

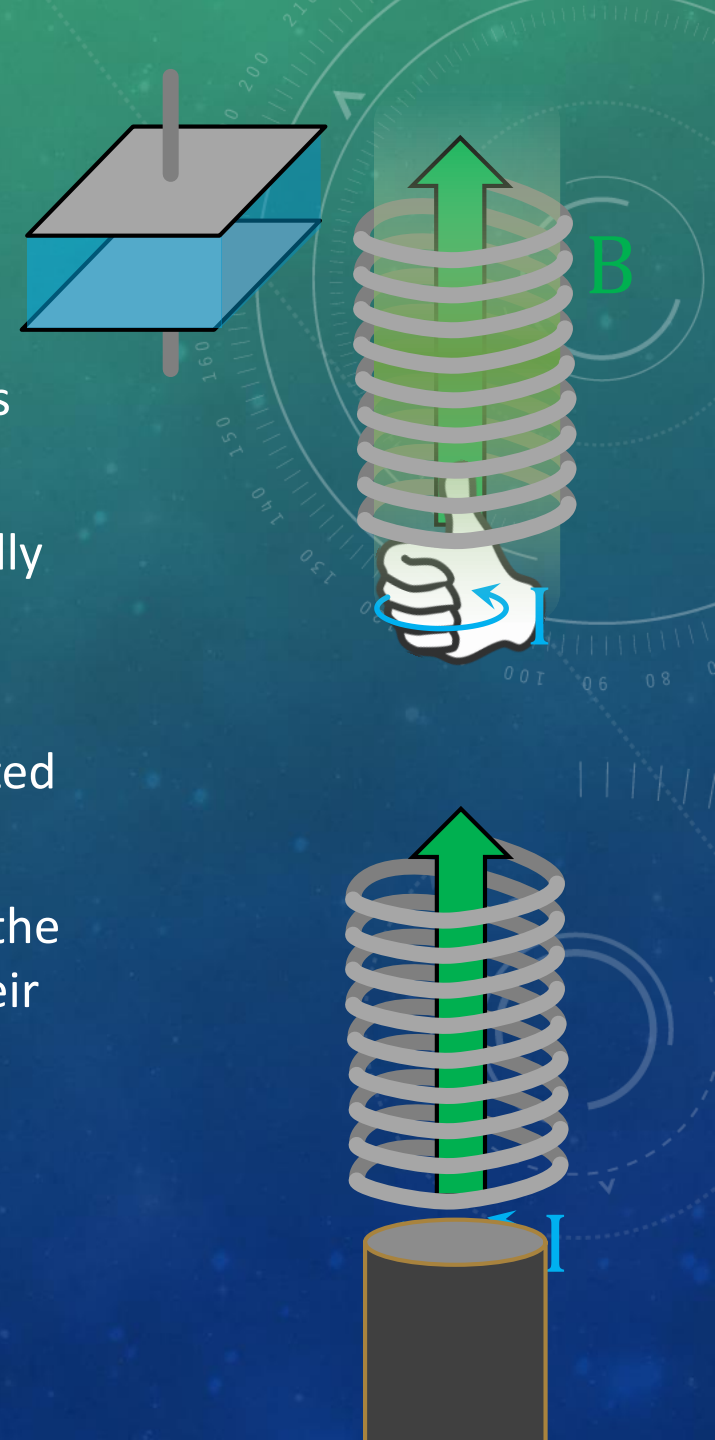
The background features a dark blue-to-green gradient with faint, glowing circular patterns and a scale on the left side. The scale has markings from 140 to 260 in increments of 10. Several circular diagrams with arrows indicate clockwise or counter-clockwise rotation, suggesting concepts like magnetic induction or angular momentum.

MAGNETIC INDUCTION

PES 1000 – PHYSICS IN EVERYDAY LIFE

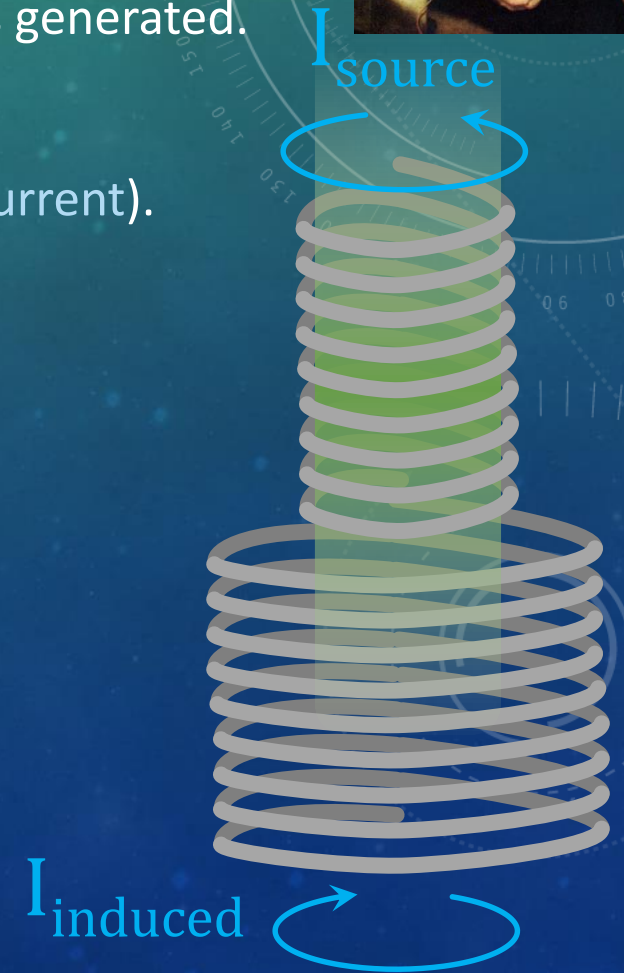
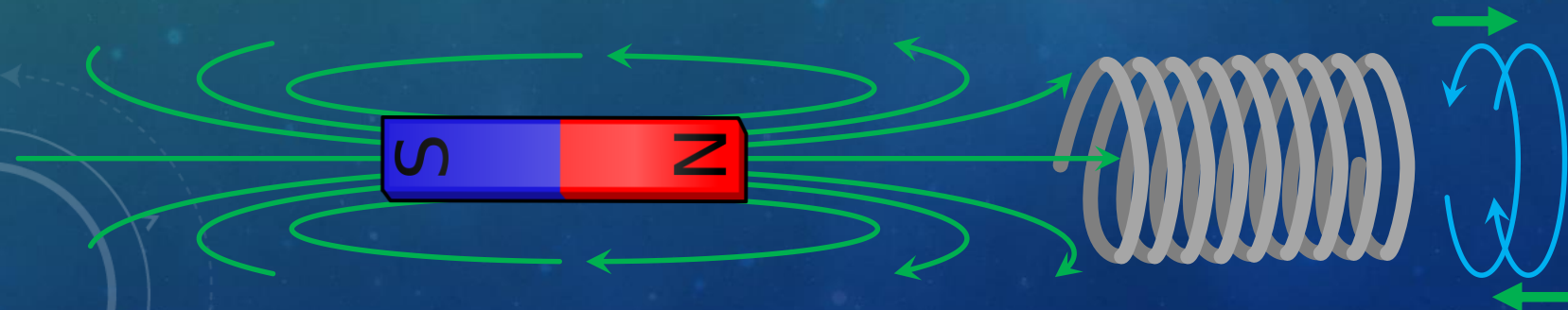
SOLENOIDS

- Forming a **spiraling coil of wire** and running current through the wire makes what is called a **solenoid**.
- The magnetic field that forms is very **uniform inside the coil** and is essentially zero outside the coils. More loops make a stronger field.
- The **direction** of the magnetic field is obtained from the **right-hand-rule**. Fingers curl in the direction of current, and thumb points along the generated field.
- The magnetic field can be greatly **magnified** by putting an **iron core** within the coils. The generated field aligns the magnetic atoms of the iron, adding their contribution to the total field. This can magnify the field by 100x in some cases.
- The uniform magnetic field **contains energy**.
- The solenoid is the magnetic equivalent of the capacitor for electric fields.



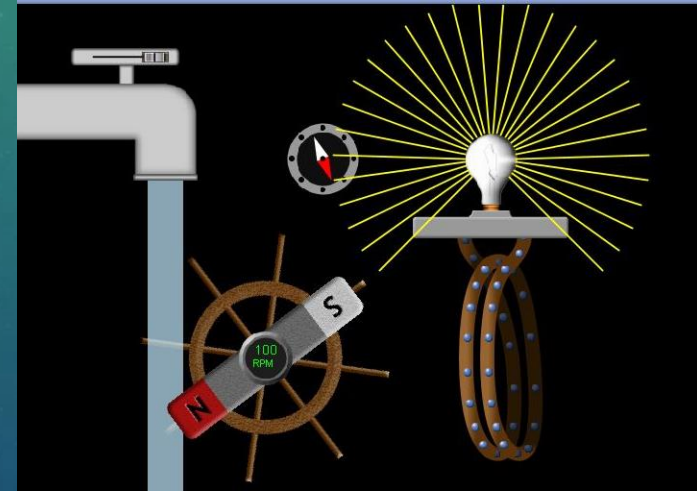
FARADAY'S LAW OF INDUCTION

- We have seen that when charge moves in a wire (current), a magnetic field is generated.
- **Michael Faraday** discovered the following symmetric behavior:
 - When a magnetic field changes, this causes charges to move in a wire (current).
 - This is called *magnetic induction*.
 - Note: Current only flows while the magnetic field is *changing*.
- Turning on or off an electro-magnetic field near a wire or coil induces a current in that wire or coil.
- Moving a magnetic field near a wire induces a current in that wire.



USING INDUCTION TO GENERATE CURRENT

- **Induction** allows us to convert **mechanical motion** into **electrical current**.
 - The **energy** of motion is carried by the current.
 - The current can transfer that energy many kilometers away.
 - **Current begins to flow** throughout the whole circuit **almost instantaneously**.
 - This is the basis of **electrical generators**. The turbines can be turned using moving water, wind, or steam heated by coal, nuclear reaction, etc.
- Electrical current generates a **magnetic field** that can interact with a **permanent magnet**, causing it to move.
 - This allows us to turn **electrical energy** back into **mechanical motion**.
 - This is the basis for electric motors. **Motors are simply generators working in reverse**.



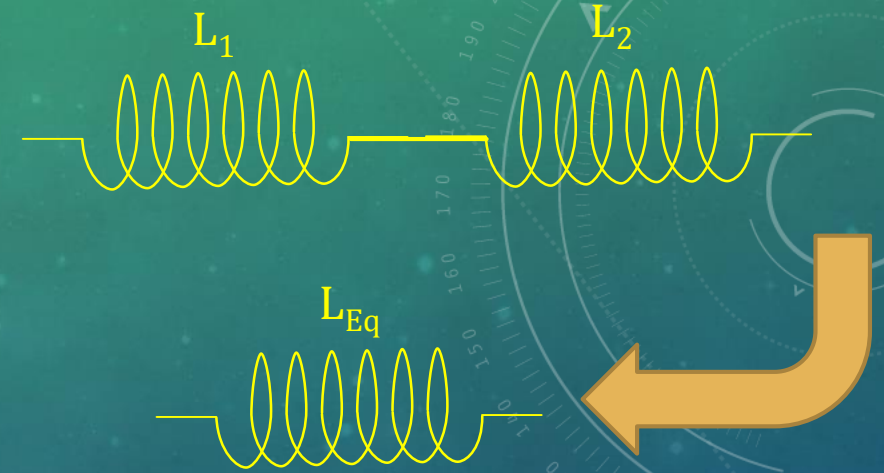
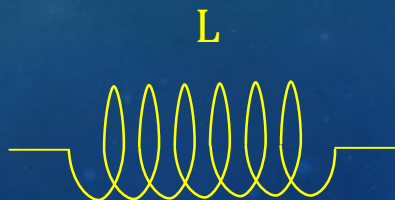
EFFECTS OF INDUCTANCE

- An **inductor** stores energy in the uniform magnetic field within its coils.
- As the current grows, expanding magnetic fields from each coil pass through every other coil in the inductor.
- This **generates a voltage** that is **opposite** the current. This is a type of 'magnetic inertia' that opposes changes in the current.
- For instance, when the circuit is first closed, the **inductance opposes the growing current**, extending the time for the current to reach a steady maximum.
- When the current flow is interrupted, the **inductance now opposes the shrinking current**, keeping it flowing for a brief time, until the energy stored in the magnetic field is expended.
 - This is the cause of the spark that sometimes happens when you unplug your computer's AC adapter. The inductance inside the box-like part of the charger keeps the current running as the plug disengages, causing the spark.

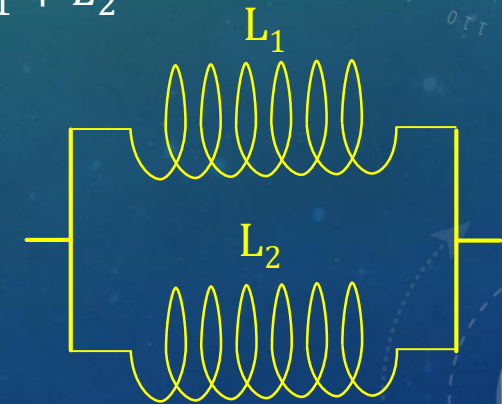


INDUCTORS IN A CIRCUIT

- The **symbol** of an inductor in a circuit is based on the solenoid or **coiled wire**.
- The **variable** usually used for inductance is **L**.
- The SI **unit** of inductance is the **Henry** (H).
- Like batteries, resistors, and capacitors, inductors can be connected in **series** or in **parallel**.
- The rules for simplification of pairs of inductors to a single equivalent inductance are the same as for resistors:
 - Inductors in **series add** their inductance.
 - Inductors in **parallel** combine as reciprocals to **decrease** inductance.



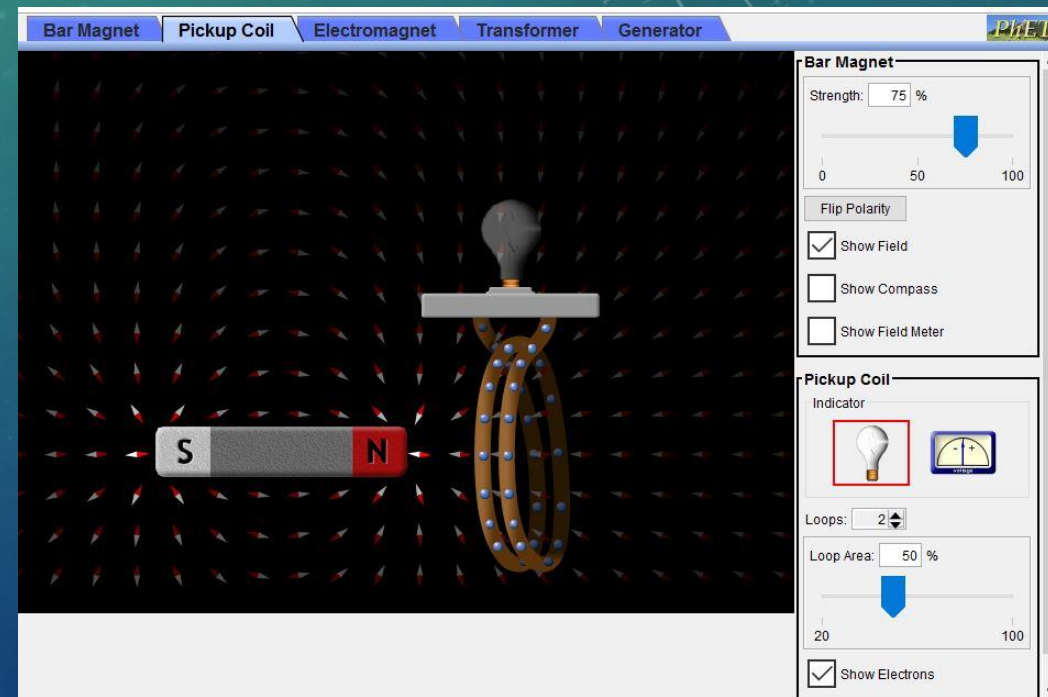
$$L_{Eq} = L_1 + L_2$$



$$\frac{1}{L_{Eq}} = \frac{1}{L_1} + \frac{1}{L_2}$$

INDUCTION SIMULATION

- Link to simulation: <https://phet.colorado.edu/en/simulation/legacy/faraday>
- Things to do:
 - On the 'Pickup Coil' tab:
 - Move the magnet back and forth. See how the light shines whenever it moves, but stops when the magnet stops.
 - On the 'Electromagnet' tab
 - Look at the similarity of the magnetic field through the solenoid and the magnetic field of a bar magnet.
 - Turn the solenoid off by stopping the current.
 - Reverse the magnetic field by reversing the current.



CONCLUSION

- A **solenoid** is a **coil of current carrying wire**. The magnetic field inside it is **uniform**.
- The solenoid is the magnetic equivalent of the capacitor for electric fields.
- A moving magnetic field can generate **current** in a coil, and a **current** in a coil can generate a magnetic field.
- **Generators** convert **mechanical motion** into **current**. Electric **motors** convert **current** into **mechanical motion**.
- In a circuit, **inductance opposes current changes**. Current takes time to reach its maximum and it takes time to drop to zero.
- Inductors can be connected in **parallel** or **series**.