



ALCAP EDUCATIONAL DOCUMENT | FUNDAMENTALS

Electricity and Magnetism

How electromagnetic fields make motors, generators, transformers, relays, and inductive loads work

Electricity and magnetism are two aspects of electromagnetism. Their interaction is the operating principle behind most equipment that generates, transforms, switches, or converts electrical energy.

WHAT YOU WILL LEARN

- How current creates a magnetic field
- How a changing magnetic field induces voltage
- Why motors and generators are closely related
- How inductive equipment affects current and power factor

PRACTICAL. INDEPENDENT. DECISION-FOCUSED.

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01 | THE ESSENTIALS

Build the right mental model

A stationary electric charge produces an electric field. Moving charge - current - also produces a magnetic field. A changing magnetic field can, in turn, induce a voltage in a conductor.

Current creates magnetism

When current flows through a conductor, a magnetic field forms around it. Coiling the conductor concentrates the field; adding a suitable core strengthens and guides it.

Changing fields induce voltage

If the magnetic flux linking a conductor changes, a voltage is induced. The change can come from motion, an alternating current, or a switching event.

Energy conversion

A motor uses electrical input and magnetic force to create motion. A generator uses motion and magnetic fields to produce electrical output. A transformer transfers AC energy between windings by induction.

ONE PRINCIPLE, MANY MACHINES

Motor: electricity to motion **Generator:** motion to electricity **Transformer:** AC voltage/current conversion
Relay/contactor: electrical control to mechanical switching.

A QUICK REFERENCE

Device	Magnetic action	Operational concern
Motor	Field interaction produces torque	Starting current, heating, efficiency
Transformer	Changing flux links windings	Loading, harmonics, temperature
Contactors	Coil pulls an armature	Coil voltage, contact wear
Inductor/reactor	Stores energy in a magnetic field	Current, saturation, harmonics

02 | PUT IT TO WORK

Turn understanding into action

This model helps diagnose why electrical equipment may draw current even when not all of that current is converted into useful mechanical work or heat.

1**Identify magnetic equipment**

List motors, transformers, solenoids, contactors, reactors, and generators.

2**Observe operating states**

Starting, light load, full load, switching, and faults create different magnetic and electrical behaviour.

3**Check ratings**

Voltage, frequency, insulation class, duty, and temperature limits are linked to magnetic design.

4**Review power quality**

Low voltage, imbalance, harmonics, and poor power factor can increase current and heating.

5**Trend condition**

Temperature, vibration, current, and insulation measurements can reveal deterioration before failure.

ILLUSTRATIVE EXAMPLE: TRANSFORMER ACTION

An AC current in the primary winding creates a changing magnetic flux in the core. That flux induces voltage in the secondary winding. The turns ratio largely sets the voltage ratio, while losses and regulation affect the real operating value.

A GOOD DECISION LOOKS LIKE

- Motors and transformers are selected for the actual duty, supply, and environment.
- Starting and switching effects are included in protection and capacity studies.
- Thermal symptoms are investigated alongside loading and power quality data.

03 | CHECKLIST AND NEXT STEPS

Use this before you proceed

- [] Confirm supply voltage and frequency match the nameplate.
- [] Record load current on all phases and check imbalance.
- [] Inspect cooling paths, fans, vents, and surrounding temperature.
- [] Review motor starting method and its effect on demand and voltage.
- [] Trend transformer and motor temperature under comparable load.
- [] Investigate unusual hum, vibration, odour, or repeated trips.

RED FLAGS

- Persistent overheating at normal production
- Large phase-current imbalance
- Repeated contactor chatter or nuisance tripping
- Assuming every magnetic symptom is a mechanical fault

PLAIN-LANGUAGE GLOSSARY

Flux	A measure describing a magnetic field through an area.
Induction	Creation of voltage by a changing magnetic field.
Inductance	A circuit property that opposes change in current.
Torque	Turning force produced by a motor.
Core	Magnetic material used to guide and concentrate flux.

SOURCES AND FURTHER READING

- U.S. EIA - Magnets and electricity
- U.S. EIA - How electricity is generated
- U.S. DOE - Electricity Industry Primer

IMPORTANT NOTE

This document is for general education only. It is not a substitute for a site assessment, electrical design, tariff review, safety study, or professional advice. Use the latest applicable standards, utility rules, municipal requirements, and manufacturer instructions. Work on electrical systems must be performed by suitably qualified and authorised persons.

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