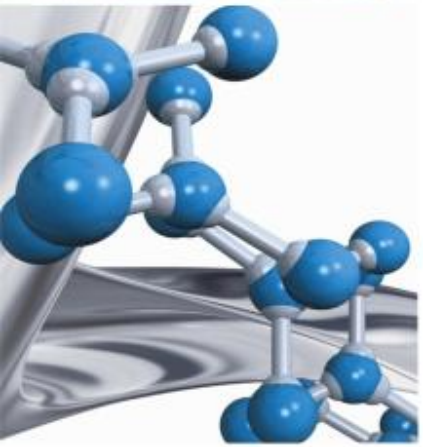

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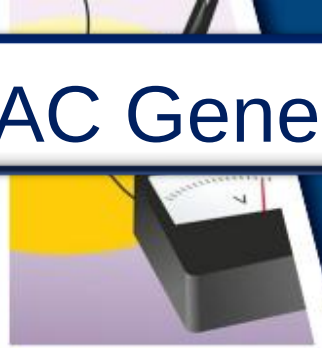
Video Series

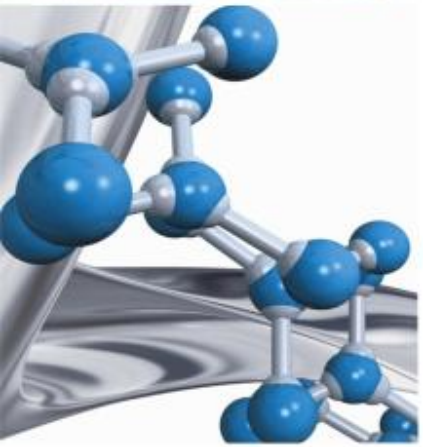
GRADE 12

CAPS Physical Science

# ELECTRICITY AND MAGNETISM

# Lesson 2: AC Generators





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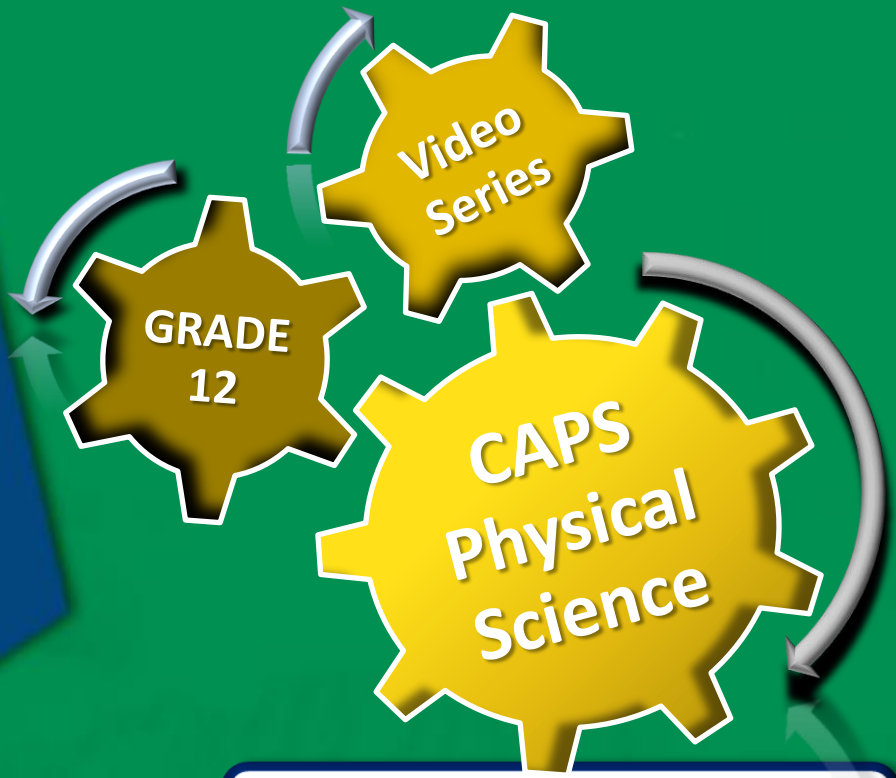
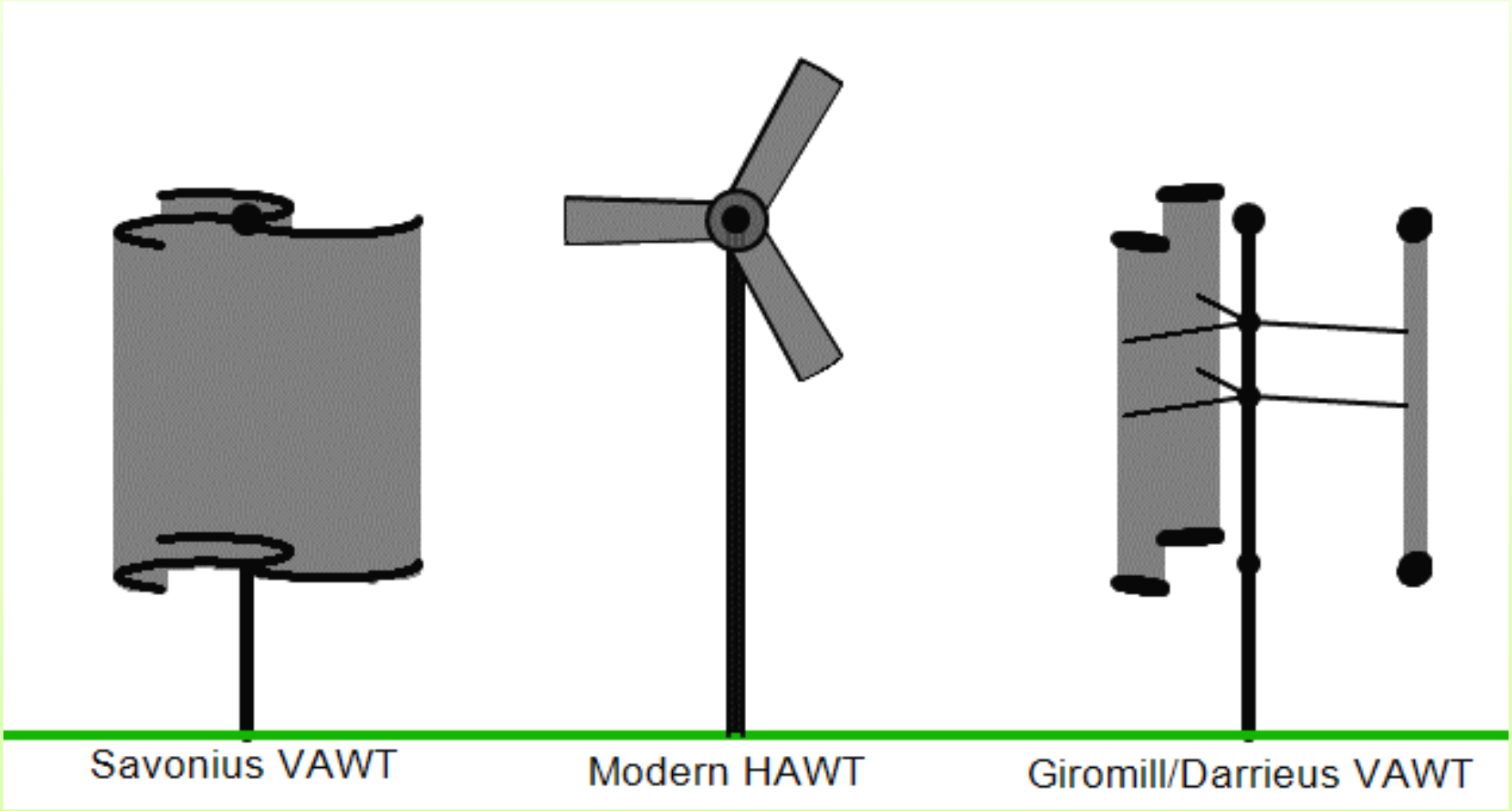



## Electrodynamics

# Some Generators



# Wind power

The construction of **wind farms** is a fairly new development in South Africa.

- As shown in this photo wind power has the advantage of being **"environment friendly".**
- Although construction is expensive and maintenance is needed, another advantage is that no other energy source needs to be bought (e.g. coal)

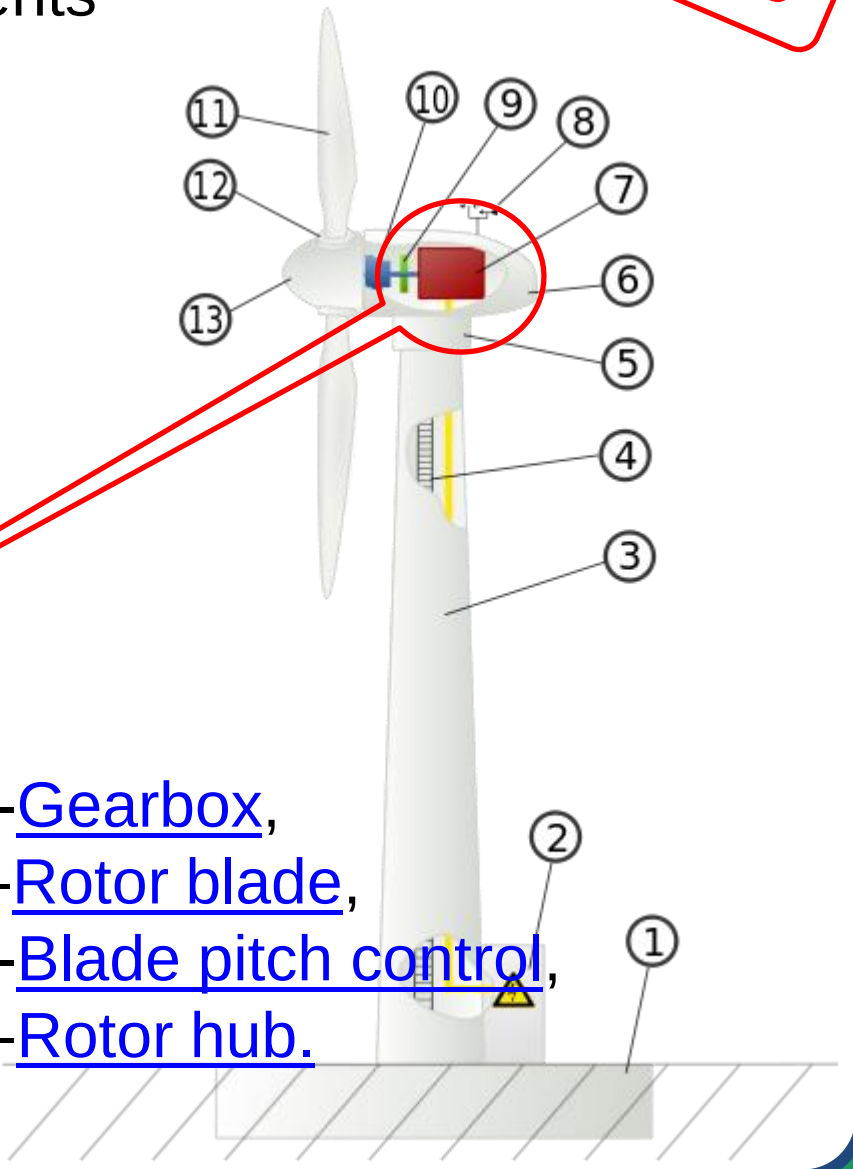
Photo by Dirk Ingo Franke

# Wind Turbine

Not CAPS

This diagram shows the components of a typical wind turbine.

1-Foundation,
2-Connection to the electric grid,
3-Tower,
4-Access ladder,
5-Wind orientation control (Yaw control),
6-Nacelle,
7-Generator,
8-Anemometer,
9-Electric or Mechanical Brake,
10-Gearbox,
11-Rotor blade,
12-Blade pitch control,
13-Rotor hub.



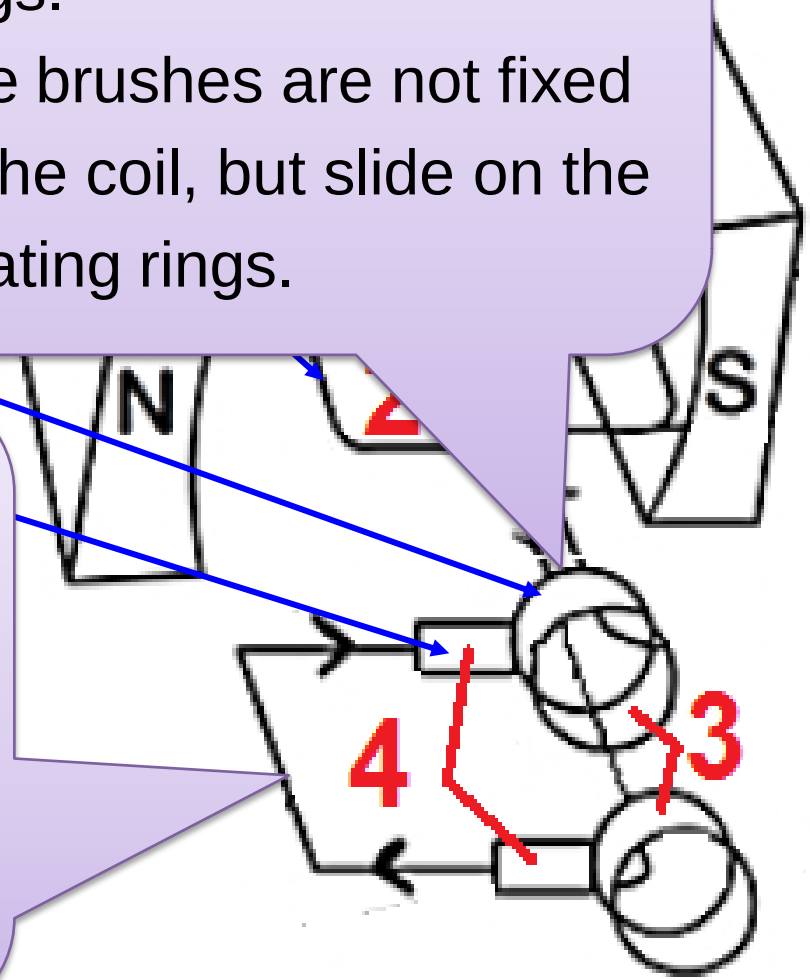
# Basic Generators

Components of a simple

1. Magnets of opposite p
2. Conducting coil (soler
3. Slip rings
4. Brushes

Note that the coil is attached to the two slip rings.
The brushes are not fixed to the coil, but slide on the rotating rings.

As the coil rotates between the magnets, a current is induced and the current is then fed into the connecting circuit via the slip rings and brushes.



# Working Principle

**ELECTROMAGNETIC INDUCTION** is the process of **generating electricity** by changing the magnetic field acting on a conductor.

In previous examples, the magnetic field was moved in relation to the coil (solenoid).

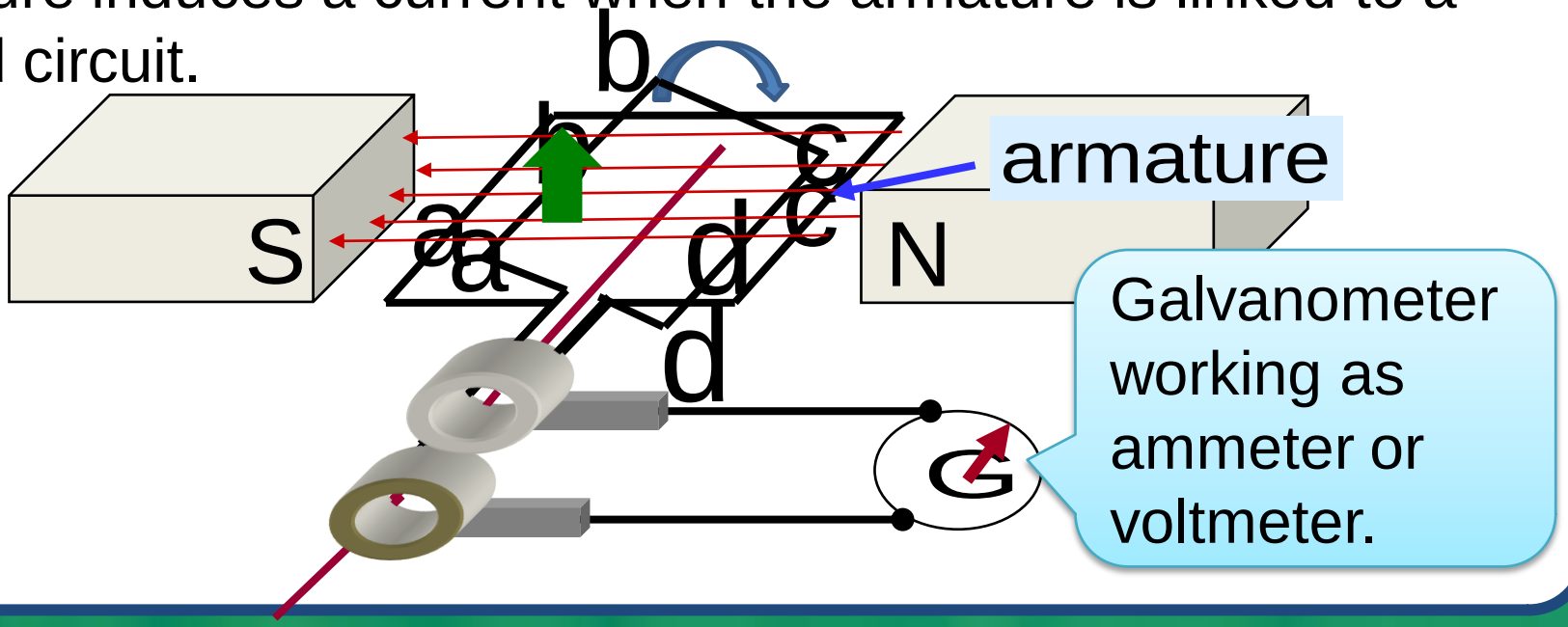
However, as seen in the diagram of the basic generator, an emf can also be induced in the coil **if the coil is moving in relation to the magnetic field**.

The magnitude of the emf induced in a coil is proportional to the rate of change of magnetic flux (**Faradays law of electromagnetic induction).**

If connected to a closed circuit, **the emf will induce a current.**

# Principle Applied

The coil / solenoid / armature lies in a magnetic field, which direction is from North to South.
The armature is set in such a way that it can be mechanically rotated.
If the armature starts rotating in a clockwise direction, side ab of the armature moves UP.
The change in the flux linkage between the B-field and the armature induces a current when the armature is linked to a closed circuit.



# FRHDR

The direction in which the induced current flows through side ab of the armature, can by determined through:

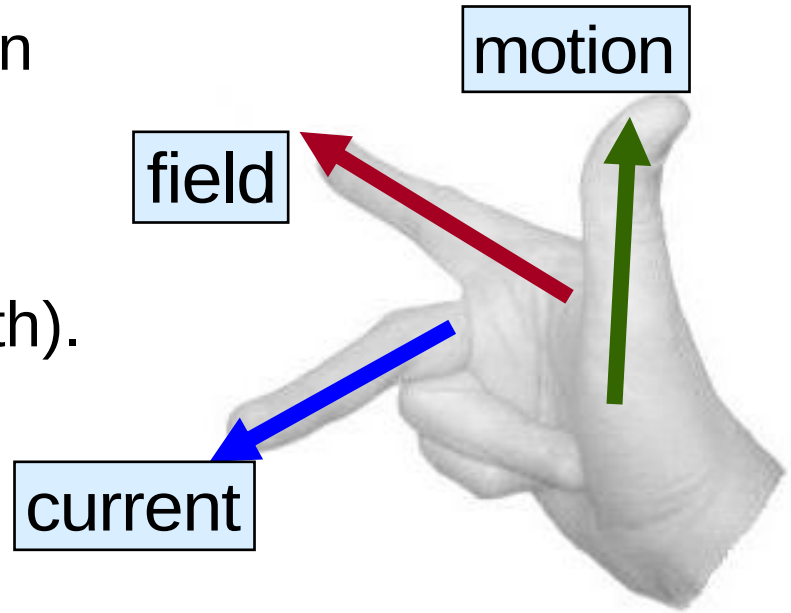
## Fleming's Right Hand Dynamo Rule

The right hand is held with the thumb, first finger and second finger mutually perpendicular to each other (at right angles).

The Thumb represents the direction of **M**otion of the conductor.

The **F**irst finger represents the direction of the **F**ield. (north to south).

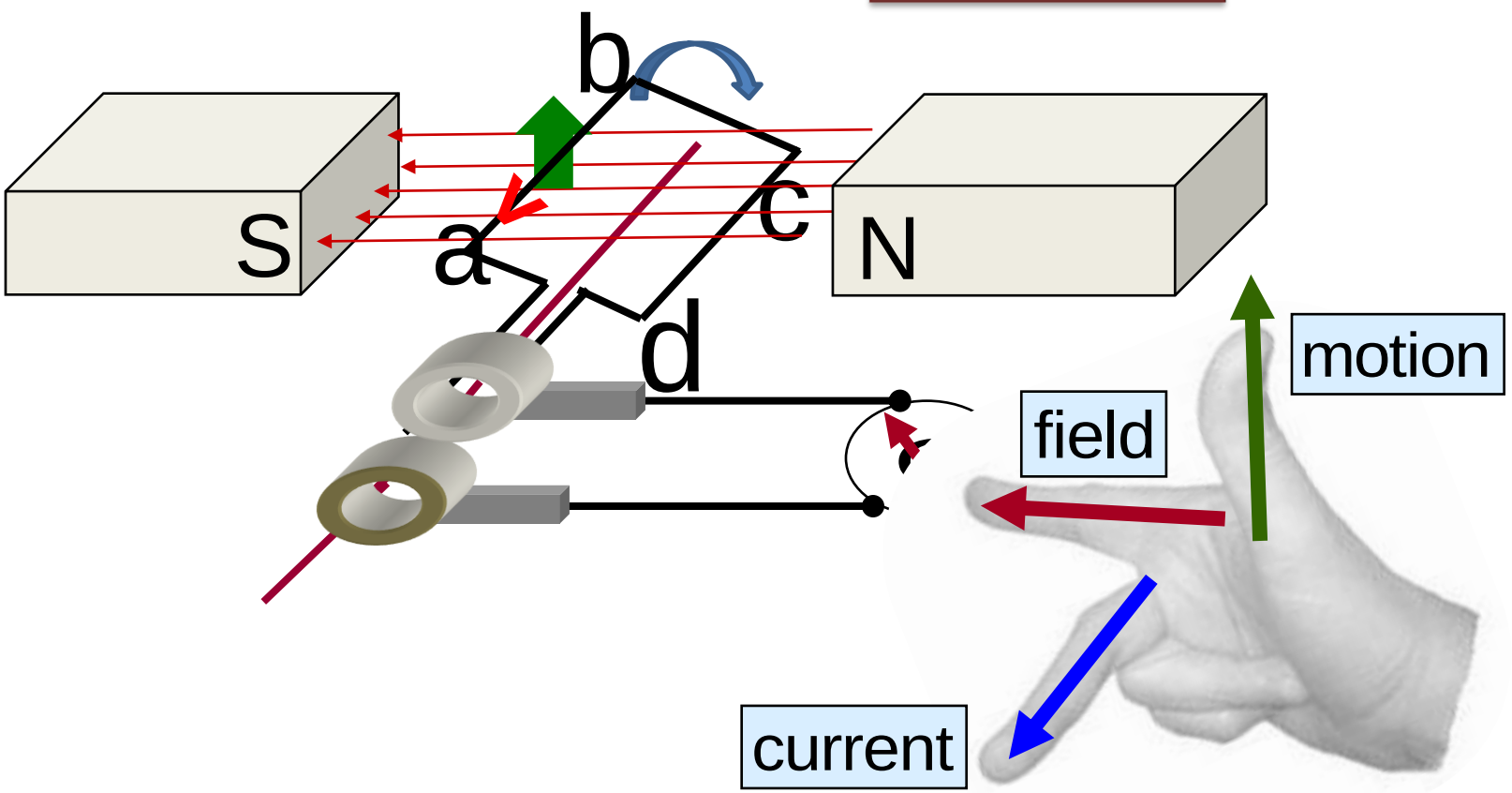
The Second finger represents the direction of the induced or generated **C**urrent



# Current in ab 1

Apply FRHDR to ab …

Then the induced current flows from **b to a**

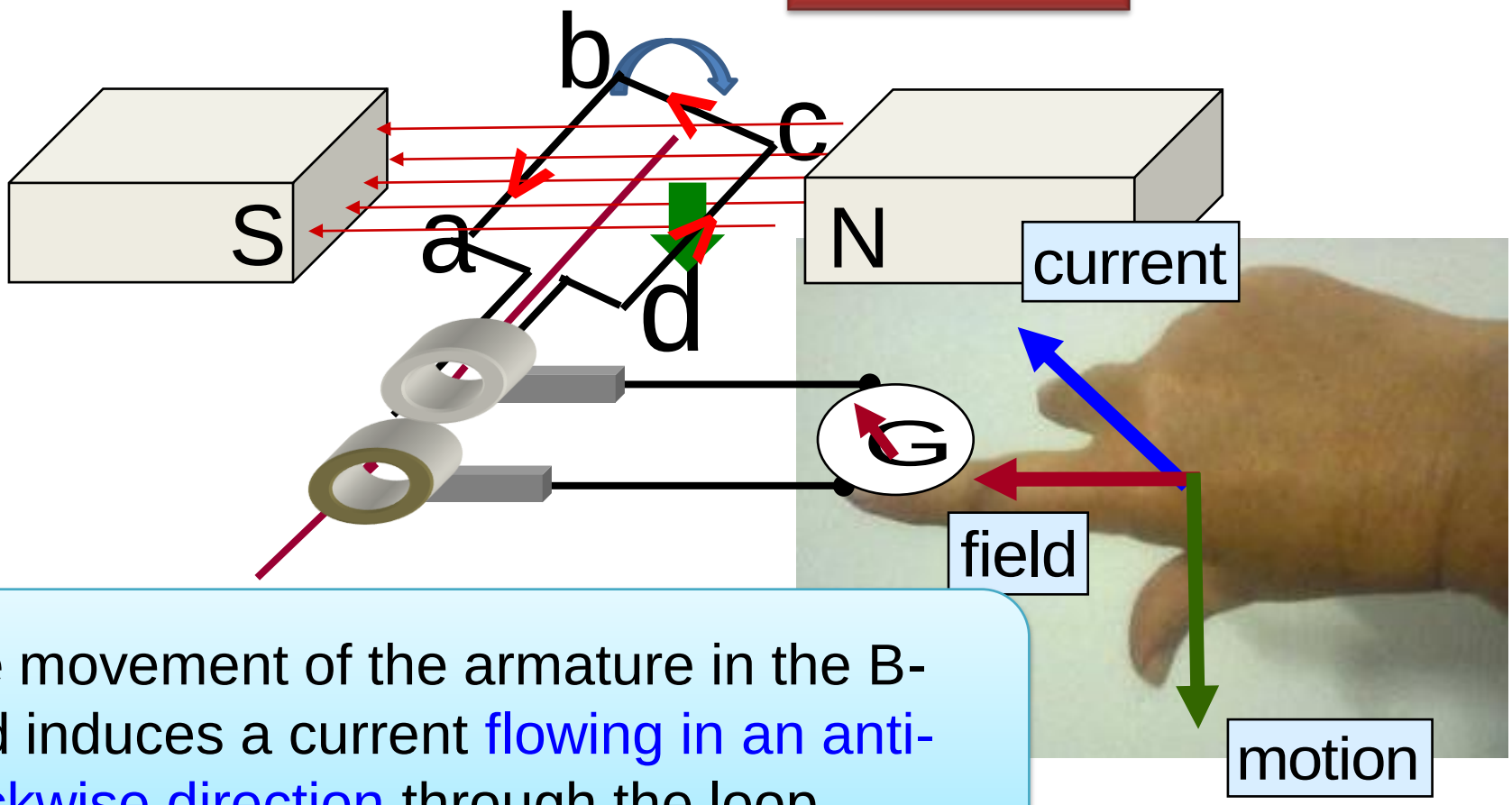


# Current in cd 1

As ab moves, cd moves…

and the current in cd flows from …

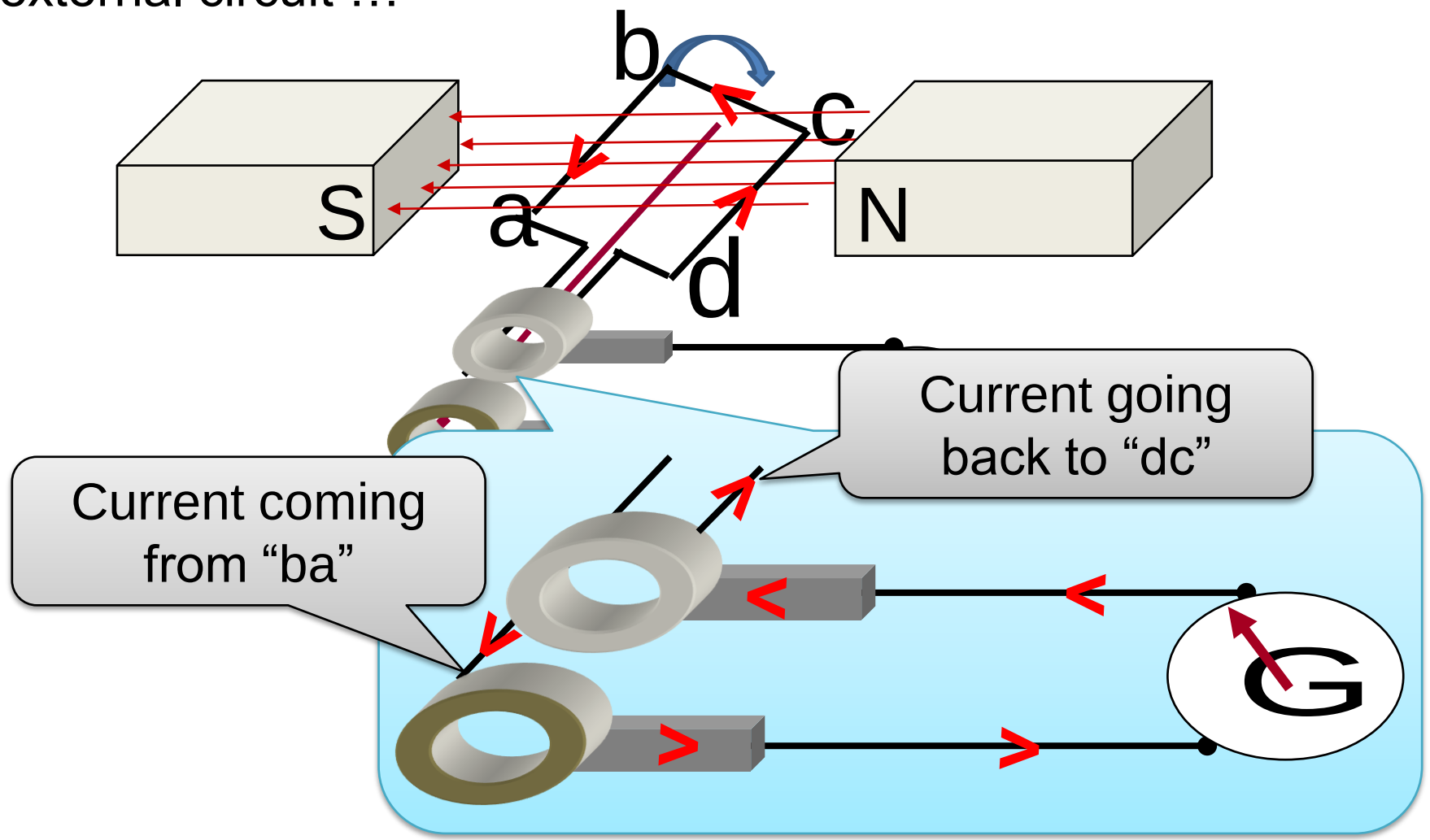
**d to c**




The movement of the armature in the B-field induces a current flowing in an anti-clockwise direction through the loop.

# Current Collected

This induced current must now be “collected” for use in the external circuit …

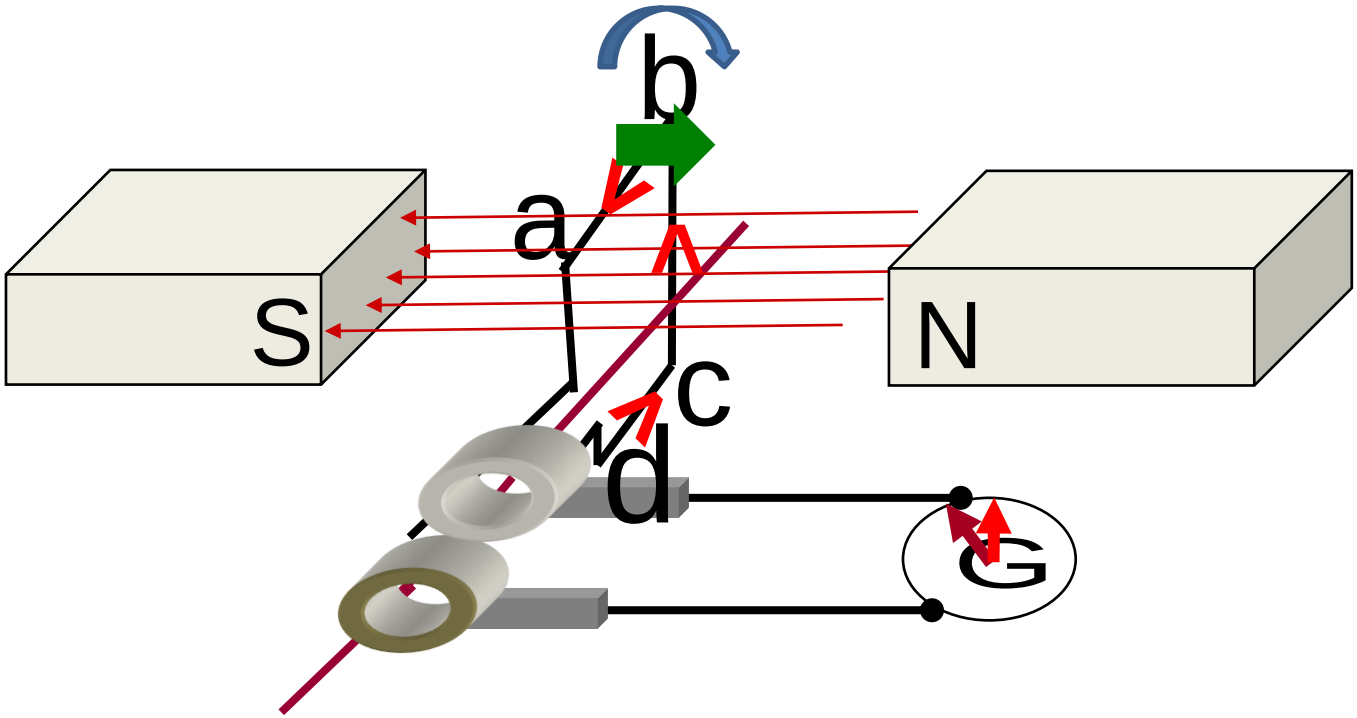


# 0°

As the armature is mechanically turned, it reaches the zero position …

The **motion** of the armature is now **parallel** **to the direction of the B-field.**

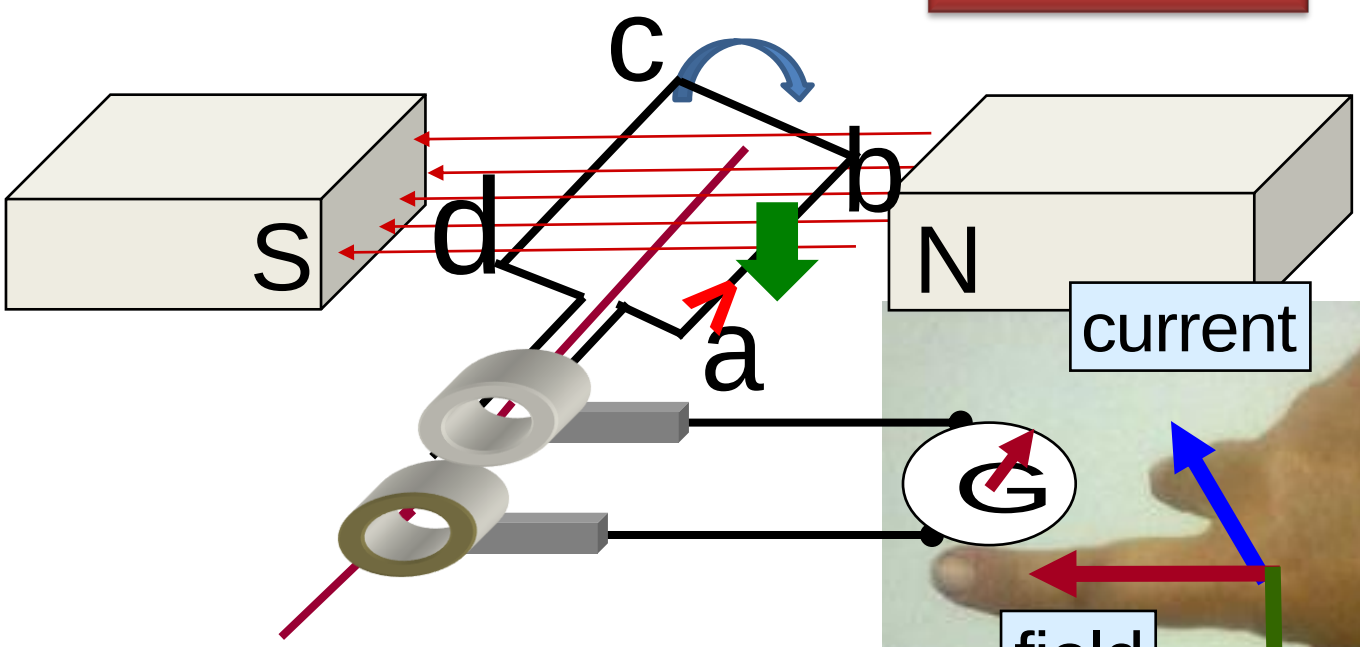
**NO flux linkage to armature** ⇒ **NO current induced!**

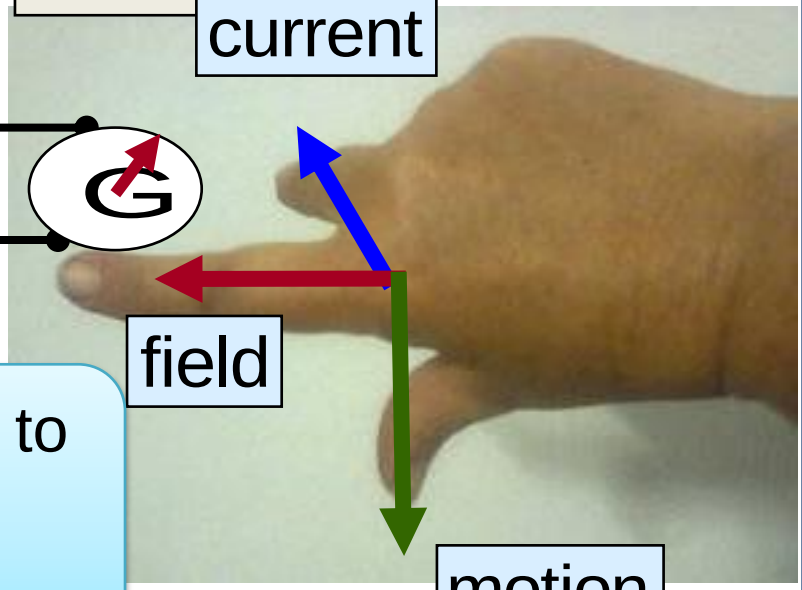


# Current in ab 2

Passing the zero position, side ab is now on its way down …

The induced current now flows from **a to b**

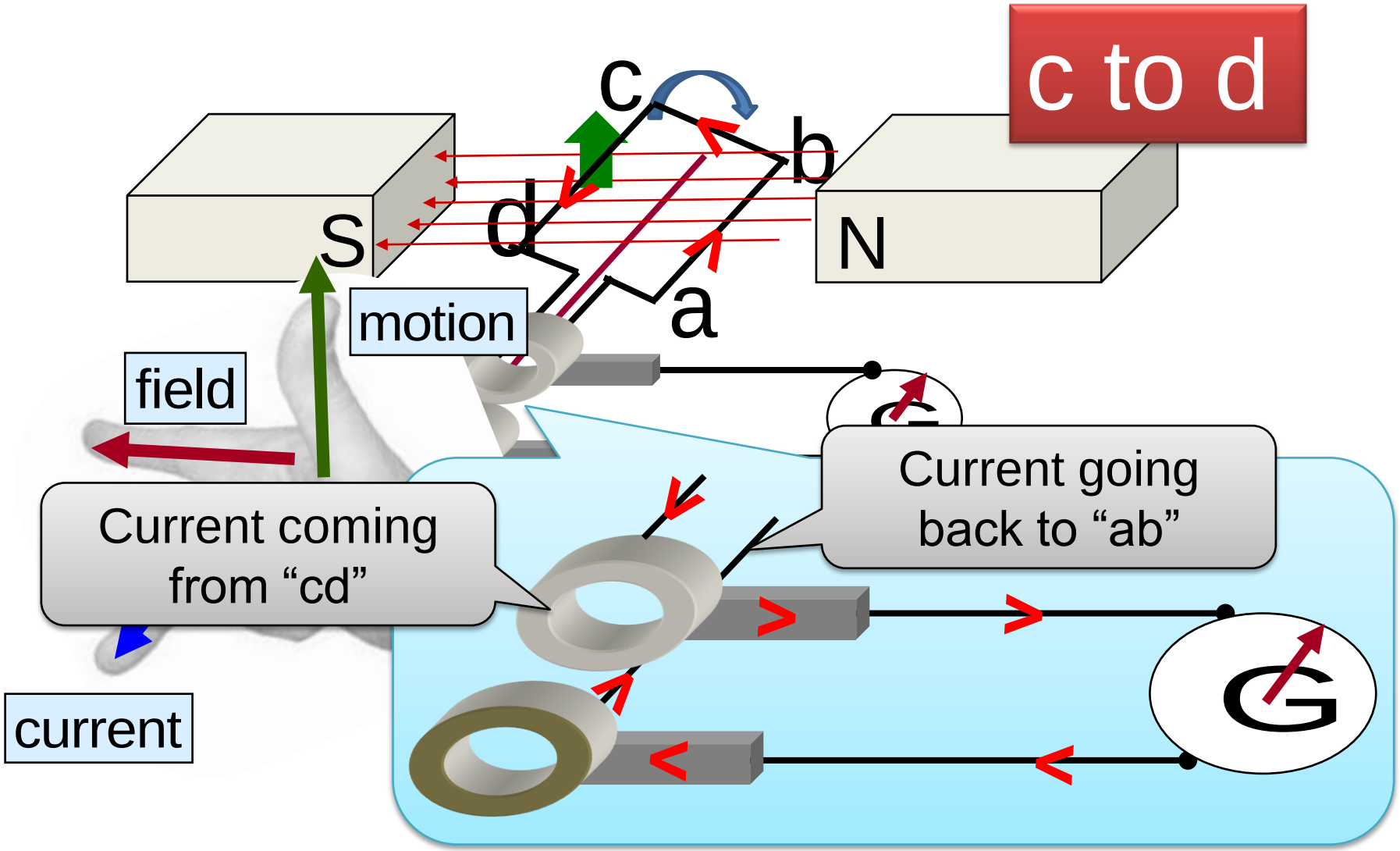



Note that the current flowed from b to a when side ab “started out”, but **is now reversed**, flowing from a to b!

# Current in cd 2

cd moves with ab, and the current in cd flows from …



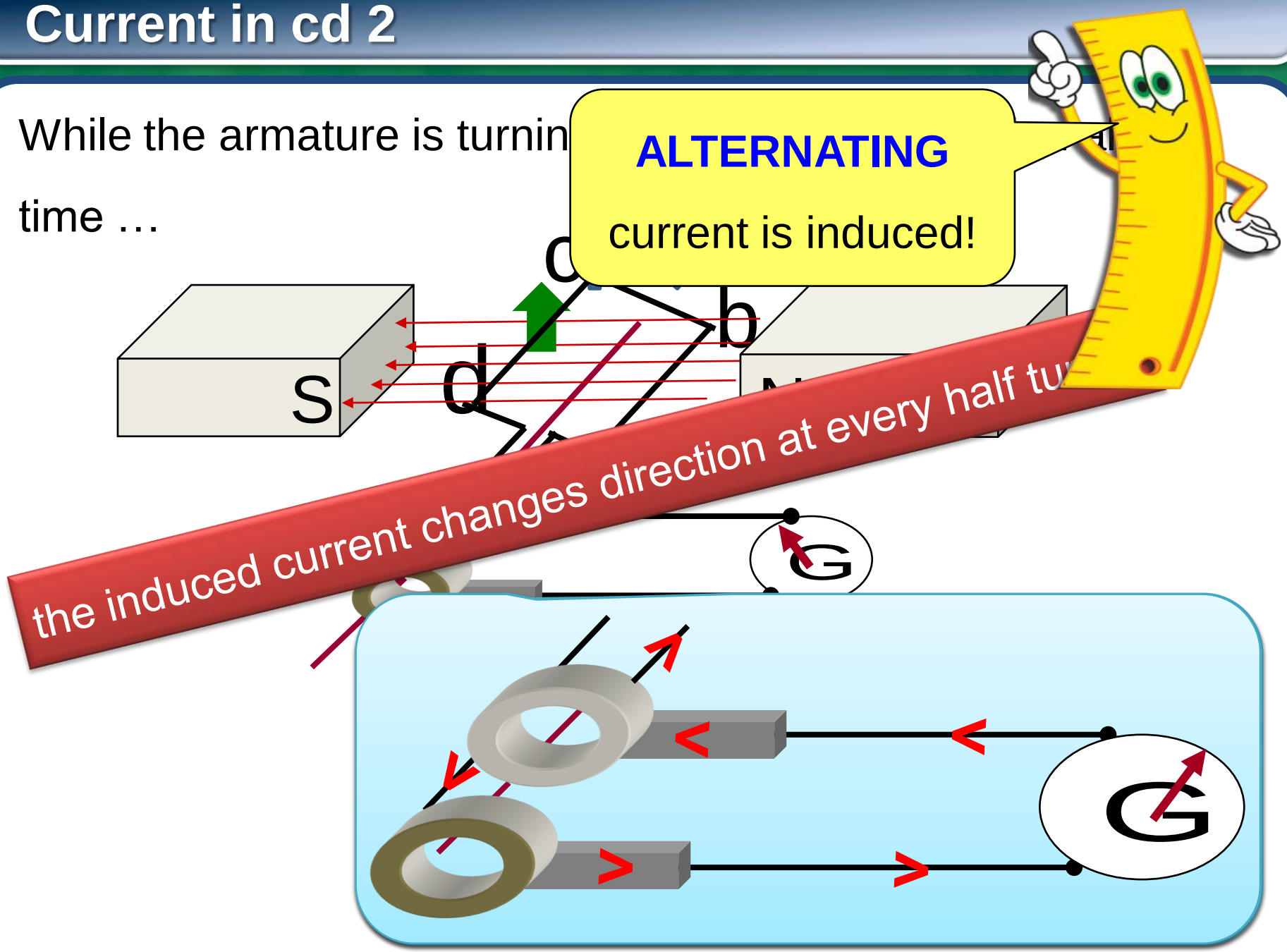
# Current in cd 2

While the armature is turnin

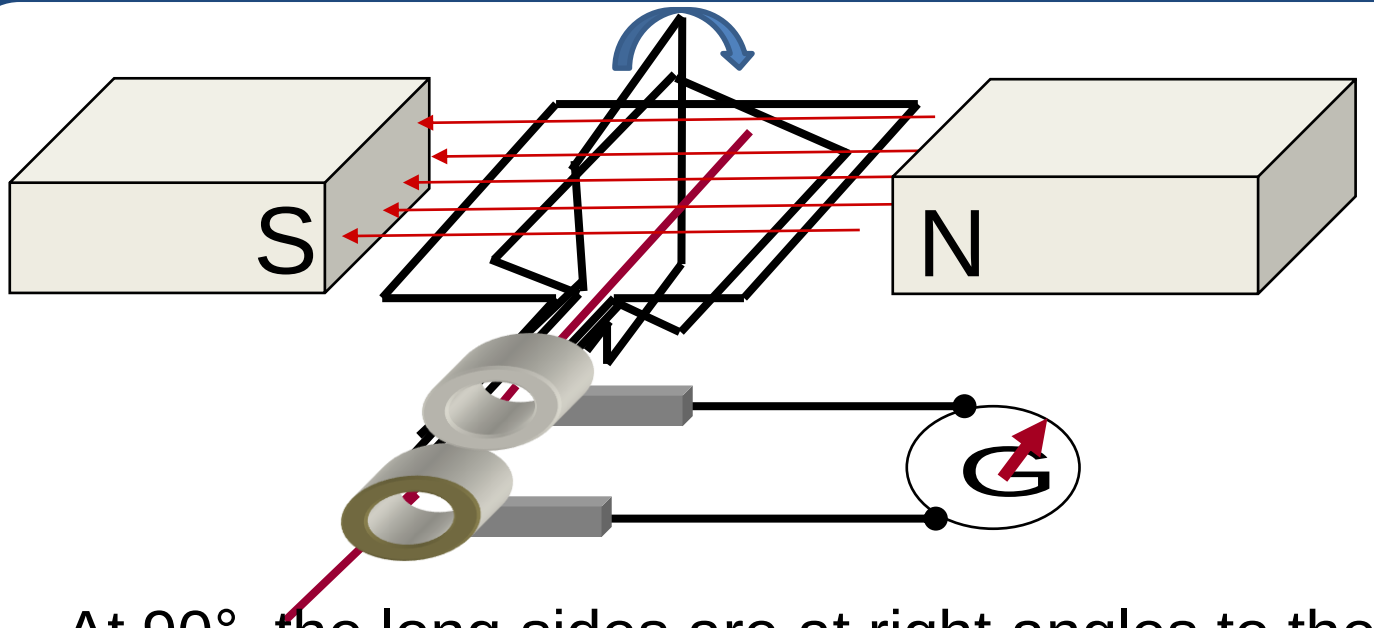
time …

**ALTERNATING**

current is induced!



# Fluctuating emf




At 90°, the long sides are at right angles to the B-field;

⇒ emf has a maximum value;

As rotation proceeds, the angle decreases

⇒ emf decreases;

At 0° the long sides are moving parallel to the direction of the magnetic field

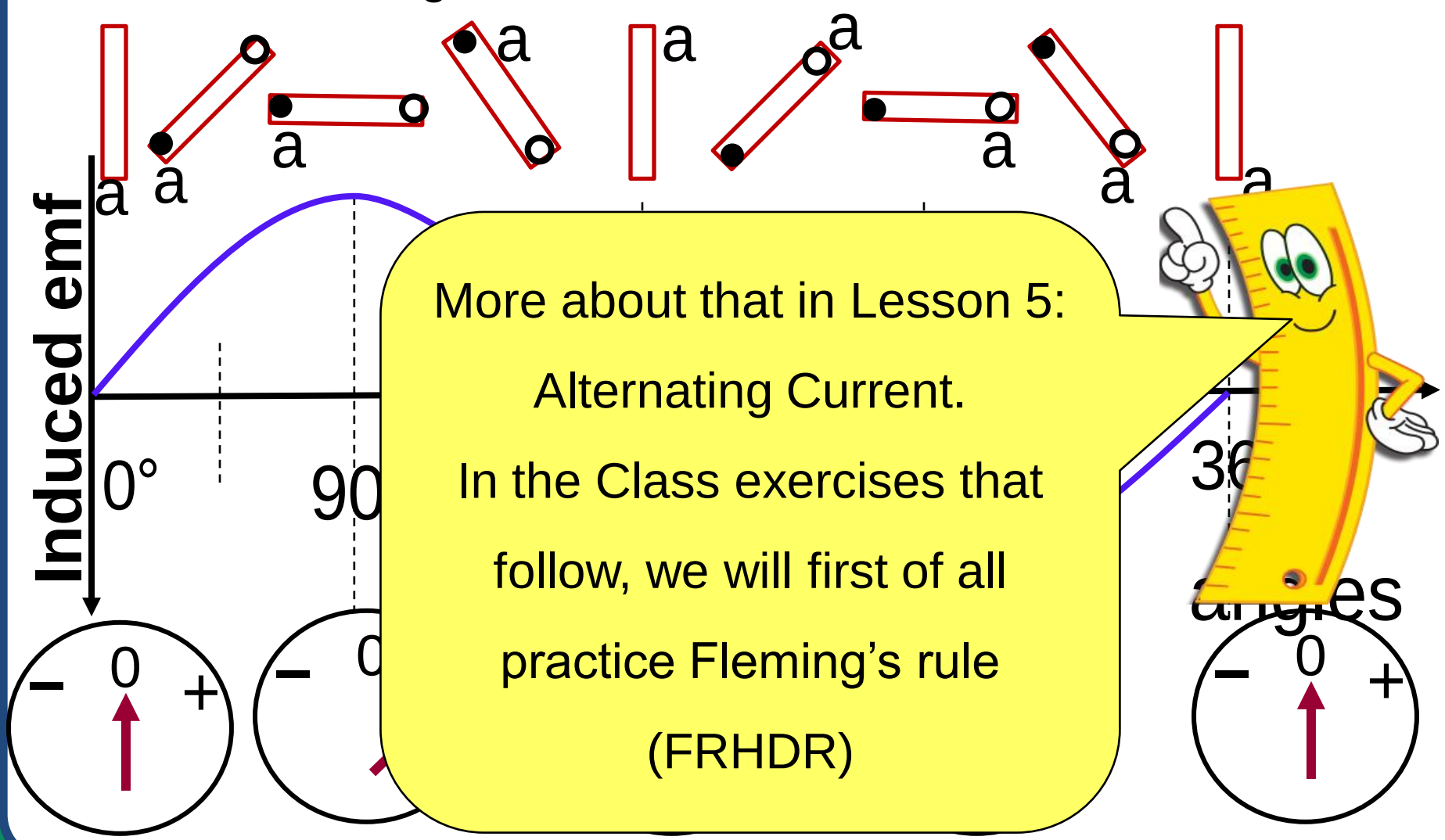
⇒ emf = 0

and so forth …

# Emf graph

A graph drawn from the zero position:

● Current coming out of screen ○ Current going into screen



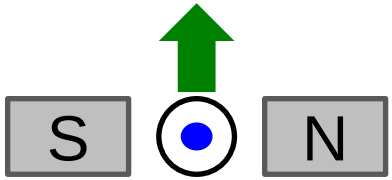

More about that in Lesson 5:

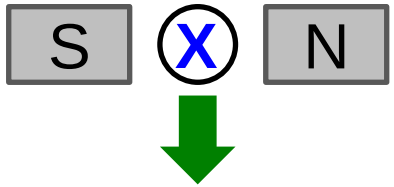
Alternating Current.

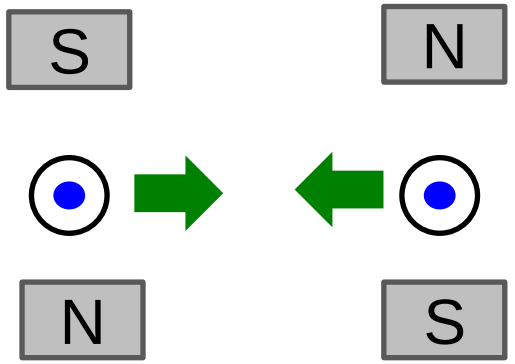
In the Class exercises that follow, we will first of all practice Fleming's rule (FRHDR)

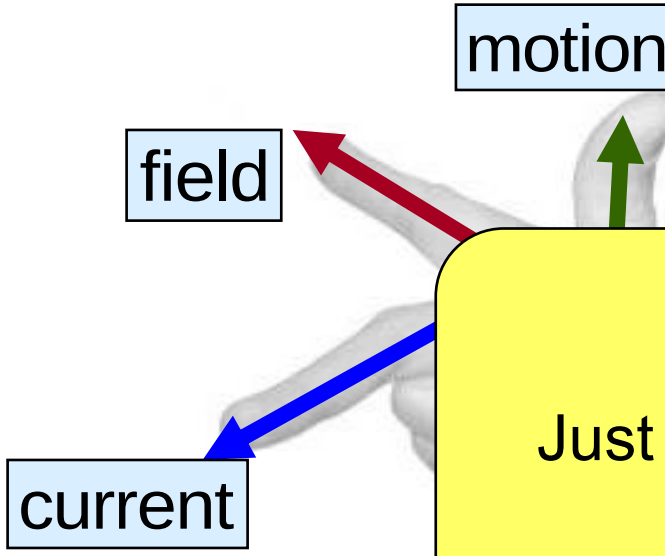
# Class Exercise 1/1

1. All of the following diagrams show a conductor moving in a magnetic field. Using FRHDR to find the direction in which current will be induced in the conductor.



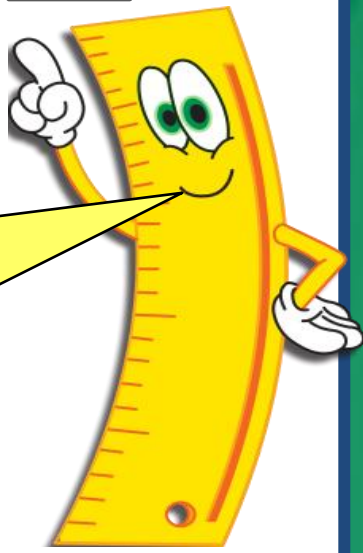




Use that hand!

Just don't get yourself into knots …



# Class Exercise 1/2

2. Electricity can be generated by rotating a wire loop between the poles of a magnet. Which of the following positions would induce the greatest current in the loop?

A The plane of the loop is parallel to the magnetic field.

B The plane of the loop is perpendicular to the magnetic field.

C The plane of the loop makes an angle of 45° with the magnetic field.

D The induced current is the same in all positions.

3. The simplified sketch represents a generator. The main components are labelled **A**, **B**, **C** and **D**.

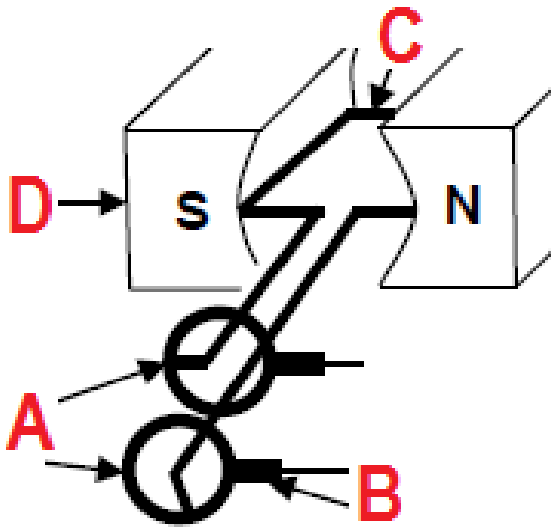
3.1. Write down the name of component:

**A** Slip ring

**B** Brush

**C** Armature

**D** Magnet



# Class Exercise 1/3

3.2. Write down the function of component **B**.

The slip rings remain in contact with the rotating coil and conduct the AC induced in the armature to the external circuit via the brushes.

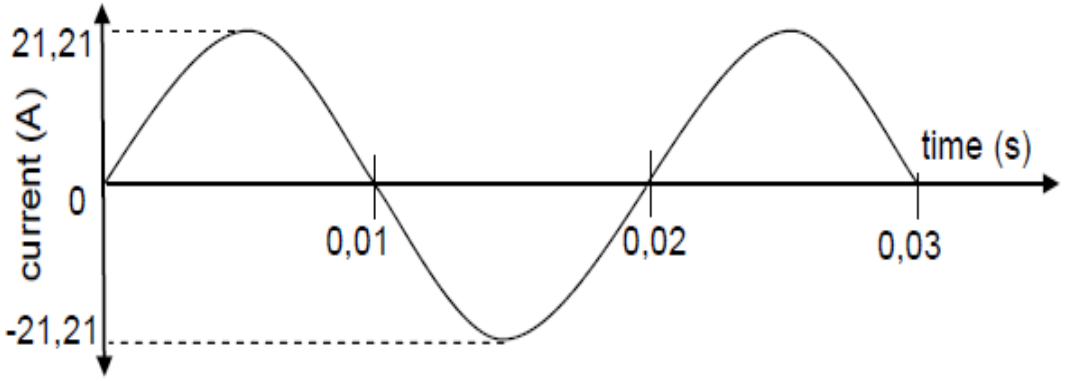
3.3. State the energy conversion which takes place in a generator such as this.

Mechanical energy to electrical energy.

4. A similar coil is rotated in a magnetic field. The graph below shows how the alternating current produced by the generator varies with time.

4.1. How many rotations are made by the coil in 0,03 s?

1½ rotations



# Class Exercise 1/4

4.2. Calculate the frequency of the alternating current.

Period (T) = 0,02 s.

Time taken for one full cycle.

$f = \frac{1}{T} = 50$ Hz

Meaning that the coil makes 50 full cycles per second.

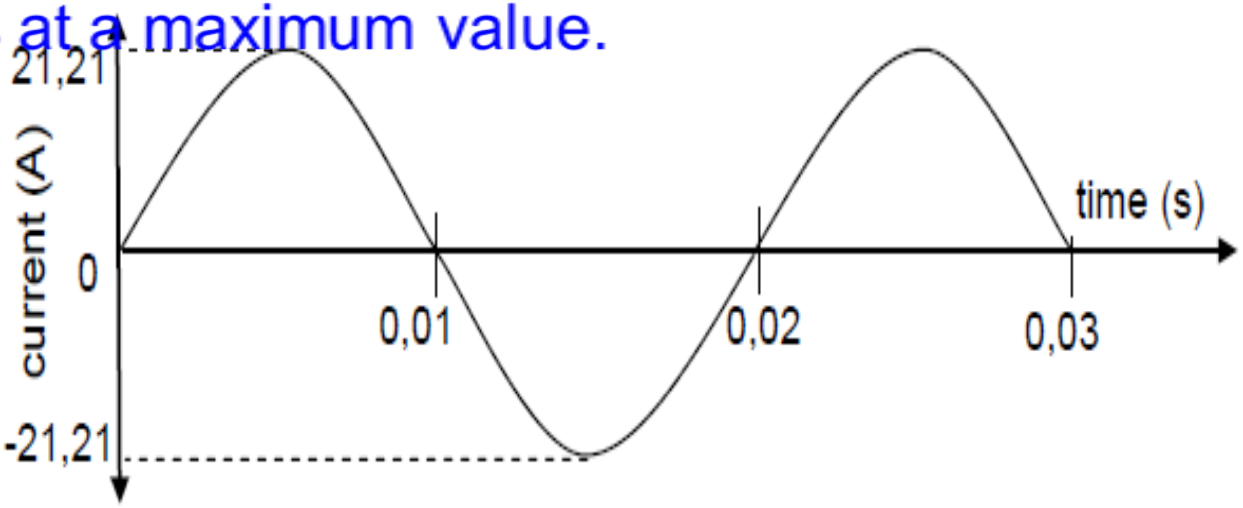
4.3. Will the plane of the coil be PERPENDICULAR TO or PARALLEL TO the magnetic field at t = 0,015 s?

Perpendicular.

The current is at a maximum value.

4.4. When is the armature in a vertical position?

0; 0,01; 0,02 and 0,03 s



# Class Exercise 1/5

5. Consider the diagram of an electrical machine.

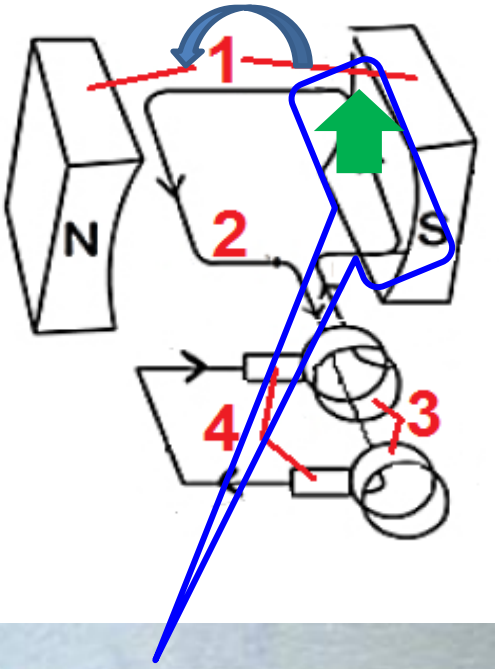
5.1. Give the function of components

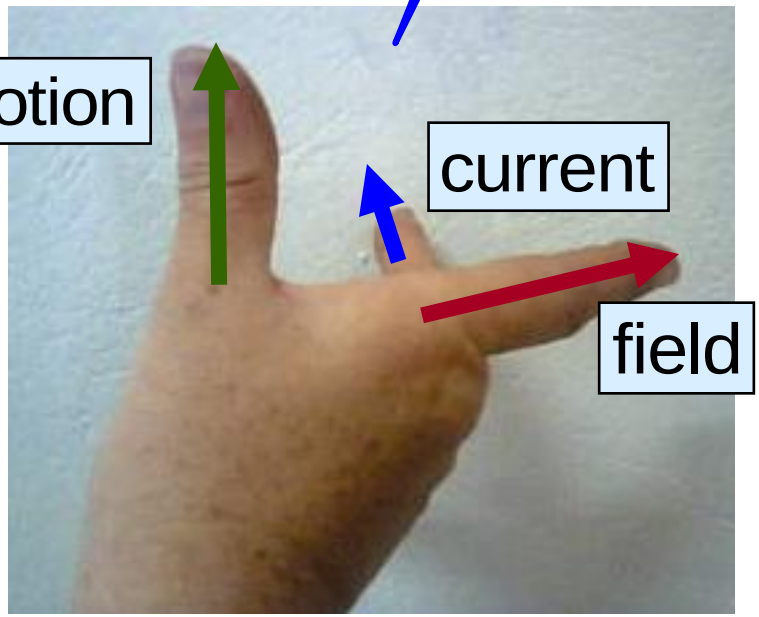
1: The magnets supply the magnetic field that links to the armature.

3: The end points of the armature are connected to the slip rings, supplying a means of a smooth rotating against the brushes.

5.2. In which direction is the armature rotating?

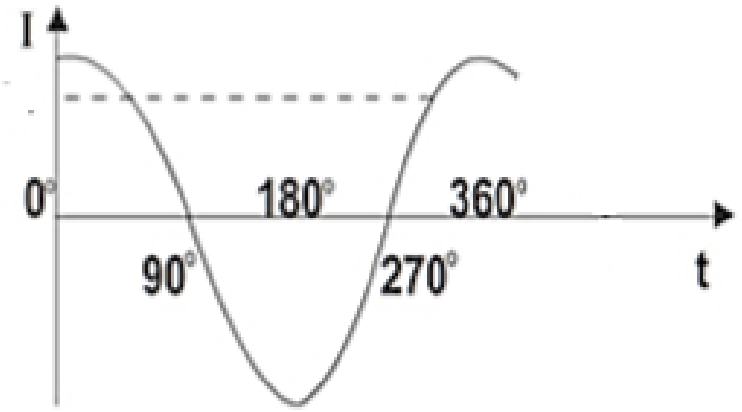
Anti-clockwise



# Class Exercise 1/6

5.3. Draw a graph to illustrate how the induced current varies with time for one complete cycle.




5.4. Is the induced emf and induced current in phase or out of phase? Give a reason for your answer.

In phase.

When the *emf is a maximum, it produces* a current which is also a maximum.

5.5. Write down the name of the rule you used to determine the direction of rotation in the previous question.

Fleming's Right Hand Dynamo Rule

# Key Concepts 1

**Electric Generators** convert **mechanical energy into electrical energy** (e.g. a bicycle lamp).

**ELECTROMAGNETIC INDUCTION** takes place when there is a change in the magnetic flux linkage to the wire

- Either because the magnet is moving
- Or the wire / coil / solenoid is moving.

The **direction of the induced current** can be determined by **FLEMING'S RIGHT HAND RULE** (for generators):
The **right hand** is held with the thumb, first finger and second finger mutually perpendicular to each other (at right angles). The **Thumb** represents the direction of **Motion** of the conductor. The **First** finger represents the direction of the **Field**. (north to south). The **Second** finger represents the direction of the induced or generated **Current.**

# Key Concepts 2

The **maximum emf** is induced when the **area of the coil is perpendicular to the flux lines**.

When the coil is **parallel** to the B-field, **no emf** is induced.

**ALTERNATING CURRENT (AC),** is induced when slip rings are used to convey current to the brushes.

# Isigama

**Armature:** the rotating coil of a dynamo or electric motor; the moving part of an electrical machine in which a voltage is induced by a magnetic field.

**Slip rings:** Conducting ring **forming a complete circle** used to convey current to the brushes of the generator.

**Generator:** An electrical machine that converts mechanical energy into electrical energy.

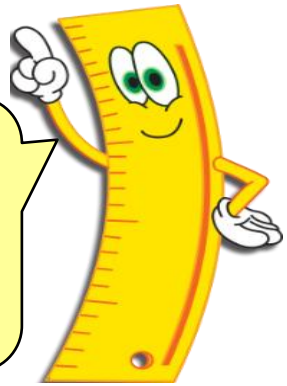
**Dynamo:** a device that creates electricity by turning around a magnet near a coil of wire.

**Turbine:** A rotary motor or engine driven by a flow of water, steam, gas, wind etc., especially to produce electrical power.

- **Memorise** the various definitions
- **Review** the exercises you had difficulty with …
- and do some **additional exercise** …
  - as given in your **workbooks** that accompany this video series or from your school textbook

Continue your learning by watching the **next video lesson** in this series:

*Lesson 3: DC Generators*



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