Does Science truly understand Electromagnetic Induction?

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Drafted: 27-11-17

A world changing discovery of Michael Faraday in 1831, Electromagnetic Induction is the very basis of today's technology, but does Science really understand Electromagnetic Induction?

It is true science has a good deal of understanding of Electromagnetic Induction. But simply looking at the definition of some terms used gives rise to doubt and rightly so!

For example; Electromotive Force E.M.F:

> ***A difference in potential that tends to give rise to an electric current.***
>
> *Ref:* ***https://en.oxforddictionaries.com/definition/us/electromotive_force***

The part: "tends to give rise", is a giveaway, it is true. We do not know for sure that a Current will always be available. We can be fairly sure under most circumstances, just not always!

Why?

Science considers two types of Magnetic Field:

- Natural (Lodestone)
- Artificial, or Man Made (Coil with N Turns with I Current)

An Example of Loadstone:

Ref: https://en.wikipedia.org/wiki/Lodestone

The definition Lodestone:

1 - A piece of magnetite or other naturally magnetized mineral, able to be used as a magnet.

Ref: ***https://en.oxforddictionaries.com/definition/lodestone***

An Example of Artificial:

Ref: https://www.youtube.com/watch?v=aMsPc73o9qw

The definition of Electromagnet:

A soft metal core made into a magnet by the passage of electric current through a coil surrounding it.

Ref: ***https://en.oxforddictionaries.com/definition/us/electromagnet***

By definition, it is a Magnetomotive Force that attracts the hook to the Electromagnet. The Magnetomotive Force is defined as follows:

> ***A quantity representing the sum of the magnetizing forces along a circuit.***
>
> *Ref:* ***https://en.oxforddictionaries.com/definition/magnetomotive_force***

Mathematically, the Magnetimotive Force is:

$$AT = NI$$

Where:

- AT = Ampere Turns
- N = Number of Turns
- I = the Current through the Turns

Here, by definition, we see that the Artificial Magnet is created by a Current, through a Coiled Conductor, in a Material, in this case a large Iron Nail.

The large Iron Nail and the Lodestone are different, they have different properties, one is soft and one is hard, this gives us an idea how hard it is to magnetise a material, the Coercive Force:

> ***The resistance of a magnetic material to changes in magnetization, equivalent to the field intensity necessary to demagnetize the fully magnetized material.***
>
> *Ref:* ***https://en.oxforddictionaries.com/definition/coercivity***

It is harder to magnetise some objects than others, it's also worth noting, some objects react to magnetic fields differently! Some materials are naturally not magnetic, or Diamagnetic, Plastic, Wood, and so on. Different magnetic properties exist in different materials.

- Diamagnetism
- Paramagnetism
- Ferromagnetism
- Ferrimagnetism
- Antiferromagnetism

The magnetic susceptibility is the direction of magnetism a material takes on as a result of an applied external magnetic field, either aligning with, or aligning in opposition, to the applied magnetic field.

Mathematically magnetic susceptibility is:

$$X = \frac{M}{H}$$

Where:

- *M* is the materials magnetization
- *H* is the applied magnetic field

Interestingly, the magnetic field **B** is related to **H** in the following way:

$$B = \mu_0(H + M)$$

Where: (SI Units)

- *B is the Magnetic Field*
- *M* is the materials magnetization
- *H* is the applied magnetic field - 1 A/m .= 1 AT/m
- μ_0 is the Vacuum Permeability

One could say that magnetic susceptibility of the stator, plays a role in Electromagnetic Induction.

Electromagnetic Induction is the most amazing process I have ever studied, and I still have a lot to learn. In saying this, let's look for inconsistencies…

The Laws of Electromagnetic Induction predict an E.M.F or an Electromotive Force, An Electromotive Force is Voltage, the potential difference in Elementary Charge from one Terminal to the other terminal.

Electromagnetic Induction does not predict Current! This should be noted!

Two equations for two different methods of Electromagnetic Induction exist, see George I. Cohn for details:

Flux Linking Law:

$$E.M.F = -N\frac{d_\phi}{d_t}$$

This is Transformer Induction. Today we know the Magnetic A Vector Potential is directly associated with this law.

Flux Cutting Law:

$$E.M.F = Bvl$$

This is typically associated with Generators, as a Rotor passes the Stator, the Magnetic Flux Cuts a portion of the length of the Coil Conductor.

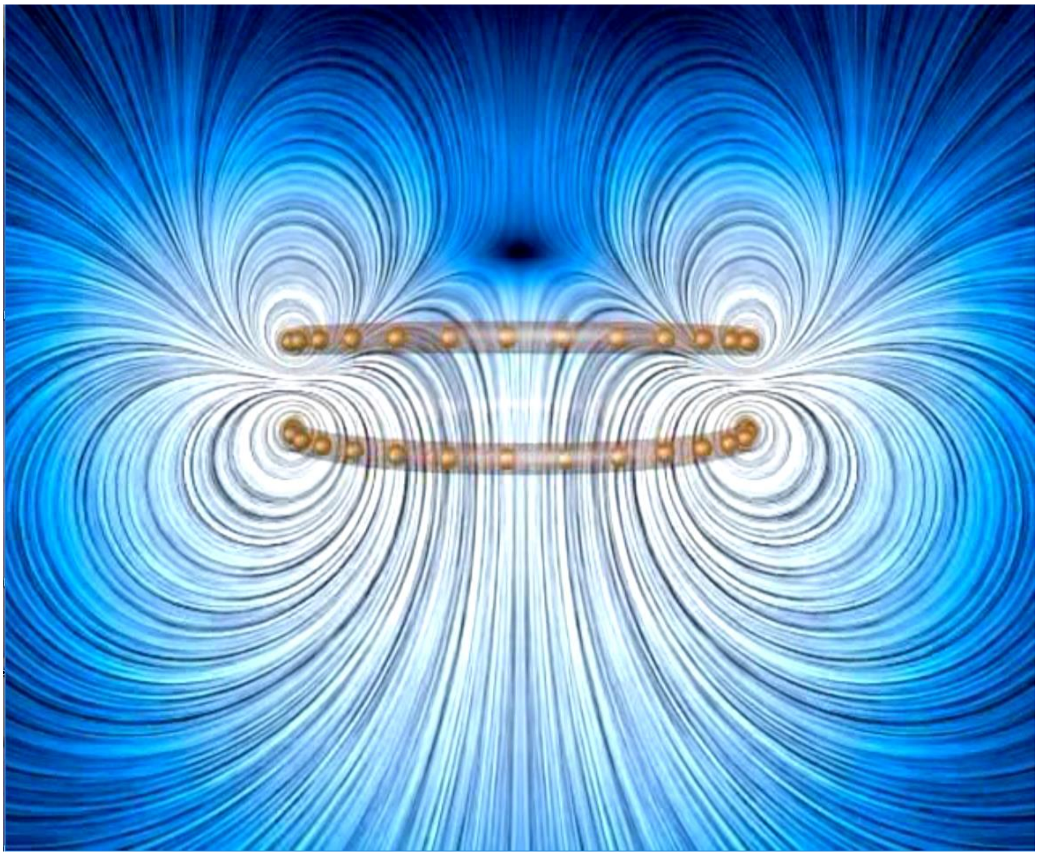
Where:

- E.M.F = the Potential difference in Charge of the two terminals
- \- is Lenz's Law
- N is the number of turns
- d_ϕ is the change in Magnetic Flux
- d_t is the change in Time

- B is Magnetic Flux Density
- v is the Velocity
- l is the length of the Conductor being cut

These equations are assuming the Flux is perpendicular to the Conductor. I think we will focus on the Flux Linking Law. Particularly the negative sign (-) which is Lenz's Law, and at the same time Newtons Laws of Motion: "For every Action there is an Equal and Opposite Reaction".

We know B, the Change in Magnetic Flux: d_ϕ relative to the Change in Time: d_t is a critical component to Electromagnetic Induction. We also know that Lenz's Law (-) predicts an Equal and Opposite Reaction. Which, in turn, looks something like the following:



Ref: http://web.mit.edu/8.02t/www/802TEAL3D/visualizations/magnetostatics/MagneticForceRepel/MagneticForceRepel.htm

Simple experiment, with a large air cored coil, 200 turns, short circuited, a large neodymium magnet, proves that this simulation is very accurate. Pretty much all the Magnetic Flux is expelled from the Coiled conductor. Pushing the magnet away from the Coil on part of the stroke and pulling the magnet back in for the other part of the stroke.

It is this same force that makes a magnet travel very slowly down a copper tube:

Ref: https://www.youtube.com/watch?v=5BeFoz3Ypo4

The only reason the magnet falls at all is because the fields die out, magnet falls, fields build, slows the magnet, fields die out, and so on.

About now I am sure we can see a possible problem?

We are seeing Electromagnetic Induction, but the magnetic susceptibility of the stator coils is actually negative, meaning almost all the magnetic field is expelled due to the magnetic field in reverse, equal and opposite! Yes we see Electromagnetic Induction, without Magnetic Flux.

So, B, the magnetic flux, is miniscule, the above equation: $B = \mu_0(H + M)$ because M is negative, the magnetic flux that does cut the coil conductor, is creating a huge field in the opposite direction, this does not make any sense either. There appears to be a problem here that I see no explanation for.

Transformers can be very efficient, 99% in some cases or even a little higher.

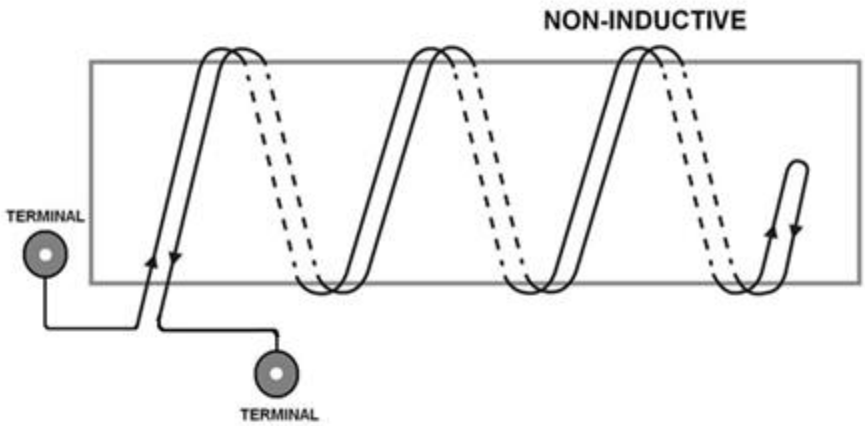
Transformers use the same Law. Flux linking, there is normally very little flux leakage! Less than 1% most of the time, in a well-designed transformer. The core material has permeability, this is the ability for flux to travel a path, the easier it is to travel the more permeable the material.

The definition for permeability is:

> ***A quantity measuring the influence of a substance on the magnetic flux in the region it occupies.***
>
> *Ref:* ***https://en.oxforddictionaries.com/definition/permeability***

With unity coupling, transformers can have a very efficient transfer of Electrical Energy. We must ask the question, what, is actually transferring, what is transforming, from what to what?

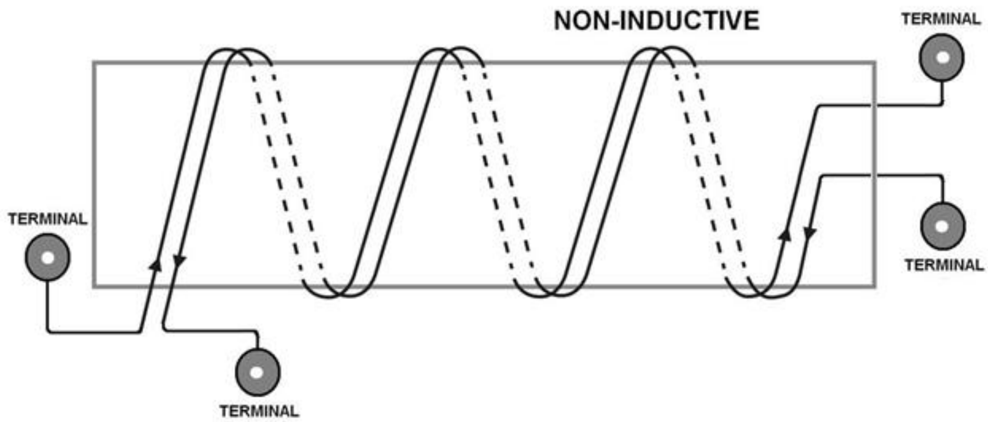
We know that if we take a length of wire, fold it in half looping it back on itself, then coil, this wire on a former, then there is almost no magnetic field when a voltage is applied. An example of such a coil:



Very little magnetic field is present, but a lot of electric field is present. Because there is almost zero magnetic field, this coiled wire looks like a resistor, it is resistive and not inductive, presenting voltage and current wave forms that are pretty much in phase, as one would expect to see.

An important note: An inductive element with in phase voltage and current is now non-inductive.

Let's change this situation slightly, let's say this is our coil of wire now:



We now have a standard, unity wound transformer! An AC voltage is applied to one coil. A load is applied to the other coil, Electromagnetic Induction is equal and opposite, Lenz's Law, output current is 180 degrees out of phase to the input current. Voltage and Current will move toward an in phase condition as more load is applied and the core saturates.

But if there was no core?

The Inductance drops away very fast, there is no phase difference at all.

Technically, there is no difference between the two diagrams, the exact same situation occurs. Experiment says this is all with very little magnetic field actually where our Laws say it should be!

The Electromagnetic Induction law predicts equal and opposite E.M.F, but at the same time the requirement is that the Magnetomotive Force (MMF) on the input coil, is equal and opposite, to the Magnetomotive Force (MMF) on the output coil:

$$MMF_P + MMF_S \simeq 0$$

Here, we see, that the MMF, which is the current in each coil, or Ampere Turns, in the primary and secondary, approximately cancel, as we saw in the first experiment and is well known.

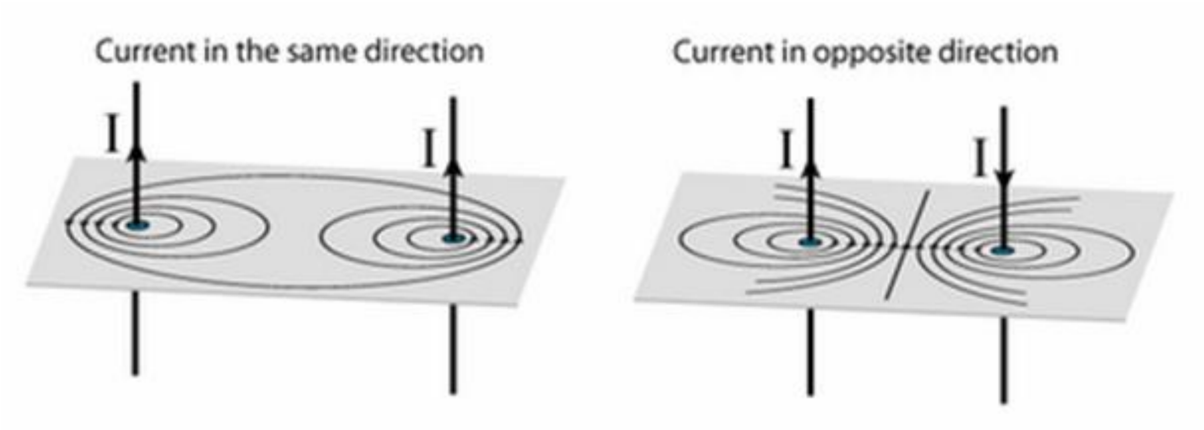
We have a situation where no Hook could be lifted with a magnetic field. The MMF is consumed.

The magnetic field is the very basis for Electromagnetic Induction. How can we get by knowing that this may not be the case? We do know about the Magnetic A Vector Potential, but this also requires the magnetic Field B.

Electromagnetic Induction as we currently understand it, is entirely based around the magnetic field B, but here we see examples, that suggest this is not the case! Experiments that show us slightly different results to what we would expect! Where the magnetic field B, makes no actual contact with the loaded output coil at all.

It is true that the magnetic field puts a magnetic pressure in the proximity of the coil conductor. This is a high stress area when Electromagnetic Induction is occurring and the E.M.F is loaded, so a current can flow. Remembering that the current and magnetic field, are one and the same thing. A current in a coil gives rise to the magnetic field.

We know from experiment that there is a magnetic boundary between opposing currents:



The magnetic fields also oppose. So, how does Electromagnetic Induction produce an opposing current? Is there something else working here we do not yet know about?