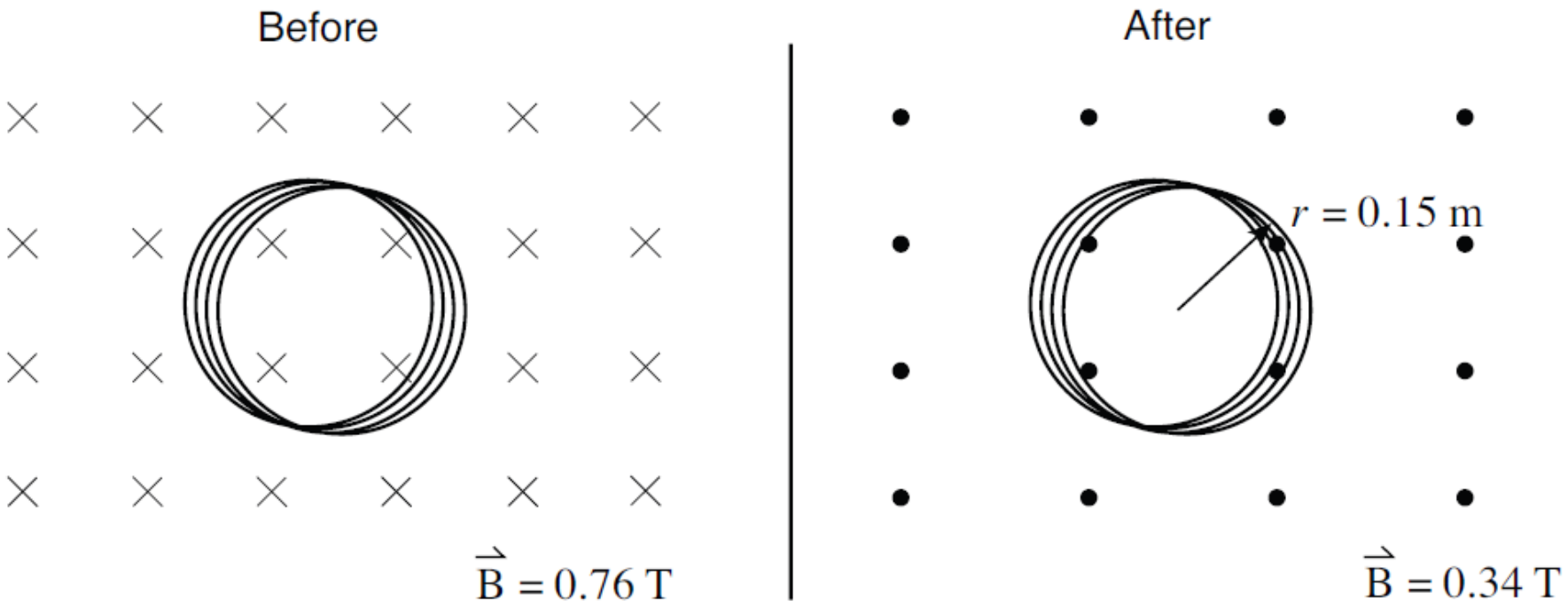


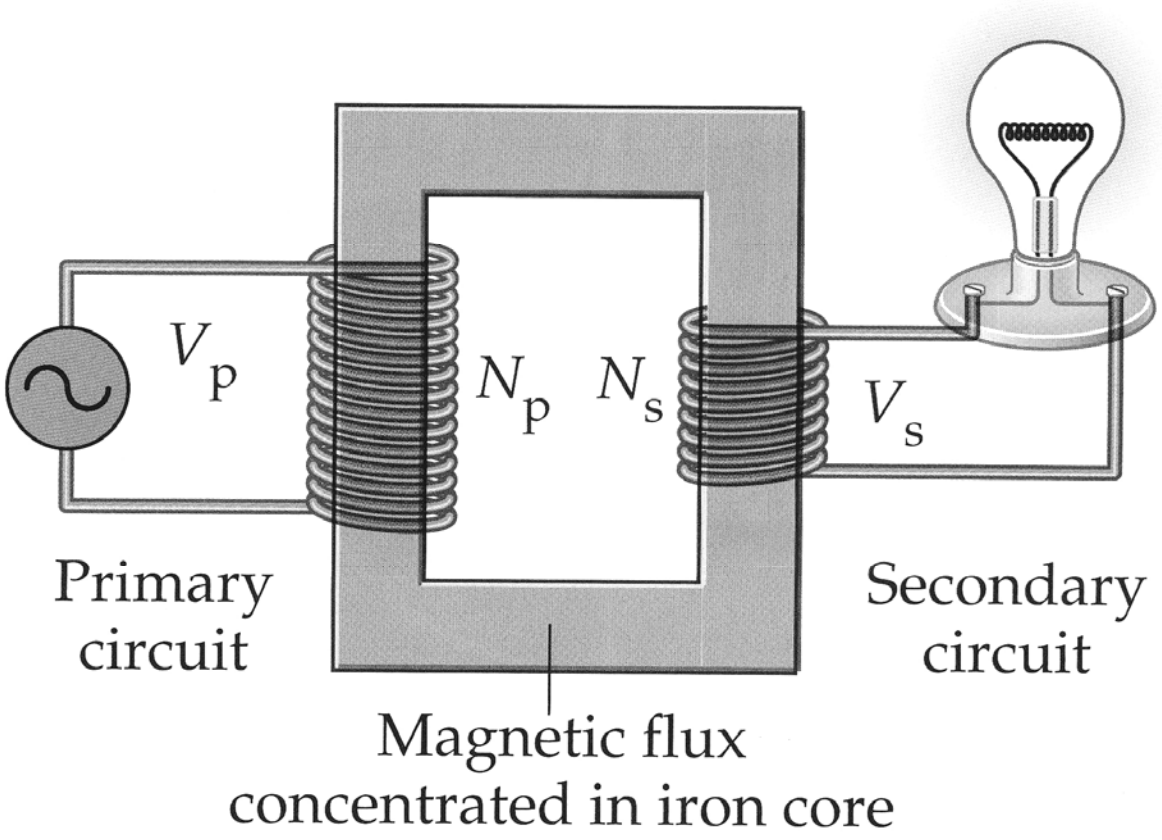
STS Connections

- Speakers
- Microphones
- Electric guitar pick-ups

- a changing magnetic field can cause an induced voltage in a conductor

- Transformers use this to convert 120 V household to different values (< 5 V for iPods to > 10 000 V for microwave ovens)


Before
After
r = 0.15 m
B = 0.76 T
B = 0.34 T



The changing magnetic field in primary coil induces a changing field in the 2nd coil which causes a changing current to flow in the secondary

STS

- Chargers, “battery adaptors”
- Induction cooktops use a changing magnetic field to induce currents in iron pots
- Resistance in the pots converts electrical energy into heat, heating just the pots and the contents

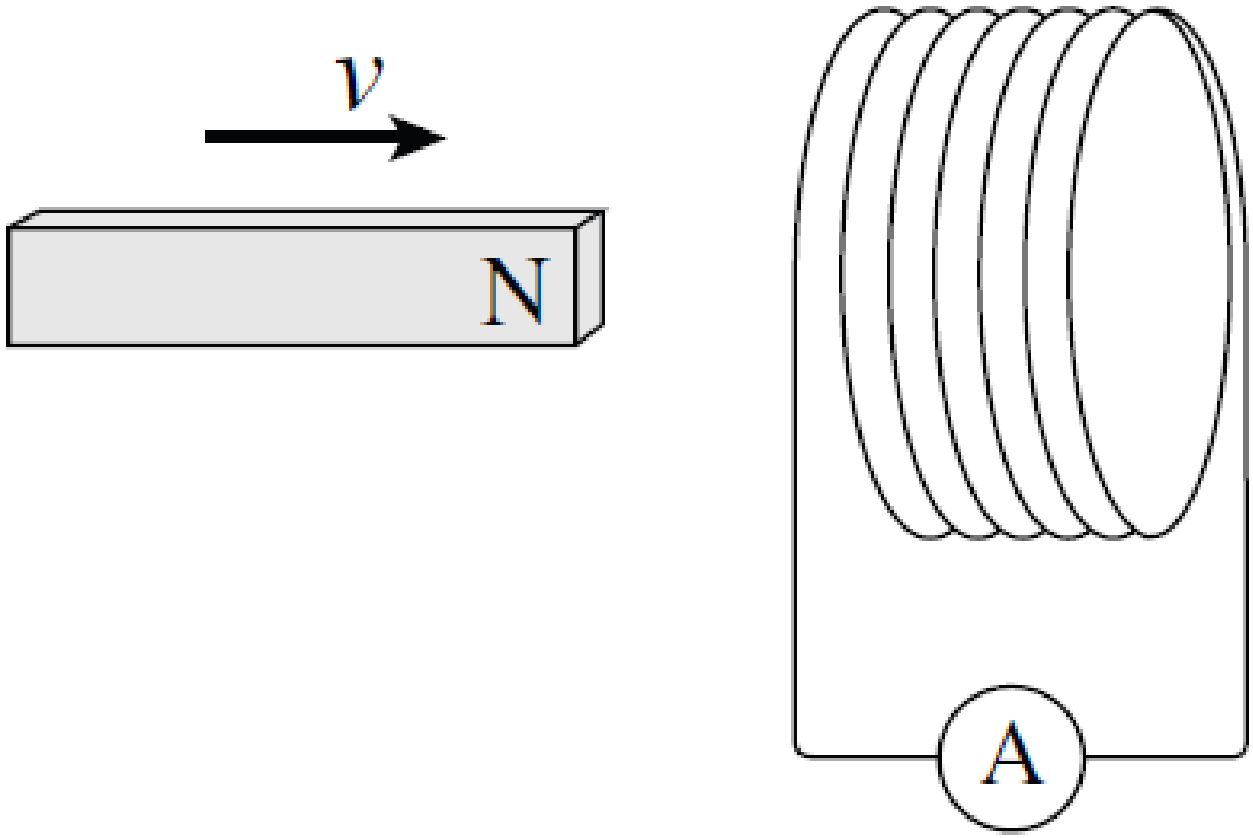
- Coil underneath has a very high frequency current flowing in it
- The higher the rate of change in B, the higher the induced V which causes a current in the metal pan
- Resistance of metal produces heat

Lenz’s Law

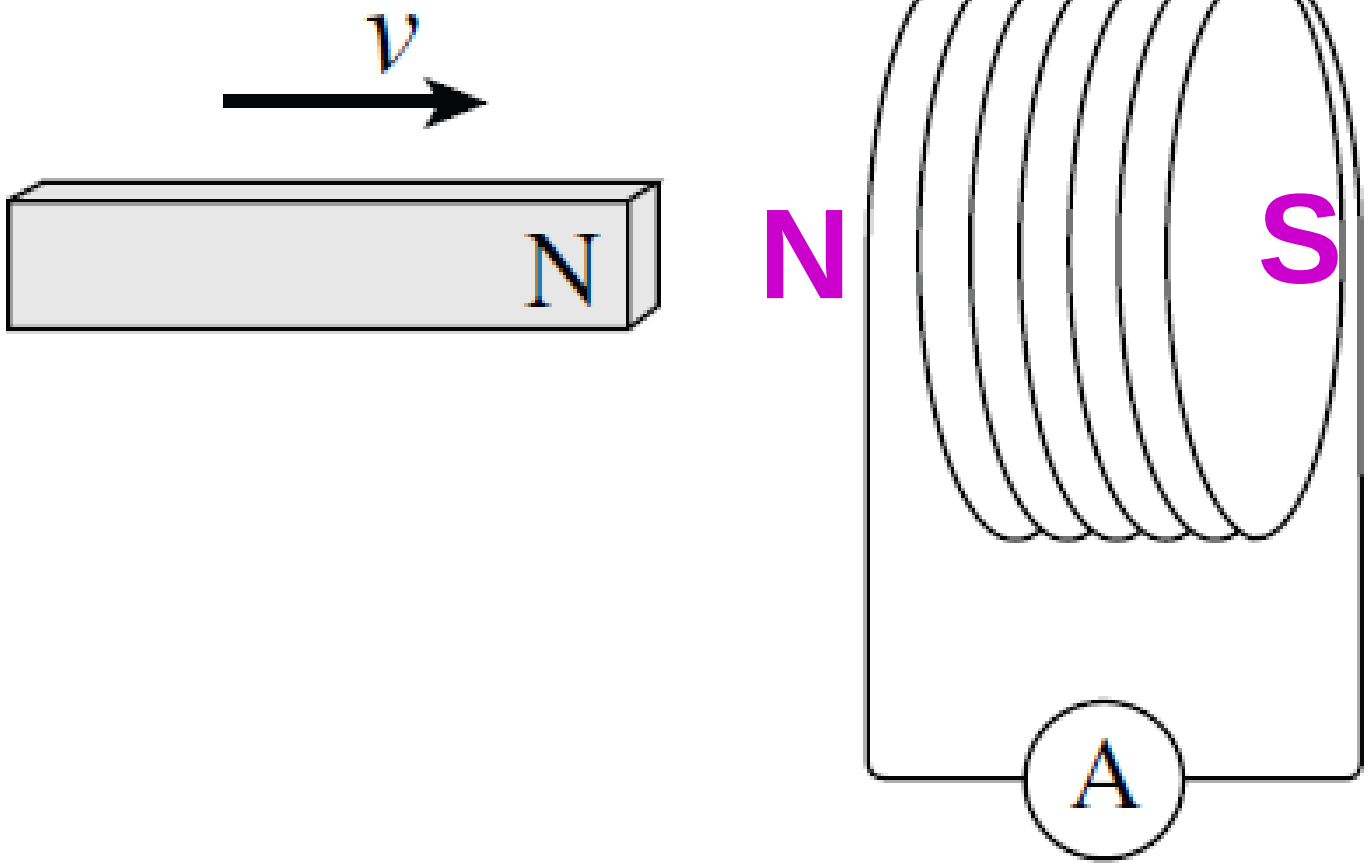
- The direction of an induced current will cause a magnetic field that will oppose the external field that is causing the induced current

- The induced current will always oppose a change in magnetic flux

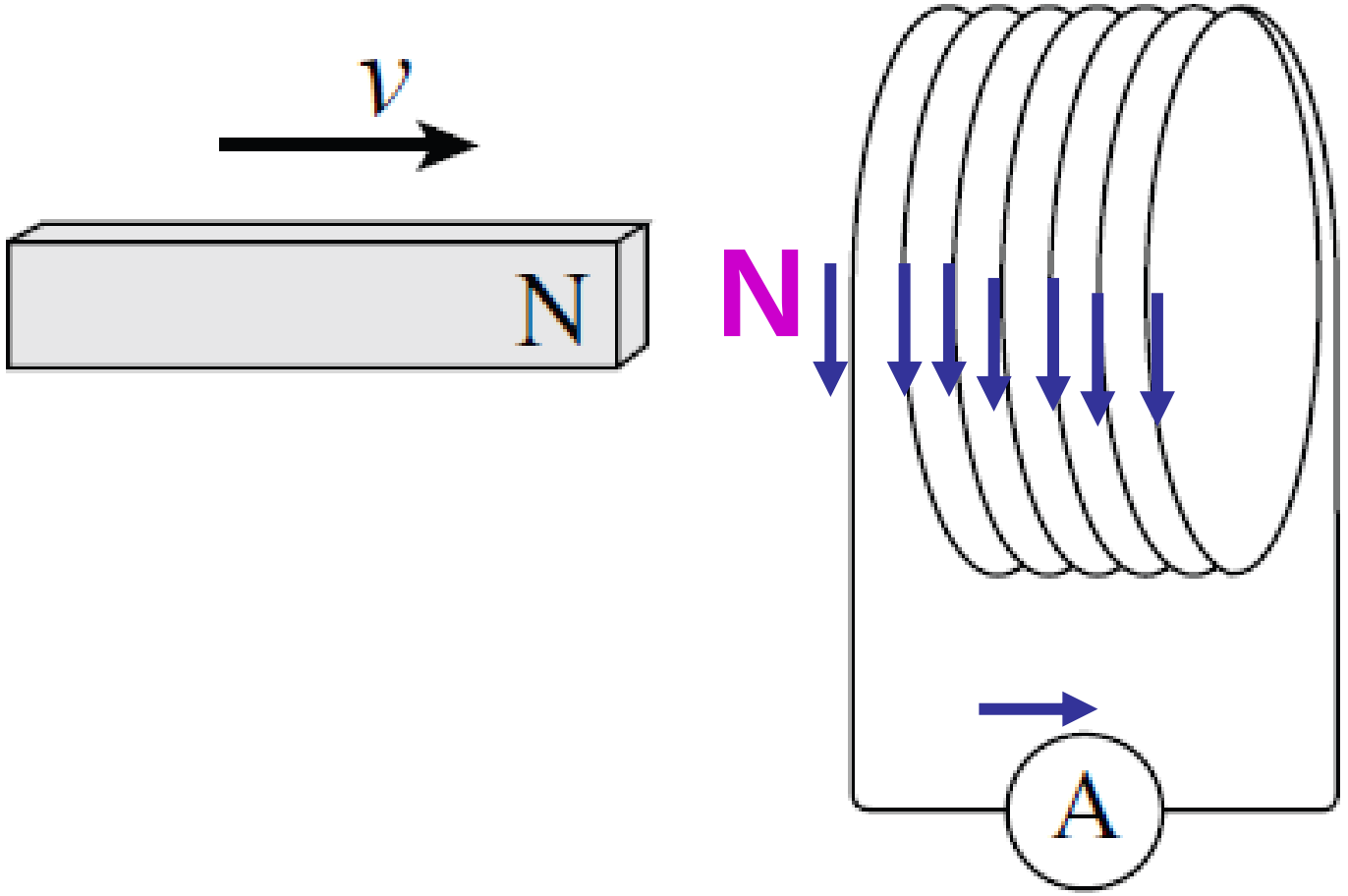
A magnet is moved towards a coil as shown. Which way will electrons move in the coil?



Induced Magnetic Field always opposes the external field

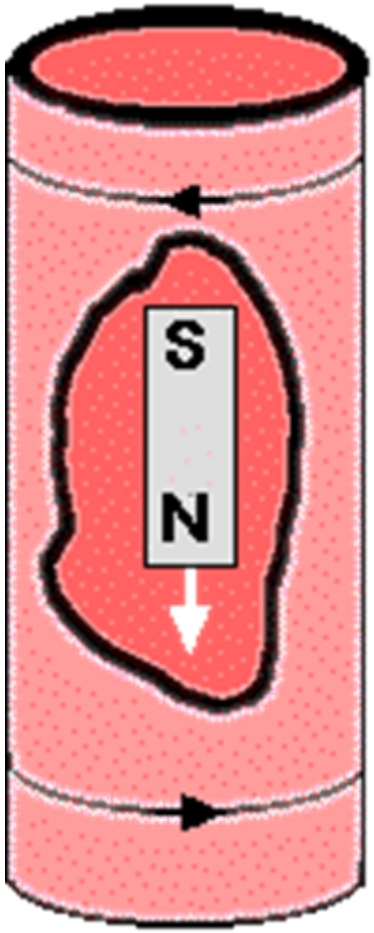


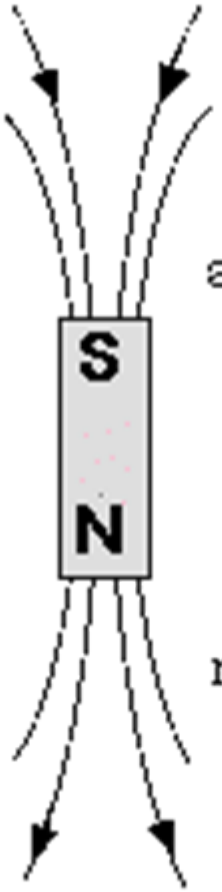
Induced current needed to create induced magnetic field (apply 2nd Hand Rule)



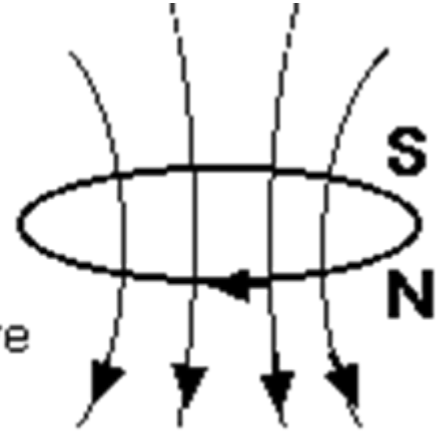
Demo

- A magnet is dropped down a non-magnetic conducting pipe. The magnet falls much slower than free-fall.

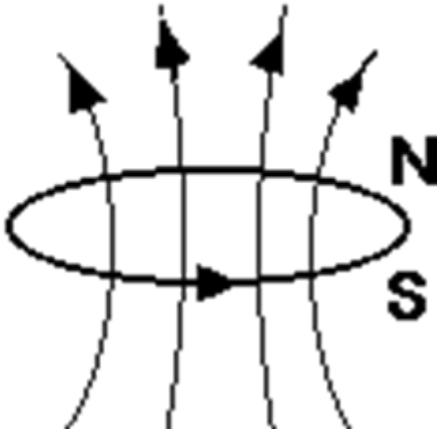




attractive force



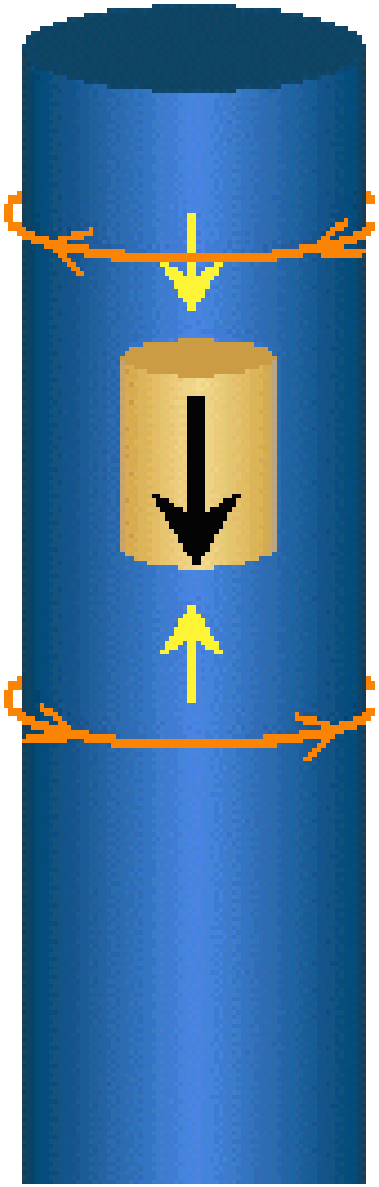
repulsive force



Conventional current flow

Induced current in pipe creates a magnetic field above the magnet which opposes the motion as magnet moves down (attracts magnet)

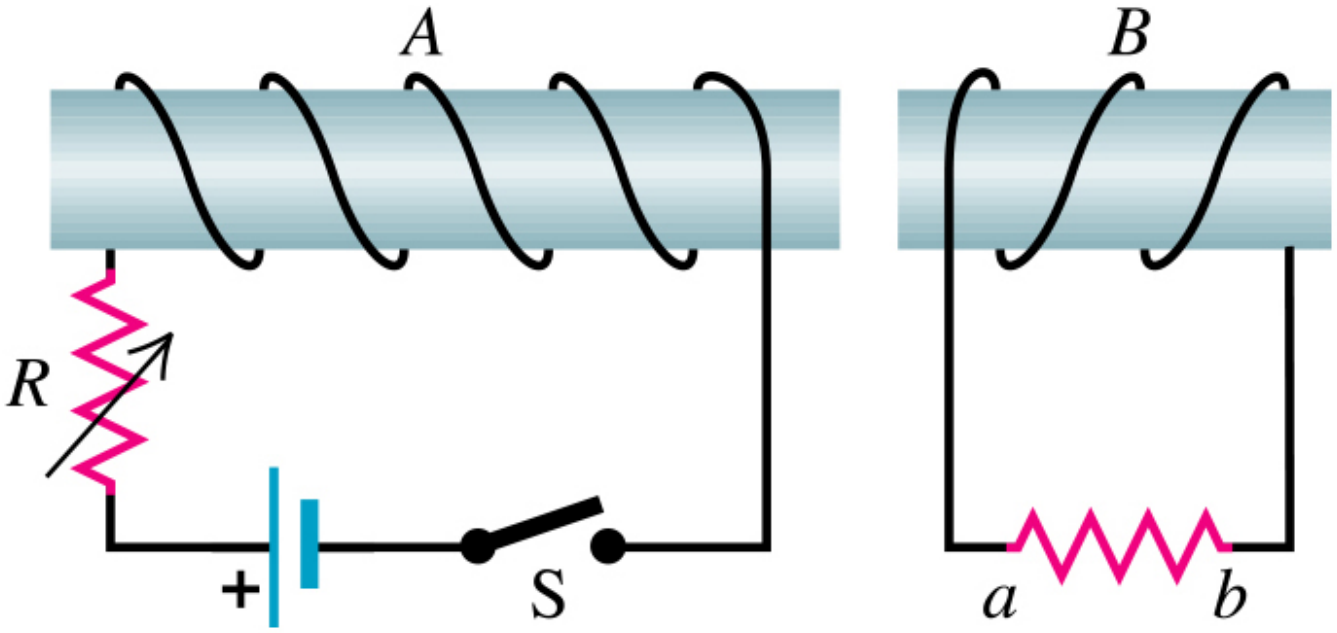
Induced current in pipe creates a magnetic field below the magnet which opposes the motion (repels magnet)



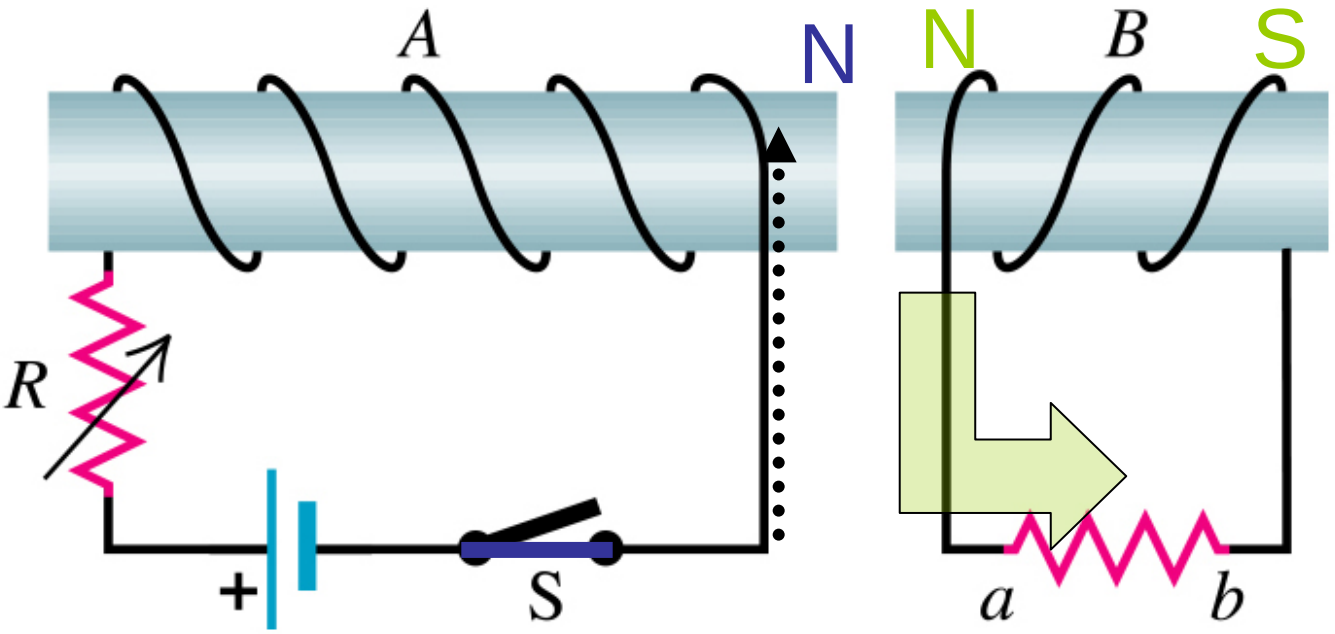
Conventional current flow

Example

- The switch S is closed and current begins to flow in coil A. Determine the direction of the induced electron flow in coil B the moment current begins to flow in A.

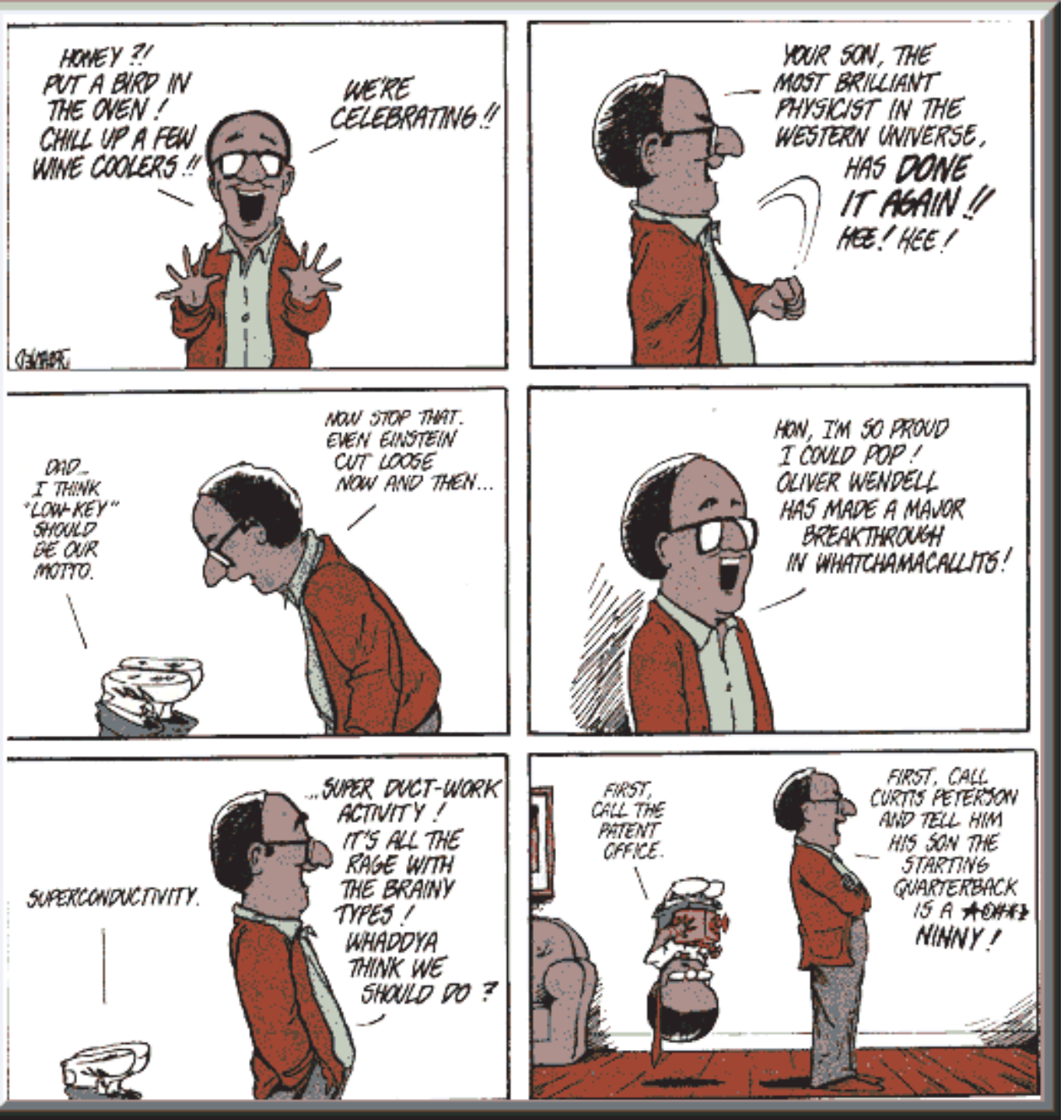


Solution



The induced field OPPOSES the field from A

As current in A increases to the maximum value, the magnetic field around A increases, inducing a current in B


HONEY ?! PUT A BIRD IN THE OVEN ! CHILL UP A FEW WINE COOLERS !!
WE'RE CELEBRATING !!
YOUR SON, THE MOST BRILLIANT PHYSICIST IN THE WESTERN UNIVERSE, HAS DONE IT AGAIN !! HEE ! HEE !
DAD— I THINK "LOW-KEY" SHOULD BE OUR MOTTO.
NOW STOP THAT. EVEN EINSTEIN CUT LOOSE NOW AND THEN...
HON, I'M SO PROUD I COULD POP ! OLIVER WENDELL HAS MADE A MAJOR BREAKTHROUGH IN WHATCHAMACALLITS !
SUPERCONDUCTIVITY.
...SUPER DUCT-WORK ACTIVITY ! IT'S ALL THE RAGE WITH THE BRAINY TYPES ! WHADDYA THINK WE SHOULD DO ?
FIRST, CALL THE PATENT OFFICE.
FIRST, CALL CURTIS PETERSON AND TELL HIM HIS SON THE STARTING QUARTERBACK IS A ★@#$% NINNY !